HEAT AND MASS TRANSFER STUDIES IN LIQUEFIED PETROLEUM GAS STORAGE OPERATIONS

(KAJIAN PEMINDAHAN HABA DAN JISIM DALAM OPERASI STORAN GAS PETROLEUM CECAIR)

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2006

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful. Praise to Allah who had given me the opportunity to complete this thesis.

The author would like to extend his deepest gratitude to his research members, Dr Azeman Mustafa and Dr Hanapi Mat for their enthusiastic effort and concern, as well as their guidance and comment, which have been conveyed, to the author throughout this research project.

Besides that, the author also gratefully acknowledged to the Research Management Center of Universiti Teknologi Malaysia, Ministry of Science and Technology of Malaysia and Department of Gas Engineering Faculty of Chemical and Natural Resources Engineering for the funding and facilities throughout the study.

Last but not least, the author likes to acknowledge all the members of Gas Engineering Department Faculty of Chemical and Natural Resources Engineering for their kindness in sharing their knowledge with the author.

HEAT AND MASS TRANSFER STUDIES IN
LIQUEFIED PETROLEUM GAS STORAGE OPERATIONS

(Keywords: LPG, storage, evaporation, left over)

Liquefied petroleum gases (LPG) are substances such as propane and butane, which are transported and stored in the liquid phase in tanks under sufficiently high pressure. It is generated as a by-product either of oil and gas production or refining. The composition components of LPG are much simpler than that of gasoline. LPG is thought to be a cleaner fuel because it is has less impact on air quality. The objective of this thesis is to obtain detailed understanding of LPG cylinder system behavior during the continuous exhaustion or natural evaporation process via modification of the existing cylinder design. Experiments have been conducted to predict the parameters affecting the evaporation process such as surrounding temperature, pressure, composition and flowrate of LPG in cylinder based on the rig set up. The investigation of these parameters during discharging process is the initial step in a usage management of LPG, which is an essential part to evaluate the left over problem. In a parallel effort, a computer model has been developed based on the unsteady state of heat and mass transfer concepts using MATCAB 2000.

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KAJIAN PEMINDAHAN HABA DAN JISIM DALAM OPERASI STORAN GAS PETROLEUM CECAIR

(Keywords: GPC, storan, baki, peruwapan)

Gas petroleum Cecair (GPC) terdiri daripada propana dan butana yang diagih dan disimpan dalam fasa cecair di dalam tangki bertekanan. Ia merupakan satu produk sama ada daripada proses pemprosesan gas atau penapisan minyak. Komposisi gas petroleum cecair adalah ringkas berbanding dengan gasolin. Ia dipertimbangkan sebagai satu bahanapi yang bersih kerana hanya memberi sedikit kesan pencemaran kepada kualiti udara. Objektif tesis ini adalah untuk memperolehi pemahaman yang terperinci mengenai kelakuan gas petroleum cecair di dalam silinder semasa proses pengeluaran berterusan atau proses peruwapan asli seterusnya mengubahsuai rekabentuk silinder sedia ada. Ujikaji telah dilakukan bagi meramalkan parameter-parameter yang mempengaruhi proses peruwapan gas petroleum cecair di dalam silinder pada rig yang dibangunkan seperti suhu persekitaran, berat, komposisi dan kadaralir. Penyiasatan ke atas semua parameter tersebut semasa proses pengeluaran merupakan langkah pertama dalam pengurusan penggunaan gas petroleum cecair yang mana amat penting untuk menilai masalah ketidakhabisan gas. Selari dengan itu juga, satu model komputer juga telah dibangun berdasarkan kepada konsep pemindahan haba dan pemindahan jisim secara aliran tidak mantap menggunakan perisian MATCAB 2000. Model komputer yang dibangun boleh digunakan secara lebih meluas dalam meramal rekabentuk sistem silinder gas petroleum cecair yang optimum.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ABREVIATIONS	DESCRIPTIONS
a	constant
A	surface area
c	heat capacity
D, E, F	constant
Gr	Grashof number
h	heat transfer coefficient
ΔH	latent heat of vaporization
H	enthalpy of vapor
k	thermal conductivity
L	length
MW	molecular weight
m	mass
N	number
Nu	Nusselt number
P	pressure
Pr	Prandtl number
q	heat flux
Q	flowrate
r	radius
R	resistance of heat transfer
t	time
T	temperature
ΔX	distance
Z	gas compressibility factor

Superscripts

ig	ideal gas
m	constant

Subscripts

Axi	axial
b	boiling
B	bulk
c	critical
conv	convective
f	film
i	internal
ice	ice layer
L	liquid
Max	maximum
Min	minimum
o	external
out	outside
p	pressure
rad	radiative
ref	reference
vap	vapor
W	wall
1	higher region
2	lower regions

Greek symbols

ρ	density
β	expansion constant
σ	universal constant
μ	viscosity

CHAPTER I

INTRODUCTION

1.1 Research Background

Liquefied Petroleum gas has become more popular compared to other liquid fuels based on a few factors i.e. easy to handle, less pollution, minimum space and can produce a high quality product (Turner, 1946 , AAA, 2001 & Jaimes and Sandoval, 2002). There are a few concepts of liquefied petroleum gas distribution to the customer and it depends on the categories of customer i.e. whether it is domestic, commercial and industry. Liquefied petroleum gas will be delivered to the customer either using cylinder, bulk storage or pipeline.

Liquefied petroleum gas or commercially known as LPG is a group of hydrocarbons derived from crude petroleum processes or natural gas, which are gases at normal temperatures and atmospheric pressures but which become liquid with either a moderate drop in temperature or pressure, or both. With that characteristic sometimes LPG is known as a ‘hydrocarbon borderline product’ (Leary, 1980). Liquefied petroleum gas is a mixture of petroleum hydrocarbons consisting mainly of propane and butane and it can also exist in its individual components such as pure propane or butane (Johnson, 1977 & Purkayasha and Bansal, 1998). Besides the main components, other minor components, which may exist in LPG, are propylene, butylenes, and butadiene with these minor components mainly depending on its sources (William, 1982). The difference in the LPG produced in crude petroleum processes is that some of the unsaturated hydrocarbon appears together with the LPG such as propylene and butylenes (Beggs, 1984 & Hazzaini, 1998). Statistically, in the market, 75 percent of LPG is derived from natural gas and 25 percent is from crude petroleum processes (Thomas *et al*, 1965). In Malaysia, however, the differential among the two cannot be identified because of the bottling plant design in such a way that the product from the gas processing plant and the refinery come with a commingle line.

An understanding of the behavior of LPG is necessary to assist in the planning and engineering design of process plant, transportation and storage, safety and other applications (Seeto and Bowen, 1983). LPG can be easily liquefied and vaporized. Propane is liquefied when it is frozen below - 42 ^{o}C under atmospheric pressure or pressurized at above 7 bar (700 kPa) under constant temperature. Butane is more easily liquefied under the conditions of –0.5 ^{o}C and 2 bar (200 kPa). Furthermore, as LPG becomes extremely less voluminous (propane reduced to one over 270, butane one over 240) when liquefied, it is feasible to be safely transported and stored. LPG has a high evaporation heat point, requiring a large quantity of evaporation heat when vaporized. So, installation of separate vaporization facilities is required when a large quantity of LPG is used such as for industrial purpose.

LPG is colorless, odorless and tasteless in liquid and vapor form, yet liquid leaks are often characterized by foggy conditions at ground level as the cooling effect condenses water vapor in the air, and frost may occur at the point of escape. Only a small quantity of odorant is added in order to detect it when leaking. A liquid, LPG is only half of the weight of water yet in gaseous form is twice as heavy as air, so it is difficult to disperse and tends to hug the ground, sliding downhill to accumulate in lower lying areas (Ditali *et al*., 2000 & Seeto and Bowen, 1983). It is propane and butane that are the most commonly used and most easily liquefied of these gases. Both have flammability limits between 2 – 4 percent in air, so just 1 liter of split liquid cloud create up to 12.5 m^3 of flammable vapor which could be ignited perhaps 50m downwind from the leak point (Stawczyk, 2003). It is observed that the flammability range of LPG becomes narrow with addition of nitrogen gas (Mishara and Rahman, 2003). The information of this limit is very much required for prevention of explosive hazards (Clay *et al*., 1988 & Chakraborty *et al.,* 1975). However, the degree of hazards depend on many factor such as the mass of substances released, physico-chemical properties of the substance in the moment of its release, flammability and toxicity of the medium flowing out (Stawczyk, 2003). Even though LPG is not poison but after expose to LPG it will cause death due to be asphyxia from hypoxia as a result of the exclusion of oxygen by the gas (Tatsushige *et al.,* 1996).

Commercial LPG in the market normally consists of propane and butane with 30 percent and 70 percent in composition respectively. However, its composition will vary accordingly and subject to the application, country and surrounding temperatures (Purkayasha and Bansal, 1998, Philip *et al.*, 2004, Leal and Santiago, 2004 & Kwangsam *et al.*, 2004). Generally, the gas industry will follow the agreement with clients or follow the specification fixed by the Gas Processor Supplier Association (GPSA) about the composition (Royal Dutch, 1986 & William, 1983). The specification of GPSA is based on the maximum vapor pressure, minimum vaporization rate and the limitation of the components that will cause corrosion such as water and sulfur. This means that the industry will use both of the cases. However, usually LPG contains certain amount of residue with higher vaporization points falling in the range of lubricant oil. The source of residue are the LPG processing equipment i.e. pump, compressors and containers (Quan *et al.*, 2004). In industries, there is a routine need to analyze residues in LPG for quality control. Usually, on specific application, residues concentration of LPG must meet industrial codes. For instance, the Australia LPG Association requires the residue concentration below 20 ppm of mass (Quan *et al.*, 2005).

LPG is economically feasible to be produced, transported, sold, and stored as a liquid fuel (Stawczyk, 2003). The obvious advantage of this liquefied fuel is that its heating energy is highly concentrated compared to other liquefied fuel (Purkayasha and Bansal, 1998). For instance one cubic feet of liquid propane can provide nearly 47 percent more heating value than the same amount of liquid methane (Clifford, 1973). LPG, however, provides low combustion velocity at low pressure than gasoline but will increase according to pressure increase (Butterworth, 1961 & Mohd Kamaluddin, 1984).

LPG has received increasing attention since it was recognized as a reasonable energy resource (Hazzaini, 1998). LPG supply for industrial and commercial use is available to the consumer in cylinders of larger capacity than the regular domestic household cylinders or in bulk tanks of even larger capacities. Commercial cylinders are generally used for restaurants and bakeries where the LPG consumption and gas delivery rate are high that the vaporization rate of the regular household cylinders cannot support. As the LPG cylinder is widely used in Malaysia it is therefore of a national importance. Commercial cylinders may be linked together to support higher capacities. It is manifold, closely linked to the economics of energy generation, and offers a great reduction in pollutant emissions (Chang *et al*., 2001). Because of these reasons, LPG can be utilized in many sectors such as domestic, commercial and industrial sectors. LPG can be transported and stored in liquid form under moderate pressures and at normal temperatures. When released at atmospheric pressure at relatively low temperature it vaporizes and can be handled as a gas (Purkayasha and Bansal, 1998). But this operation cycle included a problem related to the loss due to the residual amount of gas left at exhaustion. This problem has been considered as one of the main drawbacks in LPG cylinders that create unsatisfactory conditions.

This problem occurs when the vapor is consumed through the natural evaporation process at high exhaustion rate (Nor Maizura, 1994). In this process, the temperature of the liquid and the pressure inside the cylinder drop rapidly and may reach a point when the cylinder pressure is insufficient to supply the gas at the required exhaustion rate (Ditali *et al.,* 2000). The required exhaustion pressure is the minimum inlet pressure for a regulator and normally considers being at 5 psi for commercial sector (Che Badrul, 1994). At this point the exhaustion rate may approach zero and create residue in the cylinder.

Even though the use of portable cylinder in Malaysia has started since early of 1980s, when LPG has made its way to most commercial and residential area to cater public needs, especially in cooking and heating appliances (Ahmad Fauzi *et al.*, 1991), there is still unsolved residual problem especially in commercial size cylinder. The problem occurs when natural evaporation takes place. During the evaporation temperature and pressure in the cylinder will drop (Raj, 1981, Waite *et al*., 1983 & Vai and Chun, 2004) to the point that pressure is not able to push out the liquefied petroleum gas from the cylinder at the required level of flow. At that point, normally the pressure in side the cylinder is equal to the atmospheric pressure and some amount of liquefied petroleum gas still exists in the cylinder (Dick and Timns, 1970). It is reported that more than 10 percent of residue or 12.6 kg is found in the 108-liter water capacity cylinder (Che Badrul, 1994). The residue of the LPG in the cylinder resulted in the customer paying extra money for the unused fuel.

Gas suppliers have received complaints due to this problem. They claimed that, if this problem were not solved then they would suffer losses. Therefore, suppliers must seriously address the related problem because customers have the right to do so (Bromilow, 1955). The quantity of residue in cylinder with 50 kg water capacity is 5.78 kg with the composition of propane 2.17 percent and butane 97.82 percent by weight respectively (Che Badrul, 1994). Recently, even though there are a number of researchers investigating the residue problem, a complete solution is yet to be found.

The possible methods in reducing the residue problem and thus increasing the evaporation process in liquefied petroleum gas storage are increasing thermal conductivity and heat capacity, installing coil system inside the storage, adding absorbent material inside the storage, applying coating agents on outer vessel wall and changing initial liquefied petroleum gas composition. However, based on the results declared by previous researchers there is no single method capable to completely withdraw liquefied petroleum gas from storage or in other words to empty the storage but only to minimize the residue (Dick and Timm, 1970).

Since there is no single method or technique capable to empty the cylinder and the residue will vary with the mode of application and yet the dimension of the cylinder is also not the same with different suppliers, then another approach need to be explored. But all methods mentioned above show some potential in improvement of the evaporation process. Nevertheless, the methods lack applicability and practicability to be adopted, and hence are not possible to be commercialized (Muhammad Noorul Anam, 2002).

Therefore, the researcher suggested that it should be better if the overall concept of mass and heat transfer to the liquefied petroleum gas cylinder under unsteady state condition is carried out in detail. This is because the major factor affecting the left over is the amount of sensible heat required during the evaporation process. By understanding the concept of heat and mass transfer under unsteady state condition, it will lead to the development of the mathematical modeling. The mathematical model is considering the optimum method that can offer the better solutions related to any engineering scopes of work. The development of this mathematical model will consider the composition, diameter of the cylinder, cylinder material, discharge rate and so on that relate to all factors affecting the evaporation process. Therefore, the verification of the model developed will be based on the result using the experimental data.

Through this mathematical model that will be developed it will be capable of investigating the correct composition and the diameter of the cylinder that will minimize the residue amount. Hence, it will lead to the development of a new design of liquefied petroleum gas composition and cylinder diameter. Lastly but not least, it will benefit the customers by gaining more energy corresponding to the price that they paid for.

Therefore, through this study the complete understanding on the mass and heat transfer under unsteady state condition will be carried out in order to investigate the actual occurrence. Thus it will be beneficial to gas suppliers in any designing related to the liquefied petroleum gas for the purpose of reducing the loss incurred by the customer.

1.2 Objective and Scopes of Study

The objective of this study is to obtain detailed understanding of LPG cylinder system behavior during the continuous exhaustion. The study will focus on heat and mass transfer concept through unsteady state conditions. The research will attempt to overcome the problems of LPG leftover in cylinder via modification of the existing cylinder design.

In LPG storage operations, several main parameters affect the performance of the discharging process such as surrounding temperature, LPG composition, and charging flowrate. Therefore the first objective of this study is to elucidate the inter-related effects of these parameters on heat and mass transfer process in storage operations.

In order to synthesis or verify the experimental results, the model will be developed based on the fundamental theory of heat and mass under unsteady state conditions. Several operation parameters such as surrounding temperature, LPG composition, charging flowrate and design parameters will be incorporated in the model. This will be the second objective of this study.

Based on the results obtained from experimental study and model prediction, the design parameter and operation parameters will be proposed and compared to the existing data and will be the third objective of this study.

All the identified parameters will vary accordingly which is 10^oC to 35^oC for the surrounding temperature, commercial propane to commercial butane for the LPG composition and 2 m^3/hr to 10 m^3/hr for the flowrate. Model is developed based on the basic material and energy balance law and solved with MathCad Professional Software by employing the Fourth Order Range-Kutta method to solve for the system of differential equations.

In this study, the parameters that going are to be discussed are the profile of temperature, pressure, vapor and liquid composition, weight, flowrate and liquid level. Thus, by evaluating all these parameters, it will be beneficial in any designing related to the liquefied petroleum gas storage for the purpose of reducing the loss incurred due to residue problem.

1.3 Report Outline

This thesis report will discuss about the study of mass and heat transfer of liquefied petroleum gas storage operations. The study conducted opens up a more realistic solution to predict the actual usage of liquefied petroleum gas, which is to overcome the problems of LPG residue in cylinder via modification of the existing cylinder design.

The thesis consists of seven chapters, which starts with introduction and ends with conclusions and recommendations. In Chapter 1, the discussion is based on the research background, which highlighted on the increasing attention that LPG has received since it was recognized as one of the popular fuels, the problem occurs when the vapor is consumed through the natural evaporation process and the possible methods in reducing the residue problem. In conjunction with that, the objective and scopes of the study are also highlighted with is a focus on experimental study and also mathematical modeling.

In Chapter 2, which is a literature study chapter, the highlighted discussion is related to the basic concepts of evaporation process, heat and mass transfer and vapor liquid equilibrium. All discussions are related to the liquefied petroleum gas, which is stored in cylinder under pressure. Apart of that, the overview of the history and usage of liquefied petroleum in Malaysia has been highlighted at the beginning of this chapter.

In Chapter 3, it is about materials and methods used for the experimental study. The schematic diagram of the experimental rig with consist of all equipments have been discussed in this chapter. Apart of that, the study procedure is also highlighted in this chapter. The result gathered from the experimental study which includes temperature profile, pressure profile, vapor and liquid composition and weight are discussed in Chapter 4. Discussion was based on the four main categories that have been studied which were the variation in surrounding temperature, variation in flowrate, variation in composition and variation in weight of liquefied petroleum gas.

Chapter 5 consists of mathematical modeling that is developed based on the fundamental theory of heat and mass under unsteady state conditions. In this chapter, the discussion starts with the process description and followed by model development. Similarly with Chapter 3, the results gathered from the model that consists of temperature profile, pressure profile, vapor and liquid composition and weight would be discussed in this chapter. However, at the time writing, this chapter is still not completed yet.

Chapter 6 is the final chapter in this research proposal, which highlighted about the pre-conclusions that can be drawn from the research work.

1.4 Summary

In Chapter 1, the researcher tries to highlight the definition and general concepts of liquefied petroleum gas storage as well as the problem occurring when the gas is consumed through the natural evaporation process, which is related to residual problem. It is reported that more than 10 percent of residue found in cylinder with 108-liter water capacity size. Even though a lot of research have been done to explore and overcome that problem but no single one method is capable to do it. Therefore, through this study, which is consisting of three main objectives that are related to mass and heat transfer, it will be able to investigate the actual occurrence.

CHAPTER II

LITERATURE STUDY

This chapter will be discussing the basic concepts of evaporation process, heat and mass transfer and vapor liquid equilibrium. All discussions will be related to the liquefied petroleum gas, which is stored in cylinder under pressure. However, the overview of the history and usage of liquefied petroleum in Malaysia has been highlighted at the beginning of this chapter.

2.1 Overview of Liquefied Petroleum Gas

Liquefied petroleum gas has become more popular in the 20th century in order to create a multiple source of energy. LPG are stored and transported in special tanks and these technological processes are of high fire hazard (Shebeko *et al.*, 2003). The first development of liquefied petroleum gas was in England in year 1810 where it was stored and distributed in small quantities to customers through portable cylinders. However, the first conversion from manufactured gas to liquefied petroleum gas was in Linton in year 1928 where the first company involved was Carbide & Carbon Chemical Corporation that marketed through Pryrofox (Mark, 1983). Actually, before that, liquefied petroleum gas was burnt as fuel waste from refineries and gas processing plants (Leary, 1980). After 30 years latter, there was a lot of conversion of energy to liquefied petroleum gas. However, the drastic development and launching of natural gas system influenced the liquefied petroleum gas growth pattern (Segnar, *et al.*, 1976 & Walter and Ward, 1970). The liquefied petroleum gas usage in the world has very good potential since the source of crude oil is depleting, the increase of crude oil price six fold and Japan increasing it energy import (Johnson, 1977 & Anon, 1985) as well as environmental concerns (Edwards *et al.*, 2003).

United States is the largest consumer of liquefied petroleum gas in the world followed by Japan where LPG is used for various applications such as feedstock, cooking, vehicle and power plant (Paszkiewiaz, 1981 & Hishamuddin, 2001). They used a lot of gas to overcome the pollution problems where liquefied petroleum gas was recognized as a clean fuel (Diaz *et al*., 2000 and Choi *et al.*, 2004), which is without lead and containing very small amount of sulfur (Jabar, 2002 & Purkayastha and Bansal, 1998). Air pollution is a particularly acute problem because of the very high human exposure to these pollutants and the consequent costs to the community in terms of human life and expenses related to health care (Hung, 2004).

In conjunction with the increasing consumption of liquefied petroleum, the code of practice was launched in order to make sure that any activity that is related to liquefied petroleum gas is safe (Lemoff, 1989, DallÓra, 1971 & AAA, 2001). The code of practice describes all requirements and rules that need to be adhered.

The utilization of liquefied petroleum gas in Malaysia is considered quite new and it has a gas reserve with 72 trillion cubic feet and approximately estimated will last about 100 years (Azizan, 1993). However, the first actual usage of gas in Malaysia is in Miri Sarawak, which was found natural gas since more than 30 years ago and is distributed through pipeline to domestic and commercial users (Hishamuddin, 2001 & Peng, 2003).

The first liquefied petroleum gas in the market was in the year 1982 with average sales of 1.2 metric tones per month. The increase of liquefied petroleum gas usage was tremendous since in the year 1985 the average sales have increased to 250 metric tones per month (Petronas, 1985). The composition of liquefied petroleum gas in Malaysia is designed based on the production economic point of view (Hazzaini, 1998).

However, after that the increase of liquefied petroleum gas has slowed down after the government launched Peninsular Gas Utilization Project (natural gas system), which is a national gas project, however the area not covered by the natural gas pipelines is limited. Liquefied petroleum gas in Malaysia is used for cooking in residences, hotels and restaurants, warming or drying at various industries such as poultry, tobacco, vehicle, glass etc. The big customer of liquefied petroleum gas in Malaysia is the poultry industry in Segambut Selangor. Other customers using liquefied petroleum gas as fuel are Proton, Malaysia Sheet Glass and Metal Box (Petronas, 1985).

The development of liquefied petroleum gas in Malaysia received full support from various agencies such as Petronas, Dewan Bandaraya Kuala Lumpur and Perbadanan Kemajuan Iktisas Negeri (Abdul Halim, 1989). The mode of liquefied petroleum gas used in Malaysia is through bulk storage and portable cylinders (Surani, 1991 & Phak, 2002). Generally, the cylinders used are similar to the petroleum cylinder except for the components specifications (De Witt, 1988). Along with the development of liquefied petroleum gas industry, Malaysia has developed a few code of practice such as MS 830, MS 930, MS 641 and MS 642 to ensure that any related activities are safe. Figure 2.1 shows the typical portable cylinders currently used.

Figure 2.1: Portable LPG Cylinders

The main objective of the country is to diversify the use of energy in order to reduce the emphasis of oil as the main energy (Johson, 2003). Recently, there are 28 domestic and a few of commercial customers using liquefied petroleum gas in Kuala Lumpur (Ahmad Fauzi, 1998).

2.1.1 Liquefied Petroleum Gas Storage

Generally, gas storage is defined as a store that can keep gas temporarily in order to fulfill and to bear demand of energy during peak time load whether it is coming from domestic, commercial or industrial sectors (Peng, 2003 & Shebeko *et al*., 1995). Gas demand generally varies considerably from summer to winter in western countries where storage system is relevant for them (Ikoku, 1980). Therefore, one way to accommodate this fluctuating demand is using gas storage system.

In Malaysia, storage concept is applied in areas where natural gas line is not covered or customers make a special request for installed liquefied petroleum gas on their premises and is not related to the fluctuating demand. Specifically, gas storage is very important due to various reasons such as gas produced from well with very low flow rate, gas produced from well is not equal to a rate of gas usage, gas needed to be supplied to various locations which is not covered by natural gas pipeline and for safety aspects (Ahmad Fauzi, 1998, Marks, 1983 & Ikoku, 1980).

There are two types of gas storage which is underground storage and storage in vessel. Underground storage is defined as a storage that used a sub-surface structure as gas storage. They may be depleted reservoirs, which are saturated reservoirs or unsaturated reservoirs, aquifer which are reservoirs containing water, salt dome and carven. Storage in vessels may be low-pressure containers and high-pressure containers. Even though currently there is a few types of storage available, in this thesis only high-pressure container type will be highlighted, which is the type that is used to store liquefied petroleum gas. There are five types of storage containers available for use to install liquefied petroleum gas. They are portable cylinders, horizontal cylindrical vessels, vertical cylindrical vessels, spherical vessels and refrigerated tank (Zalinda, 1998 & Leal and Santiago, 2004).

2.1.2 Liquefied Petroleum Gas Storage Design and Operations

Propane and butane are affected by heat and pressure in as much the same manner as other liquid. As long as LPG is kept at a temperature below their normal atmospheric boiling points, they will remain in liquid and could be stored in open container. The problem with storing LPG in open container is that they have normal atmospheric boiling points below freezing are well below boiling point of water. The normal atmospheric boiling point of butane is –0.5^{o}C, which is nearly the same temperature at which water will freeze. The normal atmospheric boiling point of propane is considerably lower than butane, which is –42^{o}C. Therefore, at any temperature above their normal boiling points, LPG would immediately boil off into vapor. The relationship between temperature and pressure of LPG can be determined using vapor chart as shown in Figure 2.2 (KOSAN, 1986). Therefore, when placed in pressure tight containers, LPG can be stored as a liquid under pressure.

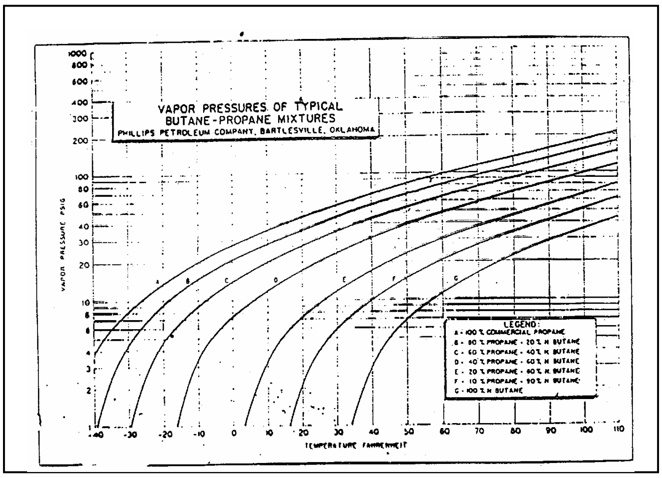

Figure 2.2: LPG Vapor Pressure Chart
(KOSAN, 1986)

Because of their low boiling points, LPG is stored and transported in pressure tight container called cylinders or tanks (Fazzini *et al.,* 2002). In conjunction with that, LPG storage tanks are designed primarily to withstand the internal pressure exerted by LPG vapor under various ambient temperatures (Fazzini *et al.*, 2002). MS 830 tabulates a list of minimum design pressures, based on vapor pressure of stored LPG at 37.8^{o}C, for the design of aboveground vessels as shown in Table 2.1 (SIRIM, 1983).

Table 2.1: Minimum Design Pressure for Pressure Vessel (SIRIM, 1983)

Vapor Pressure in psig (kPa gauge) at 100^{o}F (37.8^{o}C)	Minimum Design Pressure in psig (kPa gauge)
80 (600)	100 (700)
100 (700)	125 (900)
125 (900)	156 (1100)
150 (1000)	187 (1300)
175 (1200)	219 (1500)
215 (1500)	250 (1750)
250 (1750)	312.5 (2200)

Commercial LPG marketed in this country (30% propane and 70% butane,) exerts a vapor pressure of approximately 700 kPa (100 psig). The table requires storage vessels to have a minimum design pressure of 900 kPa (125 psig). However, it is an accepted practice that LPG storage vessels be designed to operate at 1750 kPa (250 psig). This pressure corresponds to the vapor pressures of our commercial LPG at approximately 60^{o}C (140^{o}F). With this design pressure, the vessel can be used to store commercial propane, which has a vapor pressure of 1300 kPa (180 psig) at 37.8^{o}C.

LPG storage vessels are designed and constructed to various recognized pressure vessel codes. The most common code used is ASME Section VIII, Division 1 that is Rules for Construction of Pressure Vessels (SIRIM, 1983, Nichols, 1987 & Chuse and Eber, 1984). However, portable vessels are normally designed and fabricated according to Malaysian Standards MS 641 or MS 642, which are based on the relevant specifications contained in the USA Hazardous Material Regulations of the Department of Transportation (D.O.T.) (SIRIM, 1982, Ahmad Zaidi, 1987 & Fazzini *et al.*, 2002).

The most common material used for fabrication of LPG pressure vessels is carbon steel (Date and Padmanabhan, 1992). Low alloy steels are used where certain mechanical properties need to be improved. For instance, high nickel steel has superior low temperature properties to ordinary carbon steels. However, these alloy steels are obviously more expensive than carbon steels and as such are only used in special storage tank design such as refrigerated LPG vessels (Ahmad Fauzi, 1998). Aluminum alloys have been used in the design of portable auto gas cylinders mounted on vehicles. It has superior weight-to-strength properties but is comparatively more expensive than steel. The alloy normally used is of the light strength heat treatable type. The use of aluminum alloys for LPG applications is still in its infancy and it is currently limited to only auto gas cylinders because of its lightweight properties (Ahmad Fauzi, 1998).

Basically, the vessel wall is subjected to various stresses from internal and external loading such as internal pressure, weight of vessel and appurtenances, static reactions, cyclic and dynamic reactions due to pressure variations, wind pressure, temperature gradients, impact reactions and discontinuity forces in vessel wall (Marks, 1983). The dominant loading acting on vessel walls of conventional horizontal, cylindrical vessel normally installed at consumer's premises is the internal pressure (Fazzini *et al.,* 2002). This gives rise to circumferential and longitudinal stresses in the vessel wall. ASME code gives rules and equation for calculation of vessel thickness based on the internal pressure loading and accounts for the rest of the loading by plugging in safety factors in the calculations (Kohan, 1987).

Horizontal storage tanks may be installed at site in three ways, which are aboveground, underground and mounded (Zalinda, 1998). The requirements pertaining to the design and construction of foundations for aboveground tanks as well as anchorage and backfilling methods for underground tanks are fully covered in all codes of practice. Underground or mounded tanks are installed whenever land area is limited or whenever concealment of storage facilities is needed for aesthetic or security reasons (Zalinda, 1998 & Min, 1997). However, portable cylinder is only installed through aboveground, which is by single unit or manifold system as shown in Figure 2.3.

Safety distances between a storage tank and nearby buildings houses, site boundaries, public roads, sewerage drain systems and other hazardous items installed on the premises such as vaporizers, gas vent pipes and fixed ignition sources including non-fireproofed electrical equipments need to be provided (SIRIM, 1983, Lemoff, 1989 & Leary, 1980).

Figure 2.3: Installation based on Manifold System
(Min, 1997)

These safety distances are necessary for three purposes (Min, 1997). Firstly, in the event of a leakage from the container, the safety distances would enable the LPG to be well dispersed and diluted to below flammable limits before it reaches the fixed ignition sources or public places. Secondly, if there is a fire at the nearby facilities, the safety distances would protect the storage tank from being affected by the fire. Thirdly, if there is a fire at the storage facilities, the safety distances would similarly protect the surrounding facilities or public places from the LPG fire.

Safety distances required for aboveground installation is much more than for underground installations (SIRIM, 1983, Lemoff, 1989 & Leary, 1980). This is because underground installations offer better protection from surrounding, aboveground fire hazards (Shebeko *et al.,* 2003). Another point to remember about safety distances is that they are measured horizontally and radially from the container shell to the specified feature i.e. building and property boundary except that where deflection or radiation walls are used, the distance is measured in a horizontal line around such walls (SIRIM, 1983 & Leary, 1980).

Safety distances increase with increase in volumetric capacity of individual storage containers installed at the storage area (SIRIM, 1983, Lemoff, 1989 & Leary, 1980). This is to be expected as bigger storage vessels pose a higher risk to the surrounding facilities (Melchers and Feutrill, 2001).

Safety facilities, which are readily accessible to the public, adequately to be protected are required to prevent trespassing or tampering of any container fitting, which could lead to an escape of gas (Rasbash, 1980 & Ditali *et al.*, 2000). The most effective means of protection is by fencing off the storage area using chain wire fencing with two outward opening doors which should be kept locked at all times when the tank area is left unattended.

LPG cannot be filled to the maximum during storage because of its characteristic, which is very sensitive with temperature changes and normally it is based on the situation (Roberts, 2004). For instance, propane will increase in volume nearly 17 times higher than water over the same temperature increase (Leary, 1980). As a result, tanks and cylinders are never completely filled with LP-gases liquid. This leaves a space above the liquid, which allows the LP-gases to expand freely due to changes in temperature without danger of container becoming liquid full (Zhoaci *et al.*, 2004 & Roberts, 2004).

An LPG container is like a house in one respect, which is without essential furnishings; it is not of much use. In order to put fuel in a container and withdraw it, know the volume of fuel and its pressure, protect the container from excessive pressure, and provide against hazards resulting from line breakage, it is necessary to make use of a number of items, which are designated by the general appurtenances or accessories (Zhoaci *et al.,* 2004). Many domestic systems are equipped with a combination unit incorporating the required appurtenances, which is attached to the container by means of a single opening.

In order to make sure that all valves, fittings and other appurtenances used in connection with LPG systems are suitable for such use, they must be of approved design and construction (Kohan, 1987). However, to meet the required standards, approval should be obtained from underwriter's laboratories or other recognized testing laboratory. Another requirement common to the various appurtenances attached directly to a container relates to their pressure rating. Although tank pressure varies considerably according to fuel temperature and composition, all valves, gauges and another appurtenances must be made of materials suitable for use with LPG and having a working pressure not less than 250 psig (SIRIM, 1983).

2.2 Heat and Mass Transfer Process in Liquefied Petroleum Gas Storage Operation

2.2.1 Heat Transfer Process

To design the liquefied petroleum gas cylinders or vessels one of the parameters that must be known is how much heat is transferred. Design of liquefied petroleum gas cylinders requires knowledge of heat transfer and this depends on the heat effects from surrounding and its molecules as sensible heats, which are characterized by temperature changes, phase transition and separation of solutions.

Heat transfer is one of the most common operations in the chemical industry. Many theoretical and empirical correlations have been proposed by scientist worldwide to estimate the heat transfer coefficients in different conditions (Tiwari, *et al.*, 2004). Heat transfer is a branch of applied thermodynamics. It may be defined as the analysis of the rate at which heat is transferred across system boundaries that is subjected to specific temperature difference conditions (Mills, 1999 & Frank and David, 1990). Whereas classical thermodynamics deals with the amount of heat transferred during the process, heat transfer estimates the rate at which heat transfer and the temperature distribution of the system during the process (Alan, 1967 & Frank and David, 1990).

Heat transfer enables us to analyze the temperature distribution. It may be complex analysis but nevertheless the time varying temperature and exchange rates are the goals of heat transfer analysis. The second law of thermodynamics tells us that heat flows from high to low temperature, that is, in the direction of decreasing temperature. The second law also requires certain limitations on maximum and minimum temperatures and on overall system efficiency. Otherwise the second law does not directly intrude upon a heat transfer analysis (Frank, 1998). In contrast, the first law of thermodynamics is the fundamental relation behind every heat transfer analysis. In a system, the total energy increase of the system equals the heat received plus the work received (Winnick, 1997 & Smith et al., 1996). So, heat transfer is somewhat a simpler principle than thermodynamics (Mills, 1999).

Analysis of earlier works shows that the main parameter that affected the heat transfer either theoretical or empirical are heat flux, saturation pressure, thermo physical properties of material flow rates and environmental temperatures (Tiwari *et al*., 2004, Frank, 1998 & Vijay, 1979). Heat transfer is concerned with temperature differences. There are three modes of heat transfer, which are conduction, convection and radiation. Conduction and radiation are fundamental physical mechanisms while convection is really conduction as affected by fluid flow.

Conduction is an exchange of energy by direct interaction between molecules of a substance containing temperature differences (Harriott, 2001). It occurs in gases, liquids or solids and has a strong basis in the molecular kinetic theory of physics. Conduction transfers energy from hot to cold region of a substance. In fluids, the exchange energy is primarily by direct impact but in solids the primary mechanism is relative lattice vibration, enhanced in the case of metals by drift of free electrons through the lattice (Frank, 1998). Both the molecular and the free electron interactions are well founded in theoretical atomic physics. In order for us to know how much heat is transferred by conduction, we need to know Fourier’s Law of Conduction.

Fourier's law of heat conduction is valid for all common solids, liquids and gases. Most metal have high value of thermal conductivity because they allow energy transfer through drift free electrons thus there is a good correlation between electrical and thermal conductivity of materials. Gases, with low density and few molecular collisions have very low conductivity. The kinetic theory of gases predicts that thermal conductivity is inversely proportional to the square root of the molecular weight (Reid *et al*., 1984). At normal pressures, gases and insulation material have the lowest thermal conductivity but by an artificial construction using vacuum, multiple layers and shiny surface can increase thousand times less than air (Frost, 1975).

Since almost all heat transfer applications involve free expansion of the material, so heat storage capacity should be considered. The heat storage capacity is the amount of energy it absorbs per unit volume for each degree rise in temperature (Smith *et al*., 1996). Generally, substances of high density have low specific heat so that most solids and liquids have comparable heat capacities. Gases are hopelessly poor for storage because of their low densities (Geankoplis, 1993). Since conductivity expresses the rate of heat flow into a substance and storage capacity denotes its ability to store this receive energy then the rate of change of temperature of the material should be evaluated.

Convection is defined as the conveying of heat through a liquid or gas by motion of its parts or may be describe as conduction in a fluid as enhanced by the motion of the fluid. Convection is the term applied to the heat transfer mechanism, which occurs in a fluid by the mixing of one portion of the fluid with another portion due to gross movements of the mass of fluid. Heat transfer through the convection process is considered an external process, which occurs on the surface of the body (Frank, 1998). These means that, in this process the internal structure of the body is not important. Therefore, the rate of heat transfer by convection is usually a complicated function of surface geometry and temperature, the fluid temperature and velocity and fluid thermo physical properties (Tiwari *et al.,* 2004).

In heat transfer process by convection, a higher temperature of surface body will have higher thermal energy (Holman, 1997). The thermal energy will transfer to the surrounding in order to achieve the equilibrium condition between the body and the surrounding. The actual process of energy transfer from one fluid particle or molecule to another is still one of conduction, but the energy may be transported from one point in space to another by the displacement of the fluid itself (Harriott, 2002). The fluid motion or flow may be caused by external machine i.e. by a fan, pump, etc., in which case the process is called forced convection. If the fluid motion or flow is caused by density differences, which are created by the temperature differences existing in the fluid mass, the process is called free convection or natural convection.

If the system involved these two processes of heat transfer, which are conduction and convection then the evaluation of transferring of heat or energy is depend to the average heat transfer coefficient. However, the average heat transfer coefficient depends on many variables including the physical properties of the fluids such as viscosity, thermal conductivity, specific heat and density and the solid wall, the flow rates and exchanger dimensions (Phak, 2002). The only logical way to predict the average coefficient is to use correlations for individual resistances of the solid and fluid layers and add these resistances to find the overall resistance (Harriott, 2001). The average resistance to the flow of heat from warm fluid to the cold fluid is a result of three separate resistances operating in series, which are fluid, solid and fluid. In general, the wall resistance is small in comparison with that of the fluids. The fluids resistances are generally computed using correlation for individual heat transfer coefficient or film coefficients, which are reciprocal of the resistances (Harriott, 2001 & Geankoplis, 1993).

It is virtually impossible to observe pure heat conduction in a fluid because as soon as a temperature difference is imposed on a fluid, natural convection currents will occur as a result of density differences (Frank, 1998). The basic laws of heat conduction must couple with those of fluid motion in order to describe, mathematically, the process of heat convection (Harriott, 2001).

Heat transfer by radiation or thermal radiation is directly dependent on the physical properties of the surface. There are a few types of surface material such as idea material or substance, black body and non-black body. Ideal material or substance is defined as when total heat energy absorbed by the material is equal to total heat energy distributed. Material that is called black body is defined as no heat energy able to penetrate them.

Thermal radiation is the term used to describe the electromagnetic radiation, which has been observed to be emitted at the surface of a body, which has been thermally excited. All substances at temperature above absolute zero emit radiation (Geankoplis, 1993). This electromagnetic radiation is emitted in all directions; and when it strikes another body, part may be reflected, part may be transmitted and part may be absorbed (Frank, 1998). The fraction of radiation falling on a body that is reflected is call the reflectivity, absorbed called the absorptivity and transmitted is call the transmitivity and sum of them fraction must be unity. If the incident radiation is thermal radiation i.e., if it is of the proper wavelength, the absorbed radiation will appear as heat within the absorbing body (Harriott, 2001).

Thus, in a manner completely different from the two modes discussed above which are conduction and convection, heat may pass from one body to another without the need of a medium of transport between them. In some instance there may be a separating medium, such as air, which is unaffected by this passage of energy. There will be a continuous interchange of energy between two radiating bodies, with a net exchange of energy from the hotter to the colder. Even in the case of thermal equilibrium, an energy exchange occurs, although the net exchange will be zero.

Another factor that also very important for heat transfer by radiation process is view factor because rate of heat transfer is proportional to view factor if other factors are constant (Amer Nordin, 1995). With referred to the system under study since the system in an enclosure, which is surrounded by the wall than the system is defined as a blackbody since there is a peephole on the interior wall of the enclosure (Mccabe *et al*., 1993). The value of view factor is unity if the body is facing each other.

Heat transfer problems encountered by the design engineer almost always involve more than one mode of heat transfer occurring simultaneously. To consider realistic engineering problems, it is necessary to develop the theory required to handle combined modes of heat transfer (Phak, 2001 & Sun, 2003). In this study, there are two type of combination of heat transfer mode, which is convection-radiation and conduction. Figure 2.4 shows a process of evaporation of liquefied petroleum gas in cylinder when heat energy is supplied from the surrounding. Based on Figure 2.4, when a valve is opened, heat is added to the liquefied petroleum gas by a combination of two modes, which are convection plus radiation and followed by conduction. The sequence of the heat flow onto the liquefied petroleum gas cylinder is convection plus radiation and conduction. Therefore, the amount of heat transfer to the cylinder can be calculated. However, the heat transfer rate vary with the heat flux, position and time (Wang, 2000).

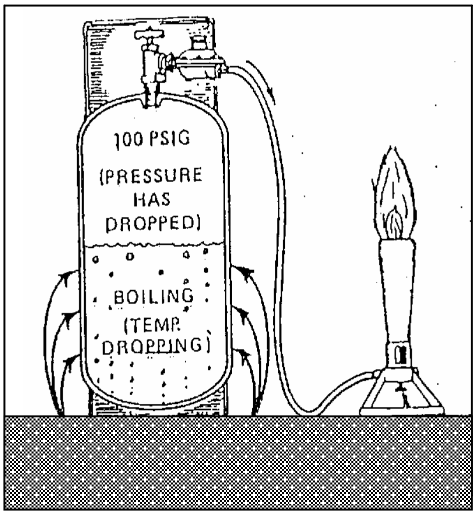

Figure 2.4: Heat Added to Cylinder
From Surrounding

Normally, the heat transfer to the cylinder occurs in two different ways, which are radial flow and axial flow as shown in Figure 2.5. Therefore, in this thesis both of the direction is taken into consideration since heat is coming from various directions.

In relation to the system under study, most of the researchers tried to increase the amount of heat from the surrounding into the cylinder in order to minimize the residue amount by various methods such as application of hollow metal tubes, warm water, absorbent material, changing cylinder diameter, coating agent and spiral coil (Woolley, 1980; Nor Maizura, 1994; Mizuno, 1994; Nor Syafawi, 1995; Phak, 2002 & Muhammad Noorul Anam, 2002).

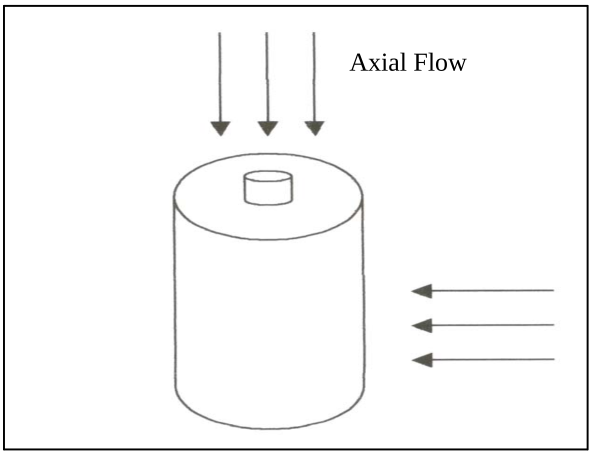

Figure 2.5: Flows of Heat Transfer to Cylinder

Hollow metal tubes of aluminum or magnesium or copper are inserted into a hydrogen cylinder is capable to increase the thermal conductivity and thermal capacity by much as 240% and 15% respectively compared to the conventional hydrogen cylinder (Woolley, 1980). The concept suggested by the researcher is to overcome the problem due to the material of the cylinder, which is metal hydride that is poor heat conductor (McKetta, 1993) which is the material requires sufficient heat from outside of the cylinder or the surrounding to release the hydrogen at a faster rate. The arrangement of the metal tubes inside the cylinder is shown in Figure 2.6.

However, the disadvantage of this method when applying to the commercial liquefied petroleum gas cylinder is that it will reduce the total amount LPG initially filled in the cylinder. Furthermore, if there is a high discharge or evaporation rate or consumption then it will fast reduce the liquid temperature to reach freezing point (Chang and Reid, 1982) and this sort of condition does not occur for the hydrogen cylinder. At that point, it will tend to form an icing layer on the bottom part of the outer cylinder wall, which may reduce the amount of heat that can be transferred to the metal tubes. The formation of icing layer is due to condensation of water vapor from the atmosphere (Conrado and Vesovic, 2000) due to the fall of temperature inside the cylinder below freezing point.

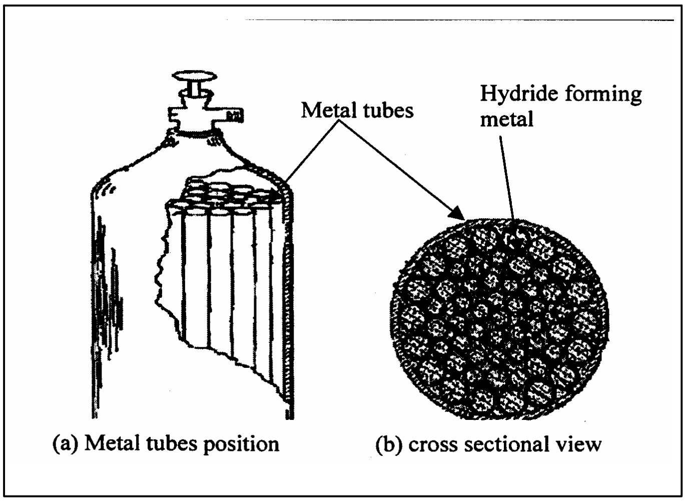

Figure 2.6: Metal Tubes Arrangement for Hydrogen Cylinder (Woolley, 1980)

Another approach is to increase the temperature and to stop the formation of icing layer on the cylinder wall is by immersing the cylinder in the warm water as shown in Figure 2.7 (Phak, 2002). Even though this type of application will overcome the problem of left over but due to safety aspects, the regulatory authority does not allow it.

Non-woven fabric is used in campaign type of liquefied petroleum gas cylinder because that absorbent will suck up the liquid gas and bring it into the vapor phase since the vapor phase is having a high temperature compared to liquid phase (Mizuno, 1994). The higher temperature is due to the radiation of heat from burner during it operation. Figure 2.8 is shown a campaign type of cylinder that completely attached with the burner. Even though the evaporation process at the bottom of cylinder is slow because of the reduction of wetted area by consumption, it has been compensated by the evaporation on the upper part because of high sensible heat may be received from surrounding or the burner on top of the cylinder or molecular itself. As a result it will give a stable burning.

Figure 2.7: Immerse LPG Cylinder in Warmer Water (Phak, 2002)

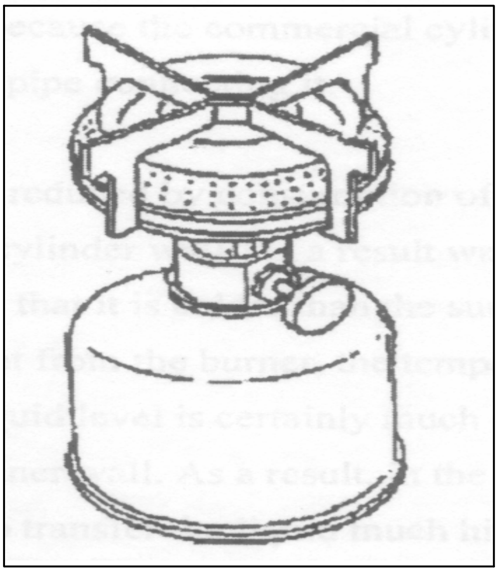

Figure 2.8: Campaign Type of LPG Cylinder

Unfortunately, this type of application and design is only suitable for a small size cylinder, which is only one small burner and limited amount of heat required. This is because the commercial cylinder is solely dependent on the heat from the surrounding because it is always placed quite far from the burner (Zainal, 1994). Regarding to the adsorbent concept, there is one researcher who studied on the possibility of using capillary action to suck up the liquid of liquefied petroleum gas for commercial cylinder. He claimed that capillary action is capable of enhancing the maximum usage of liquefied petroleum gas or minimizing the left over (Yue, 1999). However, such type of approach was not discussed in detail especially the actual conditions of the application. But that concept can be considered right if the liquefied petroleum gas is stored in refrigerated tanks, which has very low vapor pressure.

If the liquefied petroleum gas is stored under pressure, the method is possible by using a small tubing. However, this type of cylinder design is for low surrounding temperature like Genting Highlands, Bukit Freaser, Cameron Highland etc (Ahmad Fauzi, 1998). The simple example of the use of a small tubing in pressure vessel is in the cigarette lighter. Through this method customers will no longer be facing the residue problem because there is no evaporation process occurring in the cylinder (Nor Maizura, 1994). However, there is some extra cost required for the installation of the vaporizer for the purpose of vaporizing all liquid before reaching the gas burner.

Tests have been done for the various sizes of LPG cylinder and have shown that the wider diameter will offer more amount of sensible heat from the surrounding that can pass through the cylinder wall (Nor Maizura, 1994). This concept is valid since the wetted area calculated based on the cylinder diameter offered more sensible heat compared to the based on high of cylinder. Therefore, the wider diameter will offer more interfacial area of the liquid molecule to transfer from the liquid phase to the vapor phase thus less residue amount occurred.

Applying detergent water, as a coating agent on a domestic cylinder is able to reduce up to 35% of residue amount (Nor Syafawi, 1995). By applying a coating agent it will prevent the cylinder wall from condensing water or icing layer sticking on it. However, the condensation water that drops at the bottom part of the cylinder may accumulate if there is not proper handling due to drop wise condensation (Minton, 1982). In addition, it will contribute to a thicker ice formation at that particular part and less heat from the surrounding can pass through because ice formation will act as a resistance to the heat flow.

Even though using coating agent on the outer of the cylinder wall can reduce residue amount but the possibility of the application on the commercial cylinder is doubtful. This is because the result obtained is only based on the domestic cylinder, in which the evaporation rate or discharge rate is small. This means that the liquid temperature of liquefied petroleum gas in cylinder does not reach below freezing point. In other words, further study is needed in order to find out the actual phenomenon.

The insertion of spiral coil is used as a means to flow the warmer vapor through it to the liquid phase at very low temperature. By this method, heat from the warmer vapor will transfer to the liquid phase through the convection process and will increase the evaporation rate so that it will reduce the residue amount. Results obtained through this concept would reduce the residue amount up to 46 % compared to conventional commercial cylinder (Muhammad Noorul Anam, 2002). Figure 2.9 shows the coil in spiral shape in cylinder.

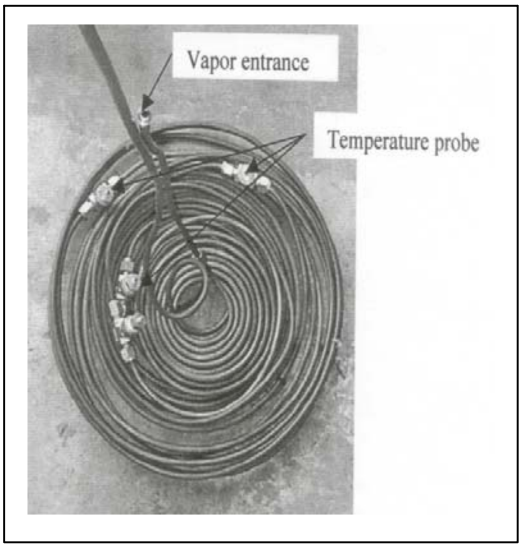

Figure 2.9: Spiral Coil in Cylinder

This method was approved since the transfer of sensible heat from the surrounding into the liquid may be restricted either by water condensation or icing layer on the cylinder wall. Therefore, another heat source identified by the researcher is in the vapor phase at the upper part of the cylinder since the temperature of the vapor at the top portion is higher. Even though using spiral coil into the cylinder wall can reduce the residue amount but the possibility of the application on the commercial cylinder is doubtful due to impracticality as well as it will reduce the total amount LPG initially filled in the cylinder.

2.2.2 Mass Transfer Process

Mass transfer process is defined as a movement of particles of a given species through a mixture as a result of a gradient in the concentration of that species (Frank, 1998). The driving force for transfer is a concentration difference, which is measured in mass per unit volume or density, or a difference in activity. It is sometimes convenient to express concentration in mole or mass fractions. Thus, it is a close analogy to the flow of heat from regions of high to low temperature. Mass transfer tends toward making a mixture uniform, just a heat transfer tries to make the temperature uniform.

The concept of LPG evaporation in cylinder is one of mass transfer process and just like a distillation process (Firas, 2002). The function of distillation is to separate, by evaporation or vaporization, a liquid mixture of miscible and volatile substances into individual components or in some cases into groups of components. There are two types of mass transfer process, which are molecular diffusion and convective mass transfer. However, only molecular diffusion is highlighted in this thesis since it is related to the system under study.

Molecular diffusion can be defined as the transfer or movement of individual molecules through a fluid by means of the random, individual movements of the molecules. Diffusion occurs in all phases of a substance. Generally, the molecules traveling are only in straight lines and changing direction by bouncing off other molecules after collisions.

Since the molecules travel in random path, molecular diffusion is often called a random walk process (Harriott, 2001).

The most common cause of diffusion is a concentration gradient of the diffusing component. A concentration gradient tends to move the component in such a direction as to equalize concentrations and destroy the gradient. When the gradient is maintained by constantly supplying the diffusing component to the high concentration end of the gradient and removing it at the low concentration end, there is a steady state flux of the diffusing component (Wangard, 2001). In some other mass transfer operation like adsorption, unsteady state diffusion takes place and the gradients and fluxes decrease with time as equilibrium is approached (Thomson, 2000).

Although the usual cause of diffusion is a concentration gradient, diffusion can also be caused by an activity gradient, as in reverse osmosis, by a pressure gradient, by a temperature gradient or by the application of external force field (Wangard *et al*., 2001). Molecular diffusion induced by temperature is thermal diffusion and that from an external field is forced diffusion. Diffusion is not restricted to molecular transfer through stagnant layers of solid or fluid. It also takes place when fluids of difference compositions are mixed. The first step in mixing is often mass transfer caused by the eddy motion characteristic of turbulent flow and this called eddy diffusion. The second step is molecular diffusion between and inside the very small eddies (Frank, 1998 & Harriott, 2001).

In distillation of LPG in cylinder, the high energy of molecules in liquid phase diffuses through the liquid phase to the interface and away from the interface into a vapor. The low energy of molecules in gas phase diffuses in the reverse direction and passes through the vapor phase into the liquid (Wangard *et al*., 2001). Molecules have a random spectrum of velocities and directions and tend to collide with each other in random fashion. The analysis of mass transfer is firmly rooted in the kinetic theory of gases and liquids (Mills, 1999 & Dutton, 1987). The kinetic theory correctly predicts that the mass transfer rate is proportional to the gradient of the concentration and this is called Fick's Law (Wangard *et al*., 2001).

The kinetic theory is based on the fact that molecules are always in motion. Therefore, the energy associated with molecular motion is known as kinetic energy (Siebert, 1982). When molecules collide, energy is transferred amongst themselves and the rate of energy transferred depends on collision properties (Barton *et al.*, 1980). Molecules do not possess the same energy, and when two molecules collide, one of them decelerates while the other accelerates which will increase the kinetic energy. Motion of molecules through space is known as translation motion and the kinetic energy is known as translation kinetic energy (Stanley, 1985). At room temperature and atmospheric pressure, molecules travel a distance of 15 times of the average molecule diameter before collision occurs (Parry, 1970).

The kinetic theory can be related to a macroscopic behavior such as pressure, volume and temperature and microscopic properties such as velocity, molecule mass and others (Hoover, 1983). Fluids that fully behave according to the kinetic theory are said to be idea but relatively such conditions do not exist. The deviation from ideal behavior depends on the composition of hydrocarbon mixtures (Levelle, 1955). The relationship can be explained using several gas models, which are gas pressure, gas temperature and gas molecular dispersed but all fluids have similar behaviors.

If the movement of any individual gas molecule is random and is not related to each other, the average of the square of the velocity component in every direction will be the same (Dickerson *et al*., 1987). When collisions of molecules happen against the container wall it will create pressure. Since the movements of molecules are random, thus pressure at similar value will be distributed on to the container wall (Katz and Lee, 1990, Segal, 1985 & Dutton, 1987). The statement above is similar to that of Boyle's Law which states that when the volume of container increases, molecules travel a greater distance and the frequency of collision against container wall per second decreases and the pressure also decreases, but it's the opposite if the volume of the container decreases.

Temperature or heat plays an important role on the velocity of molecules and kinetic energy is dependent on that factor. This is because heat is a form of molecular activity or energy (Turner, 1946). Therefore, there is a relationship between temperature and molecular behavior. However, molecules are not in static condition when the kinetic energy is zero since molecule movements are not stopped at temperature 0 K. This is due to the fact that molecules are continuously in rotational movements or static vibrations (Secrest, 1973). At that condition, kinetic energy is converted to potential energy.

When molecules dispersed through the bulk gas phase, the molecules will move and fill up the inter space of other molecular spaces. Dispersion in the gas phase is very fast compared to dispersion in the liquid phase because the gas phase has a lot of empty spaces. Thomas Graham observed that the rate of gas dispersion was inversely proportional to the square root of density. Due to the fact that the density of a gas is directly proportional to molecular weight, Avogadro concluded that the observation made by Graham was related to the kinetic theory (Lagemann, 1988). Therefore, if different types of gas are present in a container, the pressure P and volume V is the same. Thus, the ratio of the average molecule velocity for two types of gas is equal to the inverted square root of molecular weight of individual molecule.

Mass transfer rates in gases being somewhat higher than in liquids and solids may also diffuse into each other but usually at much smaller rates (Barrer, 1941 & Jost, 1960). Diffusivities in liquids are generally 4 to 5 order of magnitude smaller than in gases at atmospheric pressure (Harriott, 2001). Diffusion in liquids occurs by random motion of the molecules but the average distance traveled between collisions is less than the molecular diameter, in contrast to gases, where the mean free path is orders of magnitude greater than the size of the molecule (Harriott, 2001).

With related to the system under study, there are a few researchers tries to increase the molecule diffusion from liquid phase to vapor phase by changing the composition of liquefied petroleum gas since the votality will vary accordingly in the mixture of propane and butane (Dick and Timms, 1970). The votality is also a measure the vapor pressure of a component. At a given temperature, the component with the lowest boiling point such as propane has the higher vapor pressure and it is the most volatile component (Conrado and Vesovic, 2000; Purkaysatha and Bansal, 1998 & Evan *et al*., 1993). The component with a lower thermal capacity such as propane will absorb heat faster in heating process and at the same time it also releases the heat faster in the cooling process (Harris, 1980).

Heat that absorbed by the liquid components in order to diffuse into the vapor phase is called latent heat of evaporation. Latent heat is produced from heat present in the liquid itself and from the surrounding (William, 1982). Latent heat can indirectly determine the evaporation of liquids. Therefore, hydrocarbons with high boiling points need more heat to boil compared to those with low boiling points. During the process of evaporation the temperature of liquids decreases because of the occurrence of the capture of latent heat of evaporation (Leary, 1980). In thermodynamic, heat absorbed or released by a system in the process of phase change from vapor to liquid and vice versa is also known as change of enthalpy. Usually, absorption process and heat release are referred to endothermic and exothermic processes respectively.

Latent heat is used to break down the inter-molecular binding energy. Therefore, molecules that have sufficient energy will overcome the force or the binding energy. So that, when temperature increases further, latent heat decreases. Low kinetic energy has low temperature and to stabilize the temperature, external energy or heat of evaporation must be supplied to substitute the energy lost in overcoming the inter-molecular attraction forces in the liquid phase (Parry, 1970).

Latent heat is the total energy possessed by the molecule to establish a certain condition in order to produce potential energy that is equal to zero (Duncan, 1982). Latent heat of evaporation has a higher value compared to latent heat of melting. This is because in the case of melting process, heat is needed only to move the molecule within a short distance and the force of attraction still exists but the inter-molecular attraction must be completely overcome in the vaporization process.

In spite of these advantages of increasing the percentage of propane, the initial liquefied petroleum gas composition in Malaysia still remains as 30 percent propane and 70 percent butane. The reason for maintaining this composition is based on the production economic point of view. Therefore, in Malaysia the utilization of butane is less compared to the utilization of propane, more butane is available for LPG industry. Together with that, the selling prices of LPG also play the important role in the designing the LPG composition in Malaysia. This is because the price is determined based on the LPG heating value. The more percentage of propane used, the smaller is the heating value and also the lesser the price. Since the liquefied petroleum gas composition will be maintained, then another solution has to be obtained in order to reduce the residue.

2.2.2.1 Kinetic Theory and Intermolecular Forces

Attractive forces must be large enough to attract molecules into droplets or aggregates known as liquid. However, molecules in liquids do have kinetic energy because they are always in motion, fast or slow. If molecules near the surface travel fast, they may have enough energy to overcome the attractive forces that bind them in the liquid phase to enter the vapor phase. In the vapor phase, they behave like other gas molecules, which is colliding against the container wall to produce pressure. Total pressure depends on the total molecules colliding besides mass and velocity (Dutton, 1987 & Parry, 1970). When total amount of molecules that exist in the vapor phase is constant, the resulting pressure is known as saturated vapor pressure (Abbott, 1978).

If liquids have strong intermolecular attractive forces, only a few molecules have enough energy to overcome the attractive forces to escape. Relatively, only few molecules will vaporize. Therefore, at the same temperature and with a strong molecular attraction, the liquid has a lower vapor pressure compared to liquid with a weak molecular attraction.

Increase in temperature in liquids or gas will increase the average molecular kinetic energy. When the average molecular kinetic energy increases, molecules have enough energy to overcome the forces of attraction in liquids to escape into the vapor phase. Therefore, pressure increases with increase in temperature. After a brief period, liquid molecules that escaped into the vapor phase will collide with other gas molecules and will return back into liquid phase. When such condition occurs, the system is said to be in equilibrium condition.

But if another gas is present at the above liquid surface the molecules of that gas will collide with the molecules escaping the liquid surface. After collision, the escaping molecules may again return into the liquid phase. The rate of escaping molecules from liquid surface will decrease with the presence of another gas at the above liquid surface.

The vapor pressure is expected to be low when the rate of molecule escape is less but this is not so. This is due to the fact that a portion of the molecules returning to the liquid surface are restricted by other gas molecules (Parry, 1978). However, the presence of another gas does not influence the partial vapor pressure because liquid gas molecules at the above liquid surface are dependent on the presence of another gas above it. So that pressure at above the liquid surface is the total of partial pressure of liquid gas and the other gas.

Any gas molecule under the influence of the attraction of other gas molecule will collide against the container wall with a force lower than what it should be. The number of collision of gas molecules against the container wall is proportional to their density. This is because every collision is slowed down by an opposite attraction force and that attraction force is proportional to the density of the attracting molecule (Dickerson *et al.,* 1987).

Figure 2.10 illustrates the opposite attraction force by molecules in low and high density gases which indirectly illustrates an impact force against the container wall. Therefore, Figure 2.10(a) produces a higher impact force because of its low gas density.

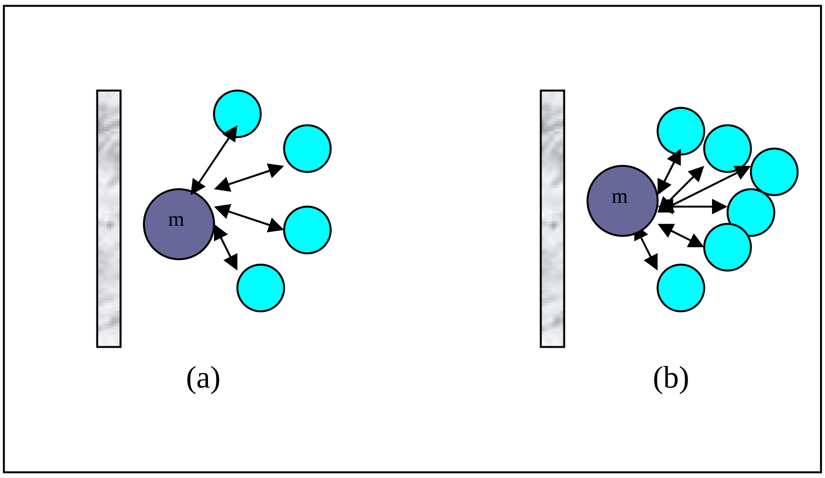

Figure 2.10. The difference of molecular attraction between low and high density gases on the Impact Force to The Container Wall (Dickerson *at el.*, 1987)

Attractive forces will also influence the viscosity and surface tension of the liquid. However, viscosity and surface tension are functions of the chemical properties of molecules and physical conditions such as temperature and pressure. When viscosity increases the surface tension also increase. Propane and butane have very low viscosities compared to water. The lower the temperature, the difference in viscosity between propane and butane becomes bigger because the viscosity of butane is higher than that of propane. Both of these properties are approaches used to illustrate how molecules move. Molecules of a viscous liquid need high energy to overcome the attraction forces between them before they can move (Malyshenko, 2002). When the heat flux increases than vapor molecule can occur more frequently due to a lower surface tension (Yun *et al*., 2005).

In liquefied petroleum gas, components with high viscosity and surface tension interrupts the ones with lower viscosity and surface tension during evaporation process (Frenghor, 1999 and Malyshenko, 2002). Temperature plays an important role to viscosity and surface tension. Decrease in temperature reduces the evaporation rate and this will interfere with the evaporation process (Morge, 1967). This is because the distances between the molecules are reduced. However, at critical temperature of the component, the surface tension is zero (Winning, 1965).

2.2.3 Liquefied Petroleum Gas Storage Operation

This sub-chapter will cover the concept of evaporation and evaporation process of liquefied petroleum gas in cylinder.

2.2.3.1 Concept of Evaporation

The definition and concept involving the role of molecules must be first understood before beginning the understanding of evaporation of liquefied petroleum gas. The phenomena of evaporation can be grouped into three categories that are evaporation of volatile liquids, evaporation of superheated liquids and evaporation of super cooled liquids (Lees, 1980). As liquefied petroleum gas is stored in pressured containers at temperatures above boiling point of the components, they are therefore grouped in the category of evaporation of superheated liquids (Zainal, 1994).

Evaporation process is defined as a process of transferring molecules from liquid phase into gas phase either below or above its liquid boiling point and this process will occur at all times (Haris, 1980). The evaporation process that occurs above the liquid boiling point is also known as a boiling point and the liquid will come under evaporation of super heated liquid category. Therefore, for liquefied petroleum gases its normal boiling point is – 42^{o}C and –0.5^{o}C for propane and butane respectively. The behavior of LPG stored in cylinder under pressure will be similar to evaporation of super heated liquid.

In the process of evaporation, molecules in the liquid phase must have enough energy to overcome the attractive forces of the neighboring molecules in order to enter a gas phase. This energy is achieved through collision between the molecules and molecules that have more kinetic energy compared to average kinetic energy will enter the gas phase (Siebert, 1982). The escape of these molecules into the gas phase cause the remaining molecules in liquid phase to experience losing heat thus reduces its temperature (Grimm, 2002 & Vai and Chun, 2004). This is because the energy of liquid molecules had been transferred to the gas molecules. In order to regain the heat energy and to recharge the kinetic energy, sensible heat must be supplied from the surrounding to the cooling liquid molecules (Yang and Zhang, 2003). In other words, the process of evaporation is also known as the process of heat and mass transports (Vai and Chun, 2004) and that will reduce the temperature as well as it can be calculated (Grimm, 2002).

The evaporation of liquid molecules into gas molecules creates bubbles on the heat source surface (Holman, 1983). Bubbles will detached from the heating surface and migrate towards the bulk of liquid but they remain closed to the wall (Okawa *et al*., 2005). In this case, the wetted surface area will act as the heat source surface. Bubbles are created by the expansion of the entrapped vapor and grow to a certain size and depending on the surface tension of the liquid vapor interface as well as temperature and pressure (Dezelbus, 2002). The bubbles volume increases particularly in the circumferential direction due to heat from wall. The distance between the center of the bubble and heating source surface rapidly increased due to the variations of the size and shape of the bubble (Okawa *et al*., 2005). More bubbles, particularly which induced more violent flow in the bulk liquid (Peng et al., 2001). Bubbles with a higher surface tension will have a greater tendency to remain in spherical shape (Lorenzo, 2003 & Okawa *et al.,* 2005). Figure 2.11 shows the effect on bubble formation of interfacial tension between liquid and wetted surface area.

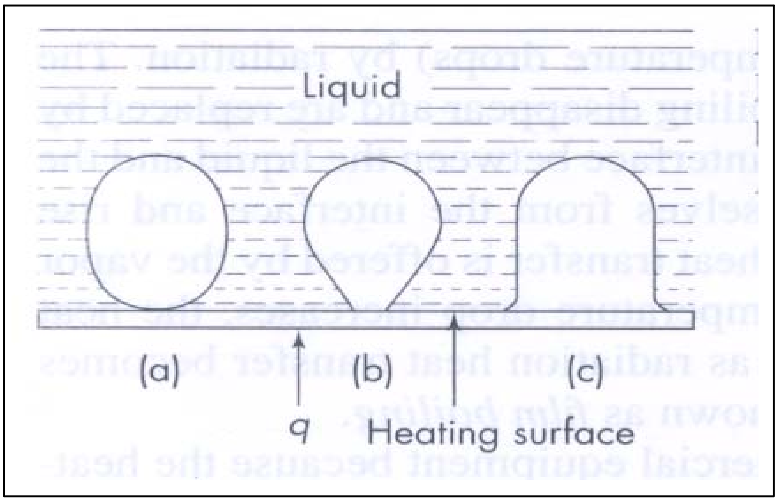

Figure 2.11: Effect of Interfacial Tension on Bubble Formation

Based on Figure 2.11, if the interfacial tension is larger, the bubble tend to spread along the surface and blanket the heating surface as shown in (c), rather than leaving the surface to make room for other bubbles, if the interfacial tension between liquid and solid is low, the bubble will pinch off easily, in the manner shown in (a) and the intermediate interfacial tension is shown in (b). The bubbles may collapse on the source surface or expand and dissipate in the body of the liquid, which depends on the temperature excess. Bubbles may also rise to the surface of the liquid and accelerated rapidly (Okawa *et al.*, 2005) before being dissipated if the temperature is sufficiently high (Ozisik, 1985 & Krupica, 2002).

The gas molecules inside the bubble hit the bubble surface and create the vapor pressure inside the bubble (Katz and Lee, 1990). This vapor pressure with the buoyancy action tends to bring the bubble upwards. However, if the pressure in the gas phase, which is on the top of liquid surface, is higher than vapor pressure in the bubble then it will stop the bubble from reaching the surface and will collapse in the liquid (Geankoplis, 1993). Once the vapor pressure exerted by the gas molecules inside the bubble is higher than the pressure in gas phase, the bubble will reach the liquid surface and break, releasing the molecules into the gas phase (Ozisik, 1985). This process or phenomena is known as boiling process and Figure 2.12 shows the liquid boiling process and could not be maintained without the heat supply (Peng *et al.*, 2001).

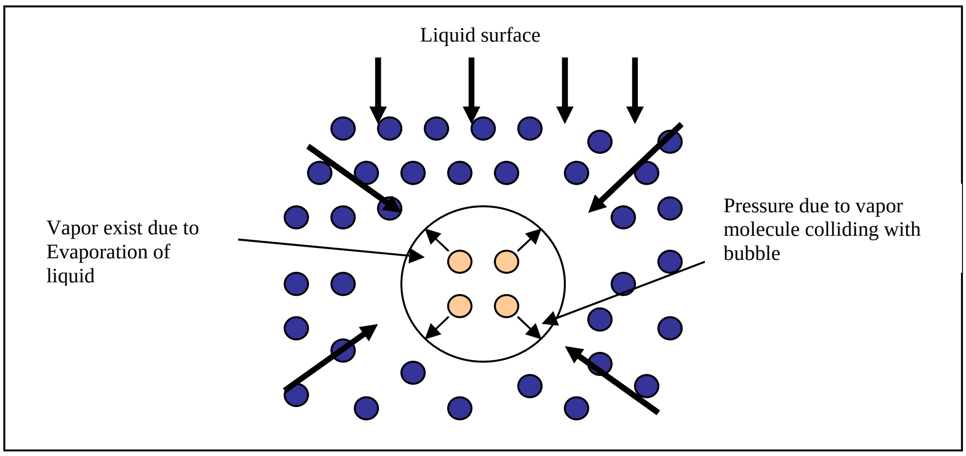

Figure 2.12: Liquid Boiling Process

The evaporation process, which is also known as vaporization is defined as the process of molecules transfering from the liquid phase to the vapor phase when the temperature is below boiling point, but this phenomena can occur at any temperature (Harris, 1980). Evaporation actually refers to molecules in free spaces and not in the saturated vapor formation.

The evaporation process of liquids in a closed cylinder that is stored above their boiling point is similar to the boiling process. During evaporation, molecules at the liquid surface must have sufficient energy to overcome the attraction forces around them to escape into the vapor phase. The energy is attained through collision between molecules and only molecules that have Boltzmann kinetic energy, which is larger than the average kinetic energy, will escape into the vapor phase (Siebert, 1982).

The average kinetic energy is the sum of energy levels of electron and the vibration and rotation of molecules (Dickerson, Grey & Haight, 1987). Electrons posses certain energy levels but not energy (Kinghoram, 1983). The distribution of Boltzmann's energy by molecules is exponential, so much so that the relationship between liquid temperature, vapor pressure equilibrium and latent heat are also exponential (Prugh, 1988 and Rose, 1985). The rate of evaporation from the surface is not influenced by the reduction or increase in the volume of the container since saturated vapor pressure does not affect the volume (Abbot, 1978). All component mixtures will evaporate together if their boiling point is about the same (Billet, 1989).

According to the molecular kinetic theory, unsaturated components will escape the surface liquid faster compared to saturated molecules (Duncan, 1982). However, the actual rate of evaporation is the difference between the total molecules that escape into the vapor phase to the total molecules that return to the liquid phase. This is because, when molecules escape into the vapor phase, they also collide and will lose energy (Yang *et al.*, 2003). Thus unsaturated components will cause a small pressure drop compared to saturated components.

The rate of total molecules that escape into the vapor phase, which is evaporation, depends on the average kinetic energy of molecules and liquid temperature where as the rate of total molecules that return to the liquid phase, which is condensation, is determined by temperature and vapor density (Okawa *et al*., 2005 & Akram Che Ayub, 1988). Actually, evaporation and condensation processes are not the same from the performance behavior pint of view (Assab, 2002). This is because the escape of molecules with sufficient energy into the vapor phase will cause the molecules that are left in the liquid phase to lose energy and in turn will reduce the temperature (Incropera, 1990 and Peng *et al.*, 2001). Thus, for kinetic energy to return to its initial condition, latent heat must be supplied from either the surrounding or from heat exchanger apparatus. In an open and insulated container, about 0.6 percent of the weight of the liquefied petroleum gas is evaporated for every one degree of temperature drop, but for a non insulated container, it depends on the properties of heat transfer (William, 1982). In summary, in evaporation process, almost the entire amount of heat delivered to the wall of container is consumed by evaporation (Krupicka, 2002) and heat transfer always accompanies by mass transfer (Romero, 2003).

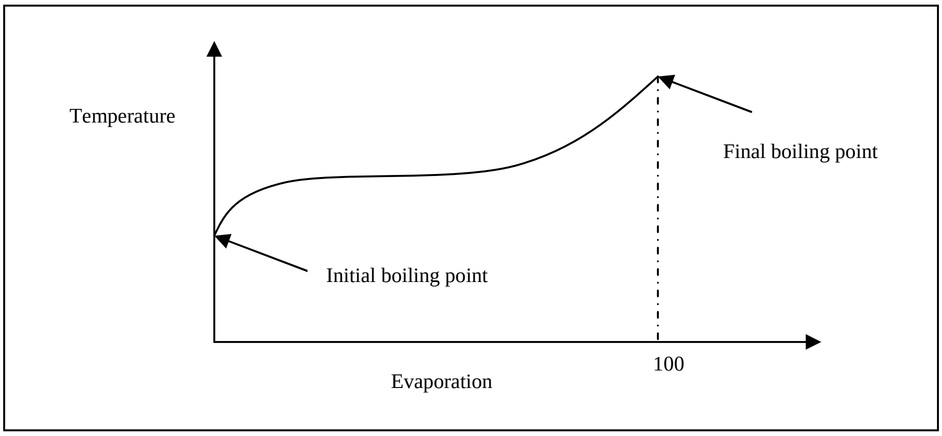

Figure 2.13. Diagram of the Boiling Process of Binary Components

Based on Figure 2.13, the boiling pattern of binary component is the S shaped curve. This is because components in that system have different vapor pressures. Initially, boiling occur only to components with higher vapor pressures followed by those with lower vapor pressures (Evan, 1993 and Thyer, 2003). The boiling process will stop if there is no increase in temperature during that process. All liquid will not evaporate until the temperature reaches the final boiling point, which is the temperature of the component with the smallest vapor pressure (Pope, 1979). This is due to the fact that, for the liquid phase, the higher pressure and the lower temperature, the more stable liquid is (Wang, 2000).

2.2.3.2 Evaporation Process of Liquefied Petroleum Gas

Schematic diagram of relative evaporation process for liquefied petroleum gas in cylinder is shown in Figure 2.14. Based on Figure 2.14, it can be concluded for propane molecules, it is easier to evaporate and pass to a vapor phase compared to butane molecules. This means that, the majority in the vapor phase is occupied by the propane molecules and in a liquid phase the majority is occupied by butane molecules, since both composition are not equal (Kinghorm, 1983 & Conrado and Vesovic, 2000).

The phenomena that occur during evaporation process of liquefied petroleum gas are (Royal Dutch, 1986):

i. Mist in white color if there is a leak

   During evaporation process, the liquefied petroleum gas will utilize latent heat of evaporation from water vapor that exist in the atmosphere and will cool it (Isao *et al.*, 2002). If these processes occur, the water vapor will condense and form a mist and will be visible as white in color. Furthermore, if the process of evaporation is continuous, it will end up with a form of ice layer at the leaked point (Waite *et al.,* 1983).

ii. Cold burn

   Cold burn is defined as damage of the skin tissue due to sudden huge reduction of temperature in the skin body (Humphries, 1992). When evaporation process of liquefied petroleum gas takes place on the skin, it will take the latent heat of evaporation from surrounding (water vapor) and also tissue in the skin body. This means that, the skins will lose the heat and damage it.

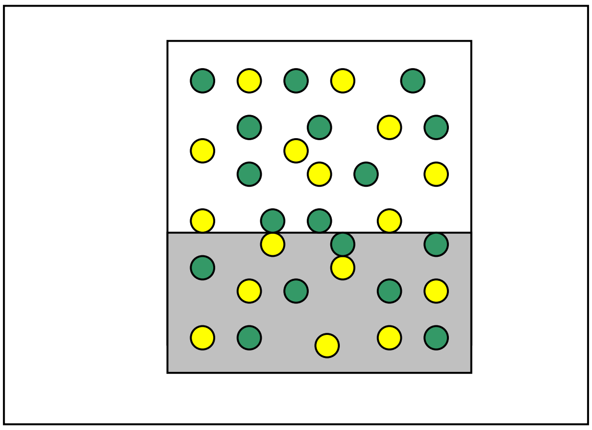

Figure 2.14: Relative LPG Evaporation Process

iii. Ice Forming outside the storage

During the evaporation process, the latent heat of evaporation is taken from the vessel sensible heat and its content and it will reduce the temperature (Verforndern and Dienhart, 1997). This concept is similar with the one explained in (i) above. When the process is continuous, the condensation water will form an ice layer (Isao *et al.*, 2002).

The evaporation of liquefied petroleum gas can be divided into two categories, which are flash evaporation and bath evaporation (Leary, 1980). This process depends on its storage and utilization type. In both categories, the latent heat that is required for the evaporation comes from surrounding and on occasions supplemented by some type of artificial heat exchanger.

Flash evaporation of liquefied petroleum gas is defined as evaporation due to sudden reduction of pressure at pressure regulator and pipe as a result of drawing off liquid (Leary, 1980). This type of application, normally storage cylinder will be installed with a dip tube as shown in Figure 2.15.

Based on Figure 2.15, when the liquid is withdrawn from a cylinder by consumption, the vapor pressure forces the liquid from the cylinder into the liquid regulator in the line. At this point, a pressure reduction occurs and part of the liquid is vaporized and the balance of the liquid will vaporized by artificial heat exchanger call vaporizer before it reaches to the gas burner (Denny *et al*., 1962). In this case, the latent heat that is required for the evaporation is taken from the surrounding.

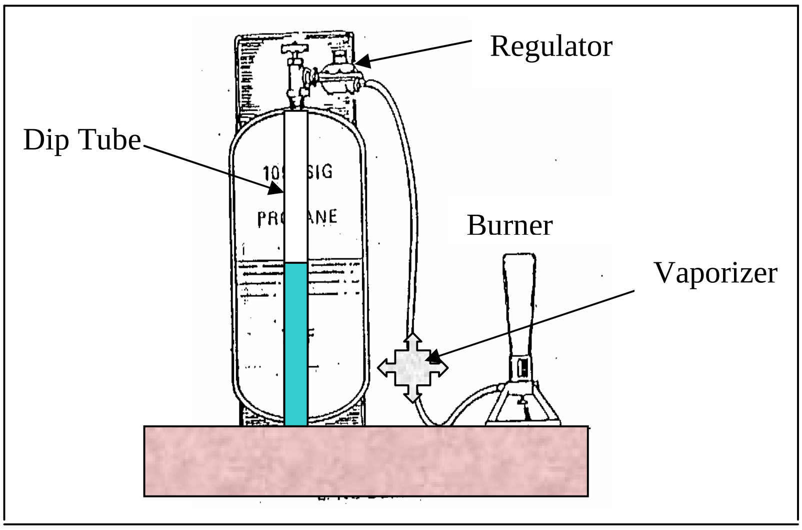

Figure 2.15: Storage Cylinder System with a Dip Tube

The fact that liquefied petroleum gas may be evaporating in the regulator and vaporizer but not inside the cylinder is the major different between flash evaporation and batch evaporation types. The advantages of flash evaporation compared to batch evaporation are the pressure in the cylinder does not drop while withdrawing liquid and the composition of the liquid remains the same until entire liquid is used as well as gas composition (Leary, 1980). Through this type of evaporation, it is possible to empty the cylinder without any residue and will maintain the flame characteristic as well as heat of combustion (Hunrichsen and Allendor, 1993; Royal Dutch, 1986 and William, 1982).

As discussed earlier, this type of evaporation is specially designed for the low temperature location like Genting Highland, Freazer Hill and Cameron Highland. This is because the latent heat of evaporation that is required for batch evaporation taken from surrounding is not capable to cause the process to occur. This means that, this type of design is only for the selected area of application. Unfortunately, flash evaporation type is not discussed in detail since it is out of the scope of this study. However, a detail explanation will be focused on batch evaporation since it implies to the method of the research, which is natural heat transfer to the liquefied petroleum gas storage.

Batch evaporation is defined as a process of evaporation due to reduction of pressure when exhaustion is made from the gas section. During this type of evaporation, latent heat of evaporation is derived from the liquid and surrounding. This type of evaporation is commonly applied to all kind of liquefied petroleum gas storage except the liquid withdrawal cylinder, which is applied to flash evaporation (Denny *et al*., 1962). This type of evaporation is also used in liquefied petroleum gas bulk storage but it is a combination between two methods, which is flash evaporation and batch evaporation (Leary, 1980).

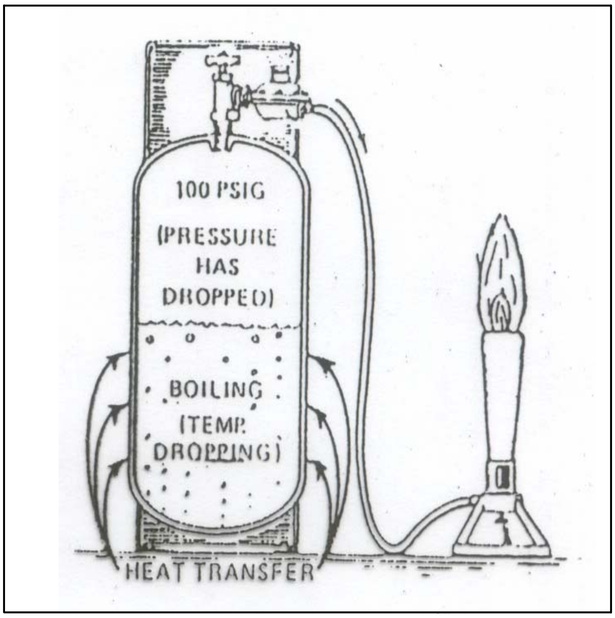

Figure 2.16: Boiling Phenomena during LPG Exhaustion Process

Liquefied petroleum gas will remain in liquid form if the surrounding temperature is below its normal boiling point. Since the liquefied petroleum gas is stored in a closed container then the relationship between its boiling point and temperature will change. In the closed container, a liquid surface will be exerted by the vapor pressure that will stop the boiling process. At this point, temperature and pressure is in equilibrium. Therefore, the boiling point will vary and is dependent on the pressure on the top of the liquid surface (Evan *et al.,* 1993). This is because the boiling resumes only when the gas pressure in the bubble is equal or slightly higher than vapor pressure or in other words only pressure will determine the boiling point of liquefied petroleum gas (Leary, 1980). The relationship between pressure and temperature during the evaporation process can be explained through a schematic diagram shown in Figure 2.16.

Based on Figure 2.16, before a valve is opened the system is in equilibrium. However, when the valve is opened, the gas will flow out as well as reduce the vapor pressure then the equilibrium no longer exists. At this time, the liquid boils immediately to reclaim the equilibrium condition (Akram, 1988; Kawamura and Mackay, 1987; Mackay *et al.,* 1980 & Hashemi and Wesson, 1971). By closing the valve, the vapor pressure will increase again and is higher than the pressure inside the bubble. Therefore, the boiling process stopped as the equilibrium is again reached. However, if the valve is open constantly it will result in vapor pressure drop continuously thus boiling process resumes but its rate decreased gradually until its normal boiling point or dew point is attained, and then the boiling stopped (LFTB, 1980). The reduction of pressure upon the liquid surface will enable some liquid to transform into the vapor phase (Verforndern and Dienhart, 1997). This transformation will cause a drop in liquid temperature since the latent heat of evaporation is given up by the liquid to form the vapor (Himmelbau, 1996). Therefore, the usage of heat is bigger compared to heat supplied to the system.

If a gas at a constant rate is withdrawn from the cylinder, the thermal equilibrium will be attained, this means that there is no reduction of temperature (Denny *et al.,* 1962). This is because the temperature difference between liquid and the surrounding is constantly maintained. In this situation, heat absorbed by the liquid is at constant rate except if there is a change of the rate of gas withdrawal (Thomas *et al.*, 1965). During the process of evaporation, there is continuous transfer of molecules in liquid phase into a vapor phase. In liquid phase, it will be richer with less volatile component compared to more volatile component and vice versa (Conrado and Vesovic, 2000) and sometimes this process or evaporation process is call distillation.

Evaporation rates in the liquefied petroleum gas cylinder differ according to the distance from the cylinder wall. The liquid closer to the cylinder wall has a higher evaporation rate compared to the liquid in the middle of the cylinder (Zainal, 1994 & Incropera and Witt, 1990). This is due to the fact that the liquid closer to the cylinder wall has a higher temperature as compared to the liquid in the middle of the cylinder as the former received more heat (Boe, 1998), which is supplied from surrounding through the cylinder wall. Therefore, the heat taken for evaporation process from the liquid in the middle is hardly replaced because the heat in the middle liquid cannot be top up by the heat from surrounding in the same manner. As a result, the liquid in the middle is colder then the one closer to the cylinder wall. However, at the beginning of the evaporation process, the rate of evaporation is the same for the whole liquid surface position since the distribution of the heat is in equilibrium (Hashemi and Wesson 1971 & Isao *et al*., 2002). However, the overall processes, the rate of evaporation decrease with the square root of time and finally will cool the substrate (Jensen, 1983 & Raj, 1981).

Evaporation rate in the liquefied petroleum gas also differs according to the height of the liquid in the cylinder. The temperature of the liquid closer to the bottom part of the cylinder is colder then the liquid closer to upper part (Muhammad Noorul Anam, 2002). The explanation for this relates to the heat transfer barrier, which accumulate at the bottom of the cylinder. During a continuous evaporation of liquefied petroleum gas, it needs a continuous supply of latent heat. In order to maintain a constant exhaustion rate, the liquid needs to receive a constant supply of heat. Therefore, some of the heat is taken from the liquid itself instead of heat from surrounding.

As mentioned earlier, the source of heat from surrounding keeps decreasing with time so that the source of heat only comes from liquid itself. So that, the heat from the liquid itself will be compensated for the decrease of heat, which results in gradual decline of the liquid temperature (Leary, 1980; Isao *et al*., 2002 and Lorenzo, *et al.*, 2003). As consumption continues, the temperature of the liquid portion continues to drop (Jensen, 1983), as the heat for the evaporation is continuously taken from it (Raj, 1981). Therefore, the liquid temperature will end up lower than the surrounding temperature. At this point, its also cools the surface of the cylinder and water condensation starts to take place at the outer cylinder wall and for an extended period of time the water condensation will form an ice layer if the liquid temperature drop below the freezing temperature (Waite *et al.,* 1983).

Figure 2.17: Ice Layer on the Outer Cylinder Wall

The formation of ice layer is thickest at the bottom of the cylinder due to the effect of gravitational force that brings the water droplets down and accumulates at the bottom of the cylinder (Assad and Lampinen, 2002) as shown in Figure 2.17. The thicker ice layer allows a smaller amount of heat from the surrounding to pass through to the liquid (Waite *et al.,* 1983 & Sun and Hewitt, 2001). Water condensation and ice layer are both heat transfer resistance. Therefore, the existence of these resistances further reduces the transfer of heat from the surrounding to the liquid thus further reduces the efficiency of the evaporation rate (Conrado and Vesovic, 2000) and will create the left over problem. The results indicate that the heat flux reduces as the inverse square root of time because an ice layer form on the cylinder wall (Raj, 1981). Figure 2.18 shows the heat transfer coefficient versus ice layer formation thickness due to film type of condensation.

However, if the consumption is not constantly used the left over problem does not exist, hence the efficiency of the evaporation remain constant (Zainal, 1994). This is because the liquid boils immediately to reclaim the equilibrium condition when the consumption stopped. Subsequently, at equilibrium condition, the vapor pressure is back to original condition since liquid temperature is also back at initial condition.

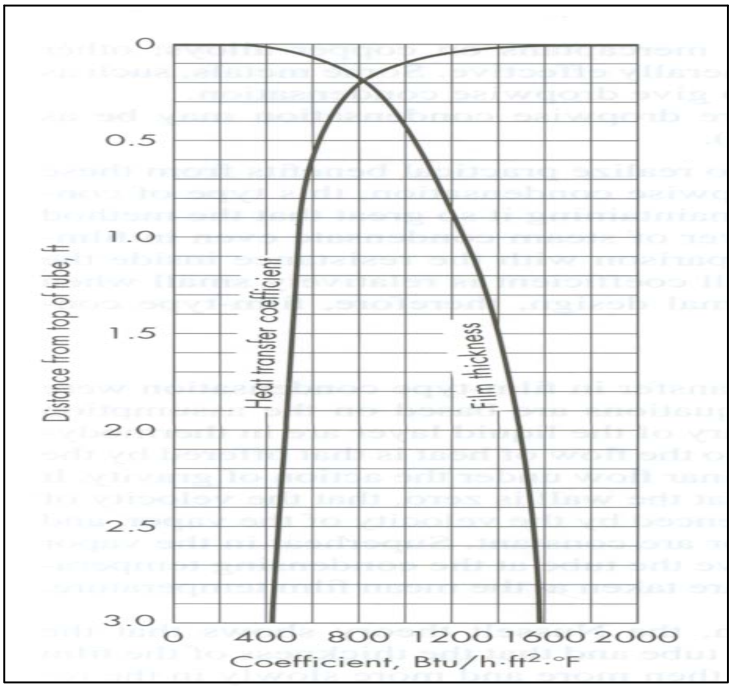

Figure 2.18: Film Thickness versus Heat Transfer Coefficient (Harriott, 2001)

Even though vapor pressure is directly determined the rate of evaporation of liquefied petroleum gas in the cylinder it is also indirectly affected by other factors that make calculations more difficult (William, 1982 & Evan *et al.*, 1993). Generally, major factors that affect the evaporation rate are cylinder parameter, liquefied petroleum gas composition, rate of withdrawal and surrounding temperature while minor factors are humidity of surrounding air, speed of the wind around the cylinder, color of the cylinder, roughness of the cylinder and direct sunlight to the cylinder (Thyer, 2003; Wang and Kido, 2003; Conrado and Vesovic, 2000; Lorenzo *et al*., 2003 & Boe, 1998).

Cylinder parameters are referred to the internal diameter, height of the body as well as shape at both sides, which are the top and bottom parts of the cylinder. These parameters may determine the area available for heat transfer process. The effective heat transfer area is only the wetted area where the liquid phase and the cylinder wall are in contact and not the whole area of the cylinder (Leary, 1980). This is due to the fact that the heat transfer through the cylinder wall, which is in contact with vapor, is too small and can be neglected (Shebeko *et al*., 1995 & Jourda and Probert, 1991). Therefore, the larger the size of the cylinder the larger is the evaporation capacity (Shaw, 1958) since it will provide a higher heat transfer coefficient then relatively smaller pressure drop (Yun *et al*., 2005).

Heat would be transferred to the cylinder from the surrounding if there is a temperature difference. At equilibrium condition, the liquid will have almost the same temperature as it is surrounding. However, when a cylinder valve is open the gas starts to withdraw, heat required for the evaporation, which starts simultaneously, will absorb from the liquid itself (Clifford, 1973; Conrado and Vesovic, 2000; Isao *et al*., 2002 & Lorenzo *et al.*, 2003). The result is a drop in liquid temperature, following which the supply of heat can start to flow from surrounding through the cylinder wall and into the liquid. This is important since the amount of heat, which can be transferred, is dependent upon the wetted surface area (Wang and Kido, 2003). However, the wetted surface area of the cylinder reduces the evaporation rate as it decreases due to the consumption even though this causes a greater temperature difference between the liquid phase and the surrounding (Shebeko *et al.*, 1995 & KOSAN, 1986) and at the same time the vapor phase temperature is higher than that of the liquid phase temperature (Turner, 1946). Therefore, if the wetted area is not enough will result in the extreme cooling of the liquid and evaporation cease (Thomas *et al.*, 1965, Kramer *et al.*, 1955). Normally, during the cylinder design an average of wetted area considered is 50% of the whole cylinder area by assuming that the thickness of the cylinder wall is the same in all sections (Dick and Timms, 1970). In practice, the increase of wetted area of a portable cylinder can be performed through installation by manifold concept.

The initial composition can be in terms either by the volume percentage or weight percentage of propane and butane components in the liquefied petroleum gas mixture (Leary, 1980). Propane and butane in the mixture will result in a complete solution and without changing of its individual characteristic. This is because both components are saturated hydrocarbon. The only differences are temperature and pressure equilibrium and it depends on the percentage of both components in the mixture (Evan *et al*., 1993).

The percentage of propane and butane affect the evaporation process because these hydrocarbon components have a different value of thermal capacity and vapor pressure (Rowlingson and Swinton, 1982; Clark, 1985; Evan *et al.,* 1993 & Thyer, 2003). The component with a lower thermal capacity absorbs and releases the heat faster in heating and cooling processes respectively (Harris, 1980 & Boe, 1998). The component with a high vapor pressure is more volatile, so that, at any given temperature, the component that has the lowest boiling point has the highest vapor pressure and vice versa (Evan *et al.,* 1993). Therefore, propane that has the lowest thermal capacity and the highest vapor pressure, plays an important role in the distribution of energy to the butane molecules in order to evaporate or to transfer at a low temperature (Kwangsam *et al.,* 2004). When mixture is done, propane molecules will spread and fill up the space between the butane molecules (Siebert, 1982).

The energy distribution by propane molecules is done through collision process. During collision, energy distributed follows the energy conservation concept, which is propane molecules will lose energy and at the same time butane molecules will gain it. This will give a chance to butane molecules to escape into the gas phase if its energy is higher than the bonding energy. However, the rate of energy transferred is more at low temperature compared to at high temperature (Barton *et al*., 1980). The mixture of the components of propane and butane do not influence the initial properties of the pure components. This is because both components are saturated hydrocarbons. The only difference is the equilibrium point of temperature and pressure and is dependent on the percentage mixture of both components (Kubben and Geld, 2001).

When the vapor is withdrawn, distillation takes place and the percentage of components changes continuously from the beginning until the end of the consumption. As evaporation continues, the composition of the liquid continuously changes. The percentage of the most volatile component will decrease and the percentage of the least volatile will increase rapidly in liquid phase (Conrado and Vesovic, 2000) and lead to an increasing temperature of the boiling liquid (Waite *et al.*, 1983).

Vapor pressure plays an important role in terms of affecting the degree of evaporative and maximizing the usage (Kwangsam *et al.*, 2004 & Evan *et al.*, 1993) or minimizes left over of liquefied petroleum gas in cylinder. However, based on the previous studies none of the compositions of mixtures possible to be completely vaporized with no left over (Turner, 1955 & Turner, 1946). Therefore, in western countries or countries with fluctuating weather, the maximum usage of liquefied petroleum gas in cylinder is achieved through the variation of propane percentage via season (Kwangsam *et al*., 2004 & Dagaut and Ali, 2003) without any modification to the cylinder design (Masami and Kusakabe, 1988 & Shaws, 1958). The maximum percentage of propane is 50% and 70% in Australia and Thailand respectively (Suphochana, 1981 & LFTB, 1980). However, in Malaysia, they used 30 percent of propane, which is based on the economic point of view for the production of propane (Hazzaini, 1998).

The rate of withdrawal is related to the pressure drop above the liquid surface so that it affects the evaporation rate (Gunther, 1957). When vapor leaves from the cylinder, the immediate vapor above the liquid surface is reduced due to the fact that there are less vapor molecules, which hit the cylinder wall to generate the pressure (Katz and Lee, 1990). This pressure reduction eventually enables the liquid to boil in order to replace the vapor, which has left the cylinder. At this point, an equilibrium state no longer exists between the liquid and the vapor. At high withdrawal rate the pressure drop faster and at the same time rate of evaporation is higher. Therefore, rate of evaporation is proportional to the pressure drop (Durr, 1984). However, the maximum withdrawal rate is subject to a storage or cylinder size in order to avoid ice layer formation onto the cylinder wall (Leary, 1980 and Denny *et al.*, 1962).

Liquefied petroleum gas is not withdraw from the cylinder at a uniform rate and usually depends according to the need of consumer. The rate changes from hour to hour, day-to-day and season-to-season and the changes occur in the form of cycles (Lim, 1992). This factor is difficult to determine when used by a group of consumers. This non-uniform rate of withdrawal causes the drop in pressure that is difficult to predict. Since pressure is related to temperature, the drop in cylinder pressure will be followed by the drop in liquid temperature. The temperature and pressure at the liquid surface during evaporation is almost the same as temperature and pressure of the vapor phase except at 2 millimeters below the surface, reading for the liquid temperature and pressure is slightly higher (Hashemi and Wesson, 1971). A continuous high rate of withdrawal causes the liquid temperature to fall very fast and may reach dew or boiling point temperature of components (LFTB, 1980). Therefore, it is important that the rate of withdrawal is small and is suitable with the cylinder size to establish effective natural gas evaporation.

If the vapor withdrawn is considered at a low rate, a thermal equilibrium state will be reached. At this point, the temperature difference between the liquid and the surrounding is constant. This is due to the liquid absorbing the heat from the liquid molecules to form the vapor may be at the same rate with the heat that is supplied from surrounding to the liquid molecules. Therefore, in this situation no further change in the liquid temperature will take place until the rate of withdrawal change. As a result, there is no problem related to left over because adequate pressure can be maintained to operate the system throughout the withdrawal. Generally, this type of condition only applies to domestic consumers that use gas at very minimum consumption (Che Badrul, 1994).

For commercial customers who apply high and continuous withdrawal rate, the liquid needs to boil at a higher rate. At this condition the liquid absorbed the heat from the liquid molecules to form the vapor may be at the higher rate with the heat that is supplied from the surrounding to the liquid molecules or in other words the thermal equilibrium is not achieved, hence the liquid will be lacking of heat (Handa and Benson, 1979). As a result, there is liquid temperature and vapor pressure drop.

Another concept to overcome the left over problem is by not applying continuous withdrawal but in batches or intermittent withdrawal since pressure is the most important factor that influence phase behavior (Wichterle, 1977) . This is because, when the cylinder supplies an intermittent flow, it has a chance to recuperate and store up sensible heat during period of no flow or evaporation stop (Dick and Timms, 1970). Therefore, the lack of heat to the system is not the main issue. At that period, liquefied petroleum gas is in dynamic equilibrium, that is the total molecules escaping into the vapor phase equals to that returning to the liquid phase. Temperature and pressure in both phases becomes equal and their compositions do not change with time (Felder and Roosseau, 1978). However, the increase in pressure depends on the components that still exist in the cylinder and at equilibrium the composition can be determined by equilibrium constant.

Any change of surrounding temperature during liquefied petroleum gas withdrawal from the cylinder will affect the evaporation process since almost the entire amount of heat delivered to the cylinder wall is consumed by evaporation (Krupicka, 2002). An increase of surrounding temperature of about 700 K will increase the evaporation rate by a factor of more than three (Lorenzo *et al*., 2003). This is because the evaporation process depends upon heat absorbed by the liquid itself. Indirectly, surrounding temperature also controls the vapor pressure in the cylinder. Referring to Fourier Law, the temperature different between liquid and surrounding is a driving force for the heat transfer to occur. Therefore, higher surrounding temperature can provide a higher heat transfer driving force than a higher evaporation rate and vice versa (Lorenzo *et al*., 2003). When higher temperature difference occurs, the liquid molecules have enough energy to pass onto the vapor phase and at the same time molecules that lose energy will gain heat supplied from the surrounding (Turner, 1946). This theory is only valid if there is no resistance on the outer cylinder wall. This means that, the weather is the main factor that affects the surrounding temperature (Lorenzo *et al*., 2003).

In order to get a higher heat transfer driving force, there are two ways, which are through a higher surrounding temperature or a lower liquid temperature. However, there is one limitation if referred to liquid temperature, which is a minimum liquid temperature. The minimum liquid temperature must be higher than the freezing point of water to prevent the ice layer formation on the outer cylinder wall. The ice layer formation behaved like a blanket of insulation and will slow down or reduce the heat transfer driving force (Sun and Hewitt, 2001). Even though the temperature difference is high, the ice layer formation will block the heat that can be transferred to the liquid. Finally, the liquid temperature continues to drop and will reach to the point that vapor pressure is equal to the atmospheric pressure (Verforndern and Dienhart, 1997) so that creates the left over problem. Therefore, a higher surrounding temperature does not always guarantee a higher heat transfer driving force if the liquid temperature dropped below the freezing point of water (Thyer, 2003 & Boe, 1998).

Since the heat source is from the surrounding then it is not possible for the liquid to achieve the surrounding temperature due to resistance during process transferring even though no ice layer formation exists. Normally, the difference is ten degrees or more and depending to the type of storage installation (Denny *et al*., 1962). If the storage or cylinder installed under ground, the surrounding temperature is 10^{o}C and liquid temperature is 1.7^{o}C, then only commercial propane can operate successfully (Thomas *et al.*, 1965 & National LPG Association, 1981). This means that, a small change in temperature of surrounding does not change much the rate of evaporation (Rao *et al*., 1986).

Besides that, surrounding temperature also affects the liquefied petroleum gas volume of liquid, which is a drop of 2.5 degree of temperature, will decrease one percent of volume of liquid but will increase 17 times compared to that of water with the same amount of temperature increase (Humphries, 1992). However, the amount of vapor volume is not related to the heat required for the evaporation process except for the safety purposes during filling (Stawczyk, 2003).

During operation, as the consumption of liquefied petroleum gas increases, additional heat from the surrounding must be transferred to the liquid to boil off the liquid. Consequently, the air surrounding the wetted surface area may be cooled off. The humidity of the surrounding air can cause water vapor condensation (Wang and Kido, 2003) on the cylinder wall. At higher percentage of humidity of surrounding air, the water vapor may cool down to a temperature that will condense on the wetted surface area of the cylinder and form an ice layer formation faster compared to lower percentage of humidity of surrounding air. These condensation and ice layer formation reduces the heat transfer efficiency (Chang and Reid, 1982). In this situation, water and ice layer formation acts as an insulator since both have very low thermal conductivity (Thomas *et al.*, 1965).

If the humidity of surrounding air is very low the temperature surrounding the cylinder can drop a great deal before any water vapor condenses on the cylinder wall. The relationship between surrounding temperature, humidity of surrounding air and ice forming temperature is as shown in Table 2.2 (Clifford, 1973).

Table 2.2: Ice Forming Temperature onto LPG Cylinder Wall (Clifford, 1973)

Surrounding	Relative Humidity (%)				
Temperature (^{o}F)	30	40	60	80	100
32.0	7.0	13.0	21.0	27.0	32.0
30.0	5.0	11.0	19.0	25.0	30.0
20.0	-3.5	2.0	9.5	11.5	20.0
10.0	-12.5	-7.5	0.0	6.0	10.0
0.0	-21.5	-16.5	-9.5	-4.0	0.0
-10.0	-31.0	-26.0	-19.0	-14.0	-10.0
-20.0	-40.0	-35.5	-28.0	-23.0	-20.0
-30.0	-	-	-38.0	-33.0	-30.0

A higher speed of the wind will give a better evaporation rate of liquefied petroleum gas (Seeto, 1983) in the cylinder. The wind can help natural formation of water droplets on the cylinder wall and make the wall drier (Atallah *et al.*, 1989 & Siebert, 1982). When the cylinder wall is in dry condition, it will reduce the heat transfer barrier thus more efficient heat transfer can take place through the wall as well as give better evaporation rate.

The cylinder that has a different color absorbed heat at a different rate. Therefore, painting the cylinder with a color that has better heat absorption can increase the evaporation rate. In western countries, they have a different color of cylinder for propane and butane (William, 1982). However, in Malaysia, the Authority fixed the color such as green for Petronas, yellow for Shell and blue for Mobil.

The roughness of the cylinder surface can also contribute to the evaporation process due to increases of surface actives sites (Yang *et al.*, 2003 & Verforndern and Dienhart, 1997). A rough cylinder surface can transfer the heat as much as twice than the smooth cylinder surface (Perry *et al*., 1984; Rao *et al*., 1986 & Thyer, 2003). When liquefied petroleum gas cylinder is exposed to direct sunlight, a greater source of heat is available to be transferred (Conrado and Vesovic, 2000) through the cylinder wall. It also enhances the evaporation of water droplets on the cylinder wall and makes it drier for better heat transfer process.

2.3 Modeling of Liquefied Petroleum Gas Operation

Mathematical modeling is the process of creating a mathematical representation of some phenomenon in order to gain a better understanding of that phenomenon. It is a process that attempts to match observation with symbolic statement. Generally, the success of a model depends on how easily it can be used and how accurate are its predictions. Therefore, a model of the process is first developed based on readily available experimental data.

Building a mathematical model is challenging, interesting and task. A thorough understanding of the underlying scientific concepts is necessary. Although problems may require very different methods of solution, the general approach to the mathematical modeling process are identify the problem, stating the assumptions, identify important variables and constants and develop the equations.

With reference to the process under study, which is an evaporation process in a closed system containing binary components, then a model is developed based on the heat and mass transfer concept as well as first law of thermodynamics. Therefore, the model development should consist of three main areas, which are mass and energy balance, evaporation process and heat transfer process. In the beginning of the model development, however, the process description is highlighted. The detail about the model development is as discussed in Chapter 5.

2.4 Summary

In Chapter 2, the discussion is thoroughly referred to the finding that was carried out by previous researchers as well as the basic concepts that are related to the subject under study. All researchers agreed that the amount of heat passed into the cylinder need to be enhanced for the purpose of minimizing the residue amount. The valuable research that are related to the study are increasing thermal conductivity, application of absorbed material, changing composition, changing cylinder diameter, applying of coating agent and heat redistribution. Therefore, the researcher will use the information gathered to enhance the understanding on the heat and mass transfer in order to investigate the actual occurrence.

CHARTER III

MATERIALS AND METHODS

3.1 Introduction

This study is an experimental and mathematical modeling of the withdrawal or evaporation of liquefied petroleum gas at different compositions, surrounding temperature, weight and discharge flowrate in cylinders. The fabrication rig was in accordance with specification, and the study was guided by specified standards for considerations of safety aspects when the experiments were operated. However, the mathematical modeling will be discussed in Chapter 4.

3.2 Fuels and Apparatus

3.2.1 Propane and Butane

Fuels used were mixtures of propane and butane in weights percentage. Maximum weight and mixtures was varies accordingly. However, the maximum weight that used was based on 80% of cylinder capacity while 20% acted as a safety factor as recommended by the code of practice (SIRIM, 1983). The weight and percentage mixtures under study are as shown in Table 3.1 and Table 3.2 respectively.

Table 3.1: Study Weight

No	Weight (kg)
1	7
2	6
3	5
4	4
5	3
6	2

Table 3.2: Study Compositions

No	Propane (%)	Butane (%)
1	100	0
2	80	20
3	60	40
4	40	60
5	0	100

The fuels propane and butane obtained from the Gas Processing Plant in Terengganu were pure components. The properties of the fuels were tested during the process of acquiring them as shown in Table 3.3. The percentage ratio of normal-butane and iso-butane was 50/50 by weight.

Table 3.3: Sample Properties

No	Fuel	Purity (%)	Moisture (%)
1	Propane	97.00	0.65
2	Butane	99.49	0.63

3.2.2 Testing Cylinder of Capacity of 18 Liter

Figure 3.1 shows a special design of testing cylinder that is made from cast iron with the capacity of 18 liter. The dimensions of the testing cylinder were as shown in Figure 3.2. Holes were drilled at fourteen locations with one at the head and the balance is at the wall side of the cylinder. These holes were for the installation of thermocouples (18 locations), for the pressure gauge (1 location) and for the sampling point (1 location). Drilled holes were fitted with female threaded screws of sizes ¼ inch and 1 ½ inch. The cylinder also has a glass window. The cylinder is tested according to standard after installation and before use.

Figure 3.1: A Special Design for Testing
Cylinder

3.2.3 Thermocouple

All thermocouples used were J type with maximum measurement range of –50^{o}C to 50^{0}C. Accuracy of measurement was up to two decimal points. The pattern of arrangement of thermocouples in the cylinder is as shown in Figure 3.2, which are located at the middle, inner wall and outer wall of the cylinder. The distance between each thermocouple in axial direction was 8.25 cm. That distance is the average height of the testing cylinder for the six locations of thermocouples. Figure H1 to H18 are the results of calibration.

3.2.4 Pressure Transducer

Pressure transducer used was of the brand Pasco with measurement range of 0 to 300 psig and with accuracy of up to one decimal point respectively. The pressure transducer with capacity of 300 psig was installed at the cylinder head through a ¼ inch hole. Both these pressure gauges were calibrated using standard pressure gauge certified by SIRIM.

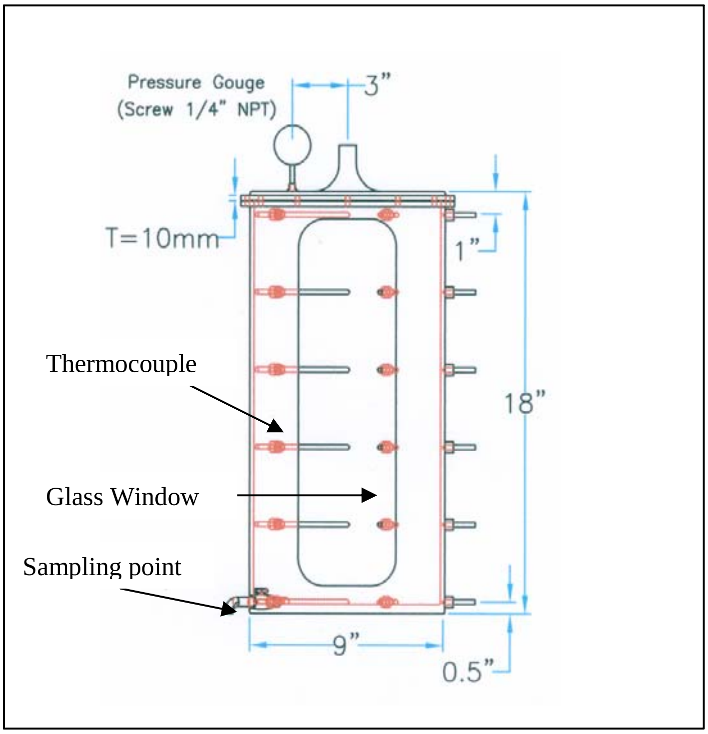

Figure 3.2. The Location of Thermocouples at the Study Cylinder

3.2.5 Regulator Valve

The regulator valve used was the needle type. The valve was fitted at the cylinder head to replace the pressure regulator. Regulation of flow rates was by widening and narrowing of the valve opening. The discharging flow rate of liquefied petroleum gas from the cylinder was done through the valve opening.

3.2.6 Gas Tubing

Stainless steel tubing with 1/8-inch diameter and an average length of 20 feet were used. Tubing was arranged in a straight line except at the section where the flow meter and the burners were installed. The tubing system was raised one foot above ground level with the help of supporters.

3.2.7 Sample Containers

A steel sample container with capacity 300 cm^3 was used. This container could withstand pressures up to 1800 psig. The sample container was fitted with an opening and a closing valve at both ends (Dick, 1971). This sample container was used to collect liquid samples in the testing cylinder to be tested for a determined time period. Figure 3.3 is shows the sample container used.

Figure 3.3: Liquid Sample Container

3.2.8 Flow meter

One unit of digital gas flow meter with capacity 0 – 100 liter per minute was used that designing for methane gas. The flow meter was used to measure the flow rates under study at the beginning of the experiment in accordance to the flow rate parameter as well as the flow rate through out the testing. The digital gas flow meter was calibrated using wet meter. Figure 3.4 is shows the gas flow meter used.

Figure 3.4: Digital Gas Flowmeter

3.2.9 Burners

One unit of burner was connected at the end of pipeline. The burner was made of galvanized pipe with diameter of 1.0 inch. The used of burner is to prevent the occurrence of reverse pressure. Closure and lighting of burner was done using ball valve. The location of the burner is fitted approximately 20 feet from the testing cylinder for the purpose of safety precaution. Figure 3.5 is shows the burner that burning a gas.

Figure 3.5: Gas Burner

3.2.10 Balance

A digital balance of the A & D type with capacity 60 kg and able to ignore a tare weight was used. Weights were recorded through pulse signal that used through data acquisition system and accuracy of the balance was up to two decimal points. The balance was used to record the weights of gas that exist in the cylinder for every range of time period and for the weight of gas residue after experiments done.

3.2.11 On-line Gas Chromatography

On line micro gas chromatograph of brand Agilent was used. Helium gas was used as carrier gas. The gas chromatograph was calibrated using gas standard of mixture propane and butane. Handling procedures of the gas chromatograph as per directed by Agilent. A clear picture of the arrangement of the apparatus is shown in Figure 3.6.

Figure 3.6. Arrangement of On-line Gas Chromatography

3.2.12 Computer and Recorder

Acer computer with frequency of Pentium II was used. The computer was connected to a third edition of Data Tacker brand data recorder system and recorded the temperatures, pressures and weights in the cylinder. The data acquisition was needed because the recording of data must be done simultaneously for the temperature, pressure and weight for a determined time period. Figure 3.7 shows data being recorded by the system.

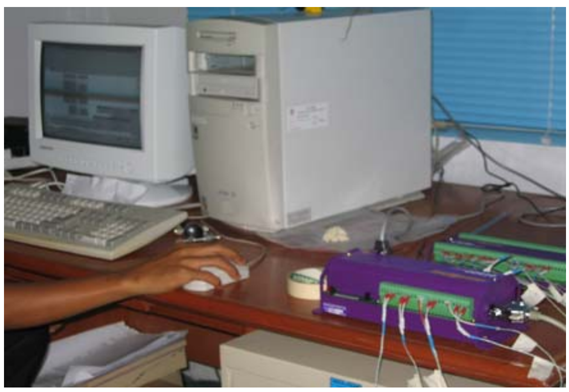

Figure 3.7. Computer with Interfacial System

3.2.13 Temperature Control Box

The temperature control box or cool incubator of brand Protech Model 300L was used with measurements of 3 feet wide and 5 feet high according to the size of testing cylinder used in the study. The testing cylinder was placed in this incubator. The surrounding temperature of the cylinder to be studied was set by controlling the temperature inside the incubator using the heat changer apparatus. The temperature of cool incubator was calibrated using standard thermocouples certified by SIRIM. Figure 3.8 is the cool incubator model 300L used in the study.

Figure 3.8: Temperature Control Box
Model 300L

3.3 Development of Rig or Apparatus

This study involved the fabrication and installation of simple apparatus as shown in Figure 3.9. The rig basically was referred to the study method done for a small size of cylinder (Dick and Timns, 1970). However, few modifications were made, such as the number and positions of the thermocouples, control of surrounding temperature and flow meter arrangements as well as the additional on line gas chromatography.

The rig was calibrated based on the pressure fall model published by Dick & Timns (1970). Figure H23 is the comparison of pressure fall between the mathematical and the experimental model on the rig. The percentage error of the mathematical model was 5%.

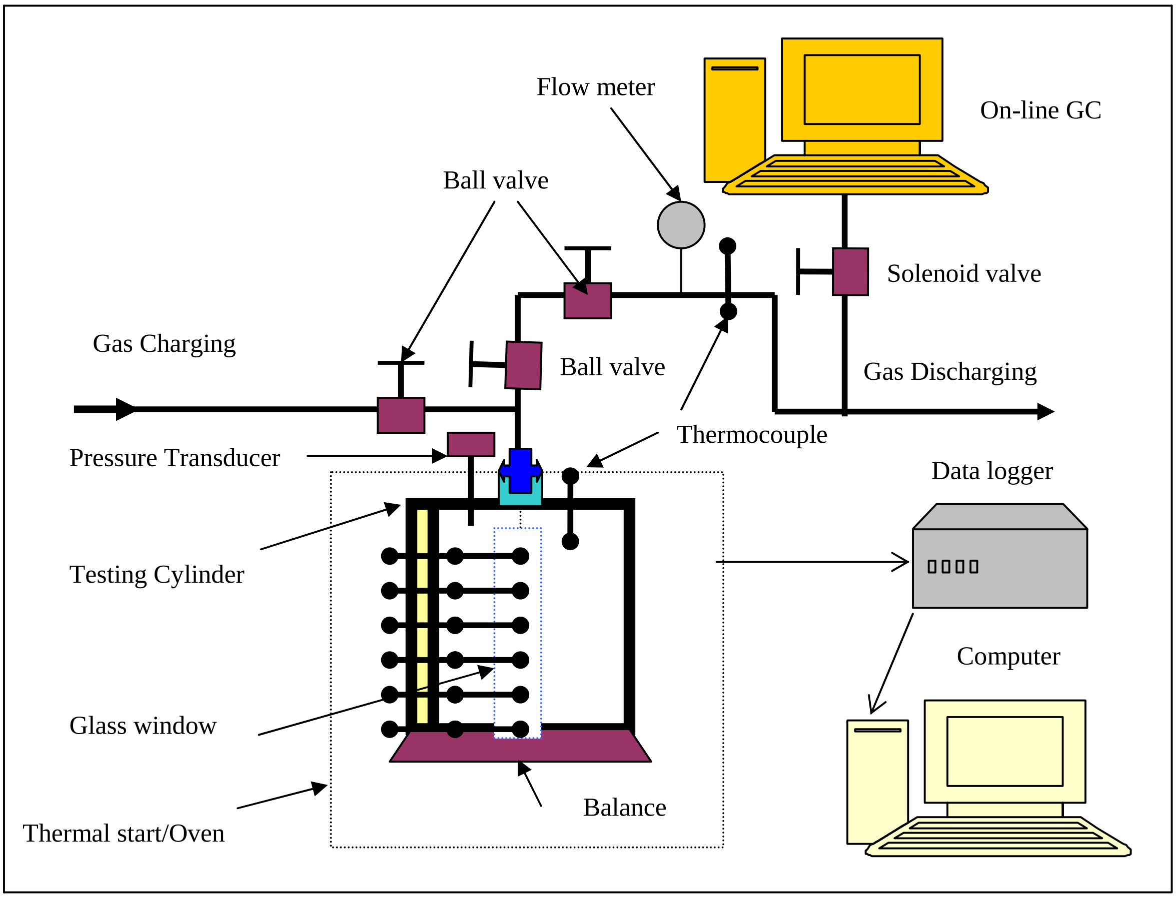

Figure 3.9. Schematic Diagram of the Study Rig

3.4 Study Procedure

3.4.1 Mixing of Components of Propane and Butane into the Study Cylinder

The mixing of the components of butane and propane into the cylinder must follow the correct procedures (Tchikou, 1986 & Handa and Benson, 1979). The procedures used in the mixing process were as follows:

1. Nitrogen gas was filled into the pure propane and butane gas cylinder (liquid withdrawal type of cylinder used for acquisition of the hydrocarbon from the gas processing plant) until pressures in the cylinders were of 200 psig and 100 psig respectively
2. The test cylinders were placed on the balance and the balance set to a reading of zero kilograms
3. The butane component was filled into the test cylinder by connecting the valve of the butane sample cylinder to the valve of the test cylinder. When butane weight needed was reached, the cylinder was changed and the propane cylinder was put in place and filled up to the total testing weight
4. The filled test cylinder was placed on the balance in the temperature control box and left for a day to stabilize the pressure in the cylinder
5. Steps (1) to (4) were repeated for every mixing done

3.4.2 Experiment Procedure

The procedures for the continuous flowrate experiment were as follows:

1. The study cylinder was connected to the pipe system while the thermocouple pressure gauge, and balance to the data acquisition system
2. The cool incubator apparatus was set to the surrounding temperature to be studied
3. The pressure, weight and temperature of cylinder were taken when the surrounding temperature to be studied was reached

4. Regulator valve was open and adjusted until the digital flow meter gave readings of flowrate under study. The burners were lighted and the gas chromatograph and the computer were switched on at the same time
5. Data such as temperature, pressure, gas composition and weight of cylinder were taken for every interval of 5 minutes for 1 hours and every 30 minutes after the period of 1 hours to the end of the experiment. Liquid sampling was done for every interval of 30 minutes to the end of the experiment. The liquid samples were tested using the gas chromatograph by manually (refer to Appendix G)
6. The experiment was continued until the pressure in the cylinder reached zero psig, that was when the cylinder weight noted was actually the weight of liquefied petroleum gas residue.
7. Steps (1) to (6) were repeated using different compositions, flowrates and surrounding temperatures.

3.4.3 Method of Measurements

3.4.3.1 Temperature of Cylinder

The temperature readings recorded at eighteen locations in the cylinder, which are 6 locations in the middle of the cylinder, 6 locations at the inner wall of the cylinder and 6 locations at the outer wall of the cylinder were directly taken from a computer installed interfacially through the data recorder. During the experiment, the computer screen gave readings at intervals of one second but only data were recorded at 5 minute intervals as initially programmed. Accuracy of data recorded or noted by the computer depended on the accuracy of the thermocouple used which was up to two decimal points. All temperature readings were plotted on a graph of temperature against time.

3.4.3.2 Cylinder Pressure

The pressure data was taken directly from a computer installed interfacially through the data recorder. This pressure transducer was able to take readings of up to one meaningful value. All pressure readings were plotted against time.

3.4.3.3 Gas and Liquid Composition

Measurement of gas compositions discharge from the cylinder was directly analyzed by the online gas chromatograph that has been set at every 5 minute for the interval time. However, the measurement of liquid sample was done using sample bomb that sucked out through the drain line or port made at the bottom part of the cylinder. The assumption when suctioning of the liquid sample was that the composition at the sampling hole is equal to the liquid composition in the cylinder. Every time suctioning was done, vacuum process of the used sampling bomb was first done. This was to free it of any remnants from the experiment before or of foreign materials that might exist which would interfere with the readings (Dick, 1971). Liquid samples sucked were then tested using the gas chromatograph. Gas and Liquid compositions of butane and propane from the gas chromatograph readings were plotted against time.

3.4.3.4 Weight of Liquefied Petroleum Gas

The weight of liquefied petroleum gas was taken directly from a computer installed interfacially through the data recorder while the weight of residue gas was the last reading when the cylinder pressure reached zero psig. The reading was determined directly from what was shown by the balance at the start of the experiment. This balance was set to only read the weight of the liquefied petroleum gas without involving the cylinder weight and other components. The readings taken were in fact the difference in gas weight in the cylinder for every time interval planned. The weight readings taken in the experiment were classified into two divisions. They were discharging weights, which were plotted as cumulative weight against time, and the residue weights as residue quantity against flowrates, temperature and initial weight.

3.4.3.5 Discharging Flow Rate

The discharging flow rates were taken directly from digital flow meter for every interval time planned. This digital gas flow meter was able to take readings of up to one meaningful value.

3.4.3.6 Liquid Level

The liquid level was measured directly using the measuring tape that initially installed at the glass window for every interval time planned. However, the possible measurement of the liquid level when the liquid level within a height of the glass window. This is because the glass window installed is only at the center of the testing cylinder.

3.5 Summary

In this chapter is highlighted in detail about the procedures that related to the experimental work and also the future work that required to be completed within given period of time. The explanations stated with types of fuels and apparatus used, development of testing rig and study procedure. Under fuels and apparatus used, researcher highlighted about the source and purity of fuels, size of testing cylinder, arrangement of temperature sensor and others sensor and equipment used. The concepts used were not only considering the accuracy of the testing result but also for the safety precautions. Therefore, for the development of testing rig consideration of safety is based on approved safety codes and practices such as Malaysia Standard 930 and Malaysia Standard 830. The final part in this chapter was discussed on study procedures. In these procedures, all steps to perform the experimental work were highlighted clearly.

CHAPTER IV

EXPERIMENTAL STUDY

Results and discussion highlighted here are based on the interpretation throughout the experimental study. All data and results presented were the best data from experiments done. Some data represented were the average of three readings when there were differences in readings for each experiment. However, the differences were very small and were not more than 5%. The discussion involved the effect of composition, flow rate, initial weight and surrounding temperature to the temperature and pressure profile, composition of vapor and liquid, discharging flow rate, liquid level, weight distribution and the quantity of residue.

4.1 Effect of Variation in Composition

In this sub-chapter, compositions were varied from commercial propane to commercial butane while other parameters such as surrounding temperature, initial flowrate and initial weight are constant.

4.1.1 Temperature Distribution Profile

The patterns of the temperature readings for all compositions and locations were similar. The lowest readings were recorded by the thermocouple positioned at the center and at the bottom of the cylinder. This was because of during evaporation process the heat required was from the surroundings and from the liquid itself (Denny *et al.*, 1962). The latent heat of evaporation was from two sources for a short period, but with time the source was only from the liquid (Ditali *et al.*, 2000). Although the fact that heat was still supplied by the surroundings but it was in a small quantity due to resistance to the formation of ice on the outer wall of the cylinder (Chang and Reid, 1982).

Figure 4.1 to Figure 4.3 were taken as examples to illustrate the pattern of temperature readings at center, internal wall and external wall of the cylinder for composition of 6040 of propane and butane at surrounding temperature of 35^{o}C and at flow rate of 48 liter per minute.

Based on Figure 4.1, at the first 15 minutes, cooling was seen terrible only at the top of the cylinder, at thermocouples Center 1, Center 2 and Center 3 for the first period of 15 minutes. Further evaporation process was accompanied by decrease in temperature at thermocouples Center 4, Center 5 and Center 6. The temperature readings for the thermocouple sensor at the internal wall also give the similar pattern. The lowest readings were recorded by the thermocouple positioned at the lowest of the cylinder and at the bottom, which is Internal Wall 6. Figure 4.2 illustrated the pattern of temperature readings at the internal wall of the cylinder.

At the end of the experiment, all temperature readings were tending to reach a control temperature, which is the surrounding temperature of the cylinder. Thermocouple Center 1 and Internal Wall 1 showed faster increase compared to thermocouple Center 6 and Internal Wall 6, which is the last one. However, internal wall thermocouple temperature recorded a higher increase in temperature compared to the temperature recorded by the center temperature. The thermocouple would be exposed to the vapor phase when there is a sudden high increase of temperature. This condition was due to heat needed for evaporation only from the liquid content and not the vapor content (Shebeko *et al.*, 1995). This meant that the liquid level after the periods of 270 minutes, all thermocouple sensors were in vapor phase. The sequences of the time that thermocouple turn the position 55 minutes for level 1, 75 minutes for level 2, 100 minutes for level 3, 130 minutes for level 4, 180 minutes for level 5 and 270 minutes for level 6. The time period required to turn the phase at every level became bigger when discharging or evaporation proceed further. The difference among the levels were 20 minutes, 25 minutes, 30 minutes, 50 minutes and 50 minutes from level 1 to level 2, level 2 to level 3, level 3 to level 4, level 4 to level 5 and level 5 to level 6. This was due to the evaporation rate reducing slowly.

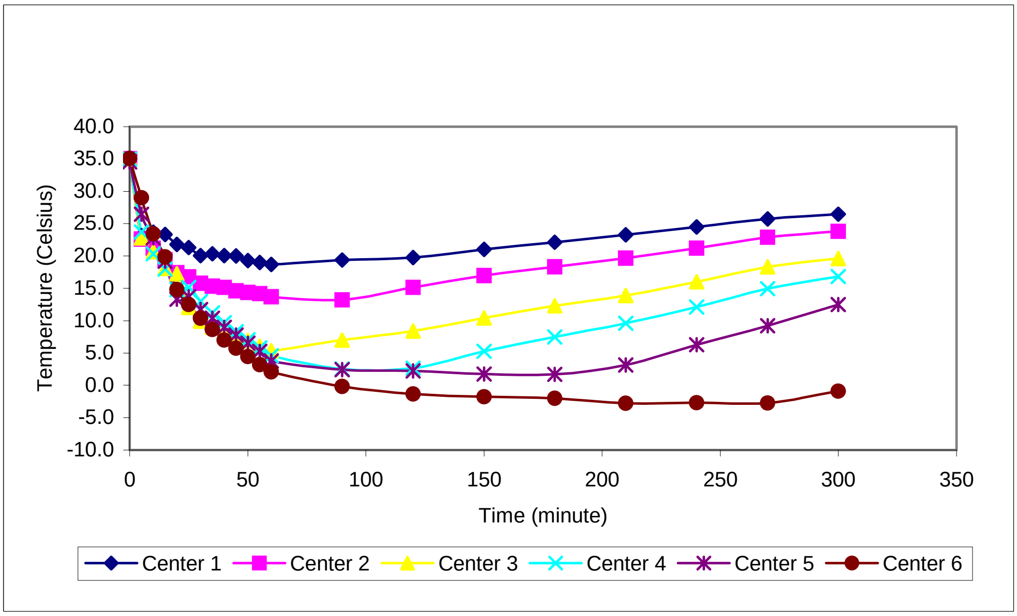

Figure 4.1. Temperatures Profile at Center of the Cylinder of 6040 of Propane and Butane at Flow rate of 48 liter/minute and Surrounding Temperature of 35°C

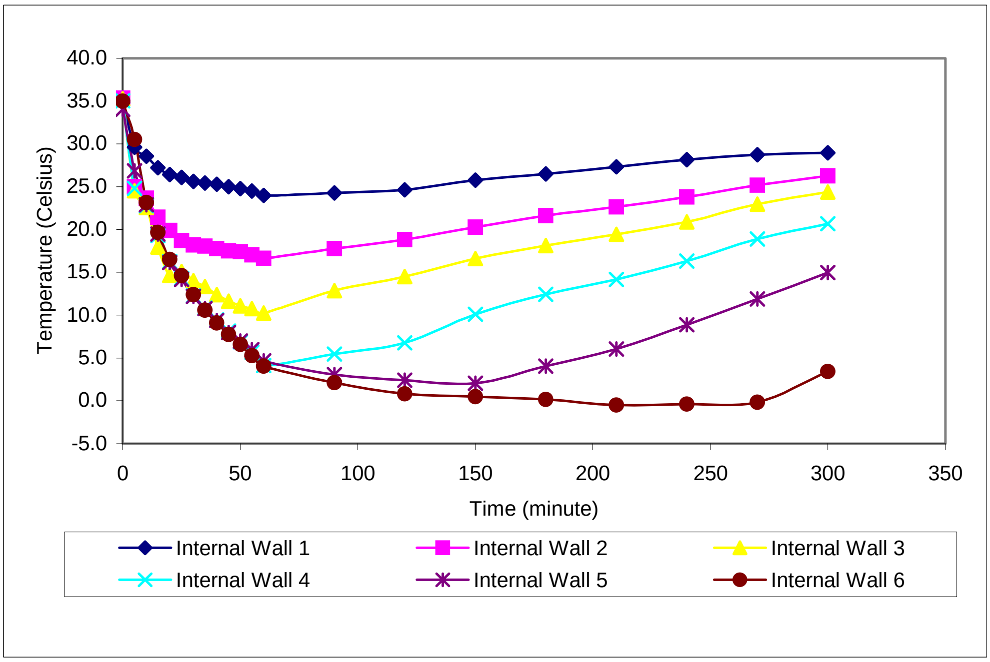

Figure 4.2. Temperatures Profile at Internal Wall of the Cylinder of 6040 of Propane and Butane at Flow rate of 48 liter/minute and Surrounding Temperature of 35°C

However, the temperature profile for the external wall of the cylinder showed some different patterns. The reduction of the temperature was not too tremendous like the temperature inside the cylinder. There are only two sensors that showed the thorough reduction, which are External Wall 5, and External Wall 6 but other four sensors showed small reduction of temperature and all were quite close. This was due to the cylinder wall being insulated by the ice formation layer. The ice started to form after the time period of 30 minutes. However, the level of the ice layer will decrease when the liquid level decreases. Figure 4.3 illustrated the pattern of temperature readings at the external wall of the cylinder.

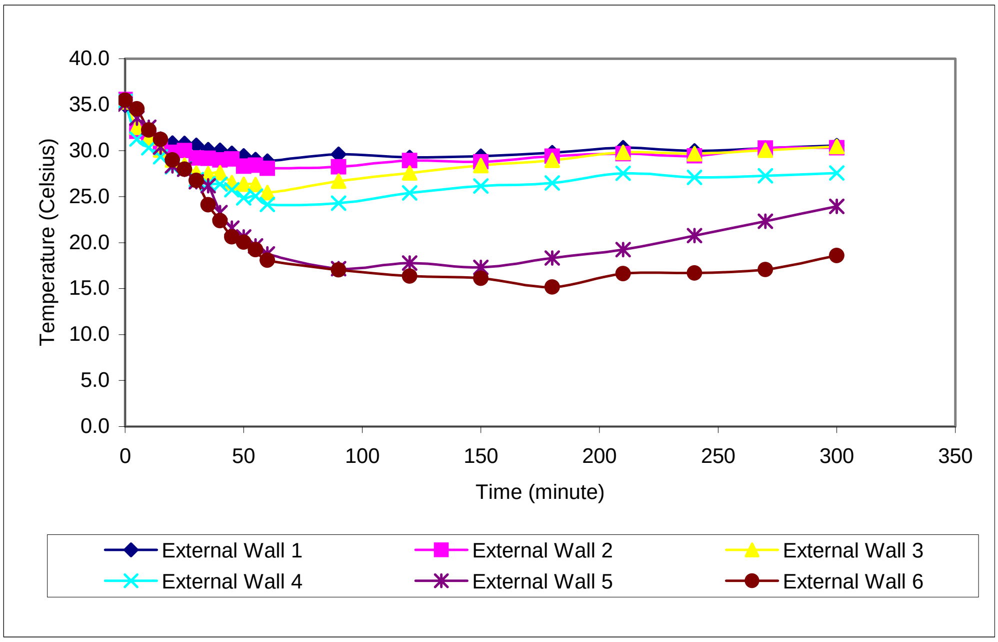

Figure 4.3. Temperatures Profile at External Wall of the Cylinder of 6040 of Propane and Butane at Flow rate of 48 liter/minute and Surrounding Temperature of 35^{o}C

The role of temperature on vaporization process was determined by comparison of temperature readings recorded at thermocouples C6, W6 and O6. These were because those thermocouples continuously recorded the liquid temperature and the lowest temperature until the cylinder was almost empty. If temperature readings at these thermocouples were close to boiling point or dew point temperatures, vaporization would be very slow and might stop if temperatures were below those point temperatures. (Leary,1980 & Zhoaci, 2004).

Figure 4.4 illustrated the pattern of the heat flow from the surrounding into the center of the cylinder. The temperature readings for the thermocouple sensor at the same level give similar pattern. Based on Figure 4.4, the temperature readings for the sensor at the center and the internal wall are quite close compared to the sensor located at the outside of the cylinder wall. However the lowest readings were recorded by the thermocouple positioned at the center of the cylinder. At the beginning of the test, both sensors which are Center 6 and Internal 6 gave very small difference but showed a further difference when the evaporation proceed further. This pattern of temperature was due to the heat supplied from the surrounding was not enough and probably just reached up to internal wall. Therefore, heat was taken from liquid molecules itself for the evaporation to take place. This means that, the temperature difference among three locations became greater once the evaporation further took place. Other compositions and conditions showed similar pattern as shown in Figures A1 to A6.

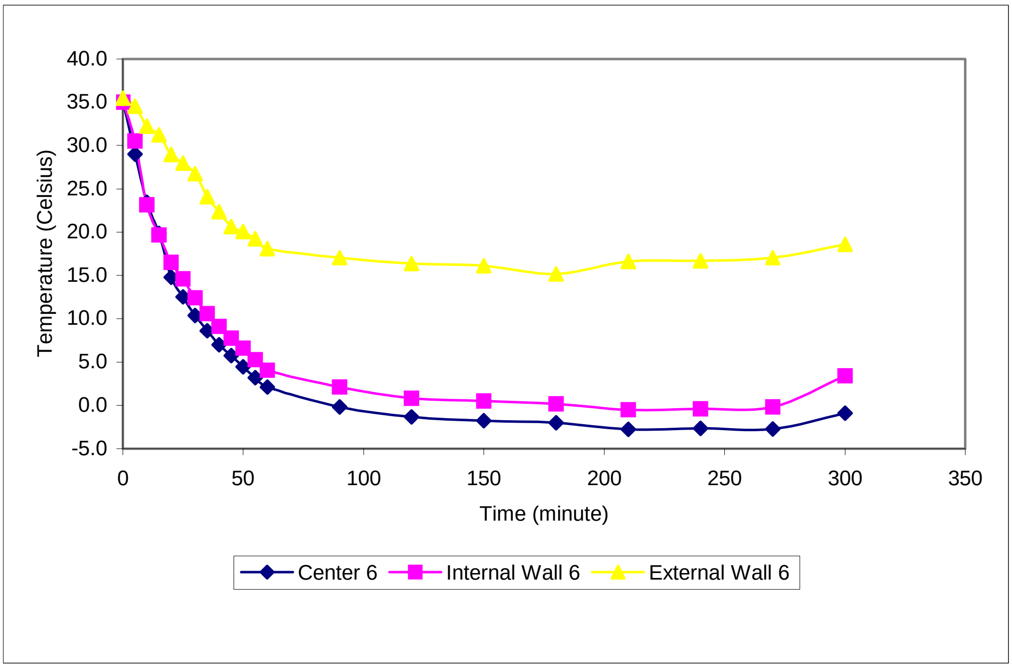

Figure 4.4. Temperatures Profile at Difference Sensor Location of 6040 of Propane and Butane at Flow rate of 48 liter/minute and Surrounding Temperature of 35^{o}C

When more propane component was mixed into the liquid, the lower was the temperature of the liquid. This was due to propane experiencing a higher vaporization process compared to compositions with lower propane content (Conrado and Vesovic, 2000, Raj, 1981 & Mackay *et al.*, 1980). Although propane had a lower temperature reading, propane was still able to undergo vaporization process because propane had a higher boiling point temperature compared to butane (Chang and Reid, 1982). The quantity of heat needed for vaporization or better known as the latent heat of vaporization needed by propane was less compared to that needed by butane (William, 1985 & Clark, 1985). However, this was only true at atmospheric temperatures. At temperatures in the range of –30^{o}C, both components needed the same amount of heat. In fact, more was needed by propane at temperatures lower than that range (Gallant and Yaws, 1992).

In the designing of liquefied petroleum gas composition, the factor of how fast or slow the boiling or dew point was reached was considered at the bottom thermocouple. Figure 4.5 to Figure 4.7 are examples of temperature readings at the bottom thermocouple for the various LPG compositions at flowrate of 48 liter per minute and the surrounding temperature of 30^{o}C.

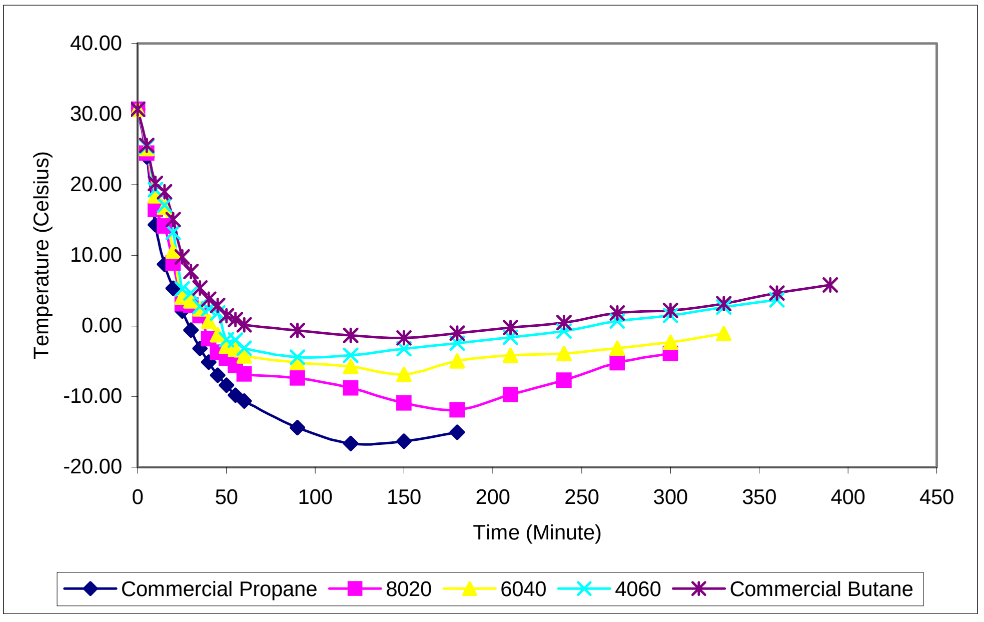

Figure 4.5. Temperatures Reading at Center of the Various Compositions at Flowrate of 48 liter per Minute and Surrounding Temperature of 30^{o}C

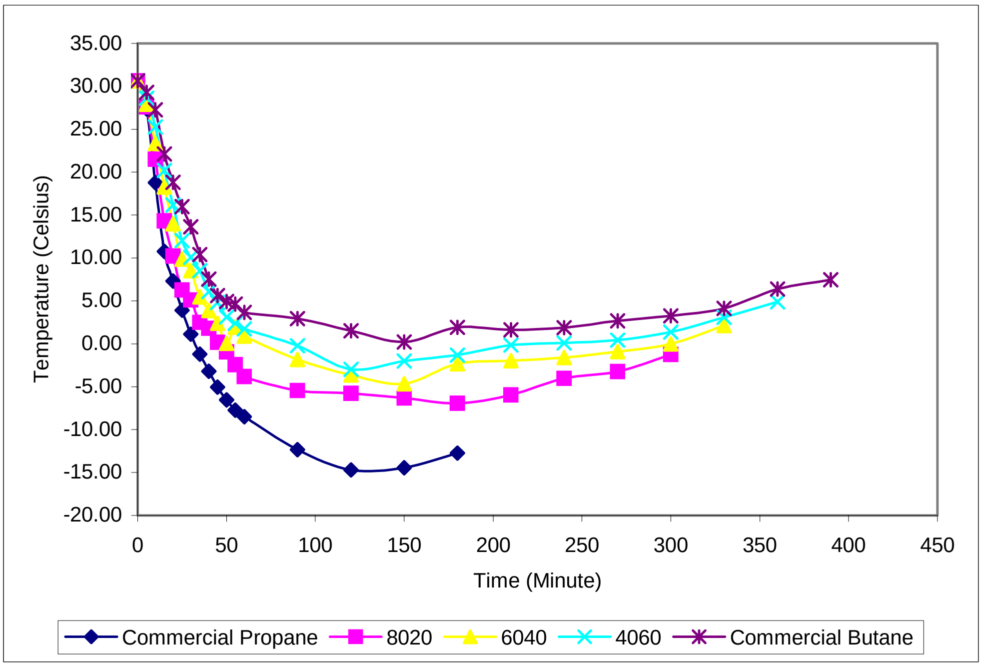

Figure 4.6. Temperatures Reading at Internal Wall of the Various Compositions at Flowrate of 48 liter per Minute and Surrounding Temperature of 30^{o}C

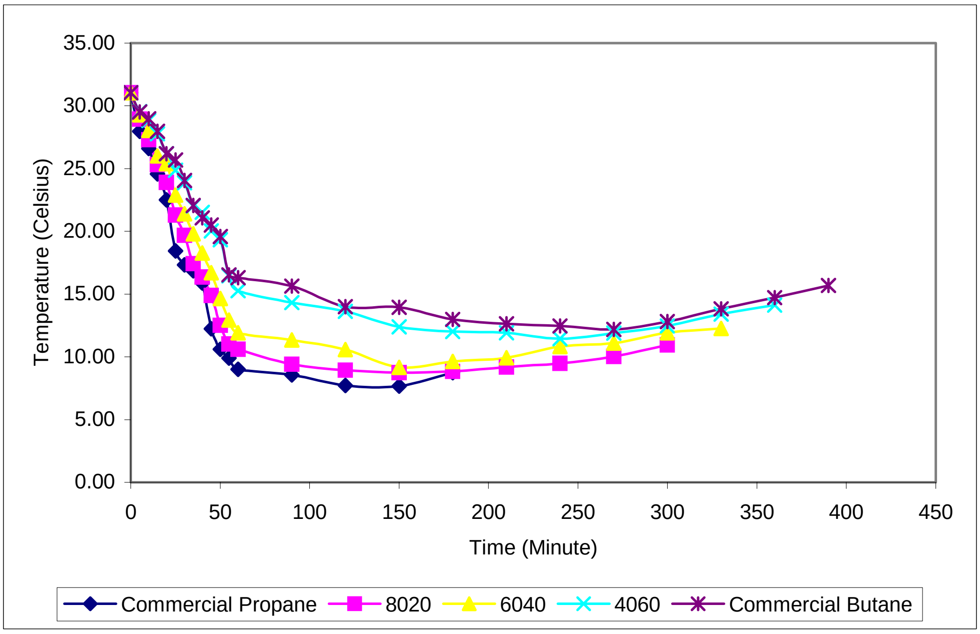

Figure 4.7. Temperatures Reading at External Wall of the Various Compositions at Flowrate of 48 liter per Minute and Surrounding Temperature of 30^{o}C

Three important characteristics can be observed based on the Figure 4.5 to Figure 4.7. Firstly, commercial propane has the lowest temperature, and this temperature increases with decrease in propane content, while commercial butane has the highest temperature. For the period of 30 minutes, the temperature –0.61^{o}C, 2.96^{o}C, 3.56^{o}C, 4.64^{o}C and 7.73^{o}C were recorded for compositions of commercial propane to commercial butane respectively at the center location. The differences become greater when evaporation further continued. However, the different temperatures will be getting smaller when sensors turn into the vapor phase. It will be observed that, at the period of 150 minutes the temperature were –16.36^{o}C, -10.91^{o}C, -6.87^{o}C, -3.25^{o}C and –1.68^{o}C. The temperatures were such because propane had a higher vapor pressure and thus made its rate of vaporization higher.

Secondly, after the thermocouples recorded vapor phase, all compositions showed a sudden increase in temperature. The fastest was commercial propane followed by compositions with progressively lesser propane content. The time reduced for composition of commercial propane to commercial butane were 150 minutes, 180 minutes, 190 minutes and 330 minutes. This was because propane had higher heat content compared to butane. Thus, it can be concluded that at that time, propane content in composition 80/20 was still large compared to compositions 60/40 and 40/60. Propane content in 8020 was almost the same to in 6040. This showed that, propane in 60% was assumed as an optimum amount for LPG. However, propane content in 4060 was almost the same to that in commercial butane whereby both compositions took a long time to increase their temperatures. This was because more propane in composition 60/40 was emitted before the liquid reached the position of the bottom thermocouple. Therefore, further productions encountered problems because supporting forces needed from propane had decreased.

Thirdly, the curve indirectly illustrates how large or small the vapor pressure possessed by a particular composition at that condition. Therefore, propane content of 60% would be able to help increase the vapor pressure of liquefied petroleum gas in cylinders at that condition since it has almost the same with the 80% of propane contents. However, compared to commercial propane the difference was too obvious. With that composition, it will provide the highest flame stability when used for domestic burner (Petronas Dagangan, 1992) reduction in pollution (Diaz *et al.*, 2000) and increase energy efficiency (Jung *et al.*, 2000 & Philip *et al.*, 2004). The propane content of 60% has also proven that for the right design of LPG used in Thailand (Suphochana, 1981). Other flowrates and surrounding temperatures too showed similar behavior, as shown in Figure A7 to A12.

Since evaporation process is an endothermic process, any finite discharge causes a drop in temperature over the entire volume of the cylinder. This temperature drop holds the key role as it has a strong impact on cylinder performance. During discharging phase, the temperature drop is a function of several parameters, i.e., gas composition, flow rate, cylinder design and geometry, material of construction and surrounding temperature.

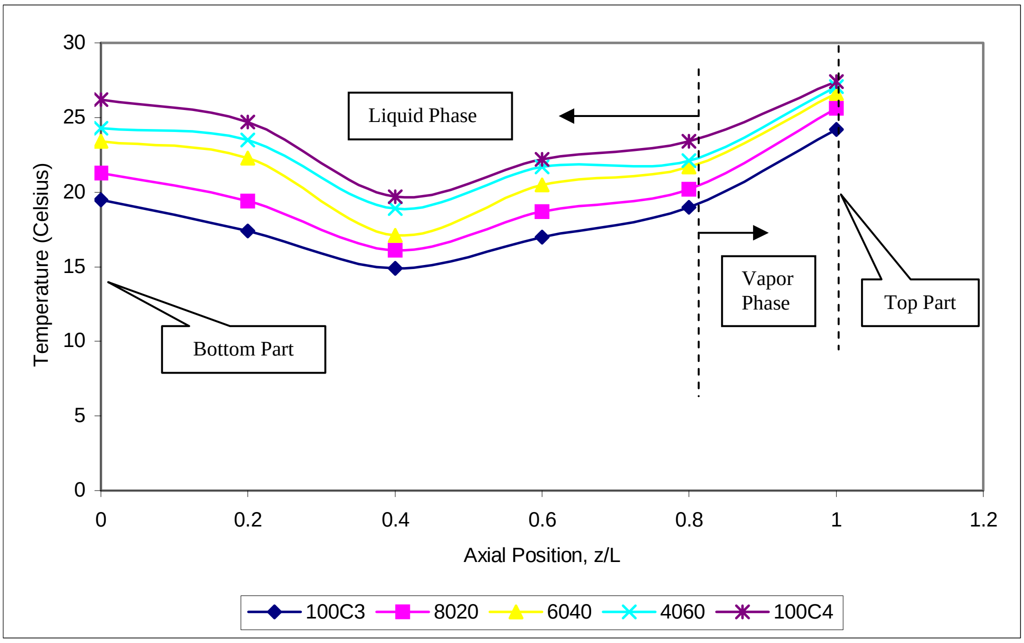

Figure 4.8: Dimensionless Axial Profile of Temperature at 10 Minute at Centre of Various Compositions at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

However, one of the useful methods to analyze heat distribution in a cylinder is based on the dimensionless analysis. Dimensionless analysis was carried out on the system to provide a clear picture on the tank thermal behavior. In order to draw a clear picture on the system, the temperature distribution is illustrated on the basis axial and radial temperature data. Figure 4.8 shows the temperature profile of centre sensor of axial direction with effects of variation in composition after 10 minutes of discharging period. Based on Figure 4.8, there were a few characteristics that can be observed.

Firstly, the trend of the heat distribution among all compositions is quite similar, which is the lowest temperature occurred at the middle part of the cylinder. It means that, at the beginning of the process of evaporation the latent heat of evaporation was derived mainly from liquid molecules nearer to the liquid surface since the sensors at the upper and the lowest part showed a small reduction of temperature. For example, at the upper part and the lowest part of the composition of the commercial propane, the temperature was 23^{o}C and 20^{o}C respectively whereas at the axial position (D/L) 0.4 the temperature was 15^{o}C.

Secondly, the lowest temperature drop among all compositions was occurring to the composition of commercial butane and the highest was commercial butane and the order of drop was commercial butane, 4060, 6040, 8020 and commercial propane. It means that, the higher the propane content the more heat derived from the liquid molecules for the evaporation process. Therefore, tendency for butane molecule to leave behind in the liquid phase is high since the boiling point for butane is far above the boiling point of propane, which is –0.5^{o}C and –42^{o}C respectively.

Thirdly, the gradient of the temperature drop will vary accordingly from commercial propane to commercial butane. However, the gradient of the temperature drop of the composition of commercial butane, 4060 and 6040 is almost the same compared to the composition of commercial propane and 8020. This is shown from the minimum percentage of propane component in liquefied petroleum gas is 60 percent in order to protect the maximum drop of temperature in the cylinder. Therefore, the minimum amount of propane component of 60 percent should be considered in liquefied petroleum gas mixture.

However, the trend of temperature drop changed towards the end of the discharging processes as shown in Figure 4.9, which is when the discharge time reached to 120 minutes. There were a few characteristics that can be observed based on Figure 4.9.

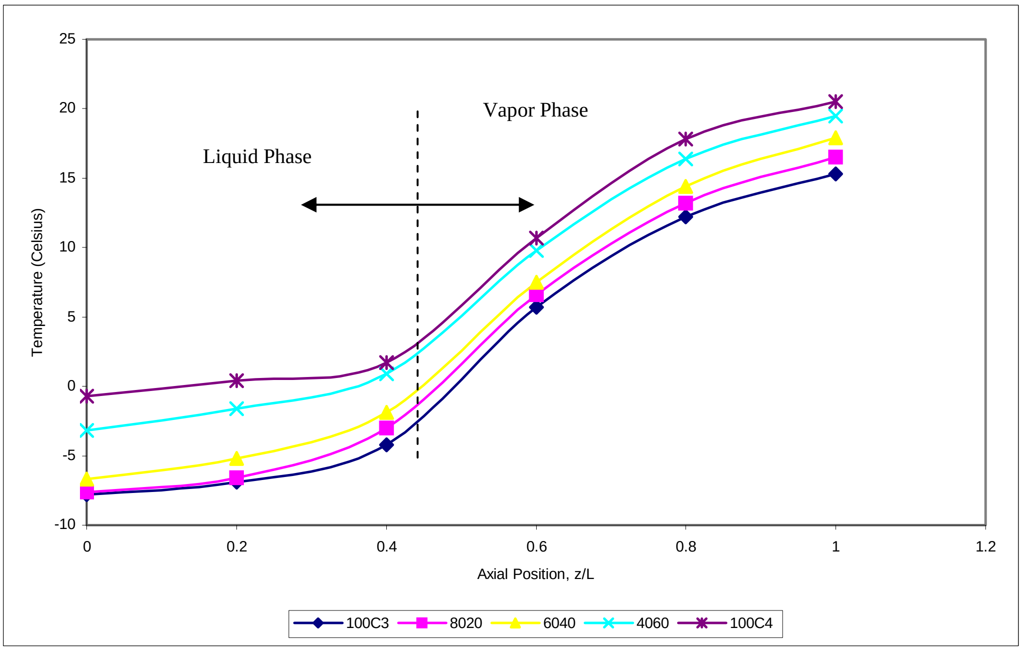

Figure 4.9: Dimensionless Axial Profile of Temperature at 120 Minute at Center of Various Compositions at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

Firstly, the lowest temperature level was detected at the bottom part of the cylinder. It was shown that, the latent heat of evaporation was further derived from the lower liquid molecules. It means that, the sensible heat that was required for evaporation process supplied by the liquid molecules as well as the heat from the surroundings to the liquid was not enough to equalize the temperature level. Therefore, the failure to get the equalized temperature level tends to create the left over problem.

Secondly, the gradient of the temperature drop was different in both phases, which is the gas phase and liquid phase. The result shows that, the gradient in vapor phase was higher then in liquid phase. It means that, the sensors, at level 1 up to level 3 are already in vapor phase whereas sensors at level 4 until level 6 are still in liquid phase. In conjunction to that, the higher gradient of temperature drops shows that the vapor temperature kept increasing since the heat was not used as a sensible heat for the evaporation process.

Thirdly, the pattern of temperature drop varies accordingly to the composition. However, the pattern of the composition of 4060 tends to be like the composition of the commercial butane where as the pattern of the composition of 6040 and 8020 was like the composition of commercial propane. Therefore, since the commercial propane was used as a referred composition in order to minimize the problem of residue, then the minimum amount of propane component in liquefied petroleum gas mixture should be 60 percent.

Fourthly, at the bottom part of the cylinder, the temperature level of composition of commercial propane and 8020 was the same. This indicated that, at the period of time of 120 minute there was no more butane component left behind in the cylinder. Therefore, the amount of propane of 80 percent was enough to settle the residue problem due to inactive butane molecules.

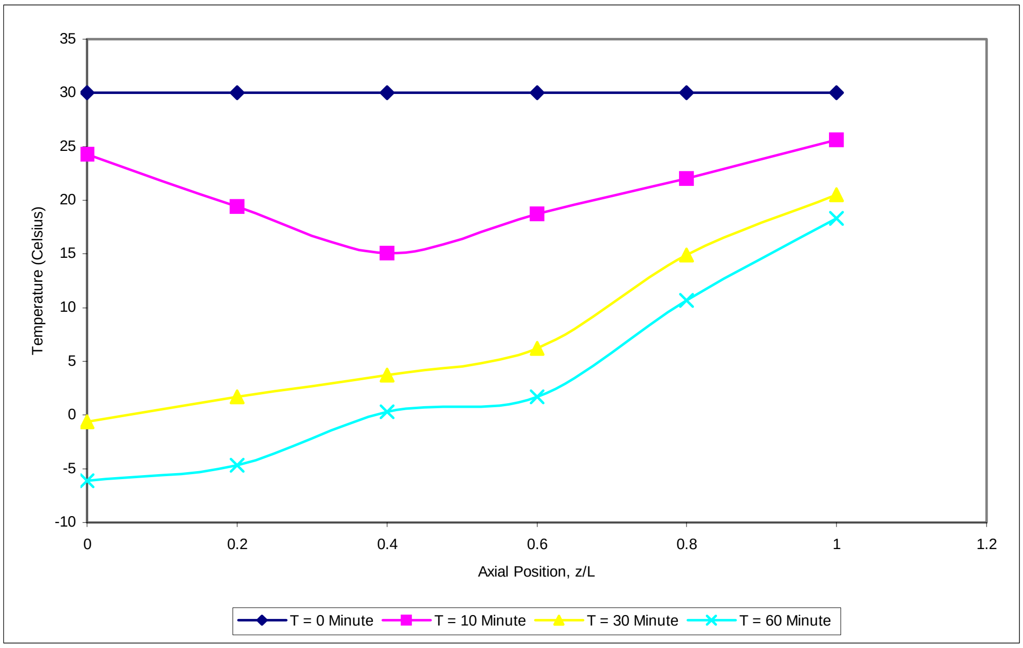

Figure 4.10: Dimensionless Axial Profile of Temperature at Early Stage at Centre of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

In all compositions, it was observed that the behavior of thermal distribution in the cylinder dropped tremendously at the beginning of the discharging compared towards the end. The behaviors were shown in Figure 4.10 and Figure 4.11 respectively. Based on both two figures the drop of temperature was tremendous for the first 60 minutes and became slower toward the end of discharging process.

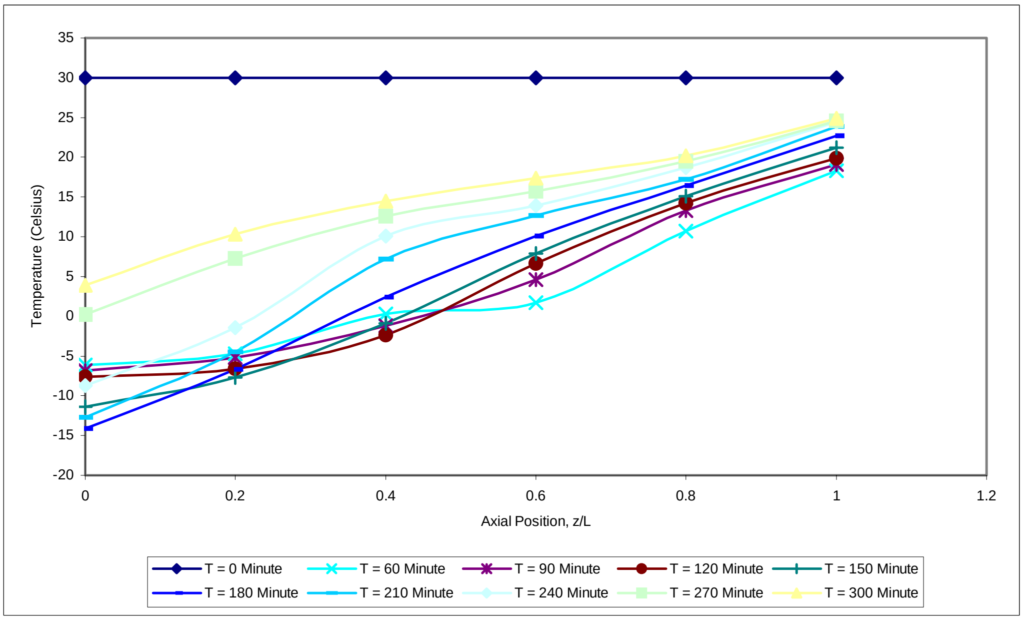

Figure 4.11: Dimensionless Axial Profile of Temperature at Centre of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

Figure 4.12 shows the temperature profile of the sensor at level 6 of radial direction with effects to variation in composition after 10 minutes of discharging period. Based on Figure 4.12, there were a few characteristics that can be observed. Firstly, the reduction of temperature from the external wall to the internal wall was less compared to temperature drop from the internal wall to the centre of the cylinder. This was shown that, the heat derived as a sensible heat for the evaporation process was not enough supplied from surrounding. Therefore, the heat was consumed from the liquid molecules.

Secondly, at the beginning of the discharging process, the overall temperature drop in the whole system was not too high. It means that, at the early stage of discharging process the distribution of heat from the cylinder wall to the centre was distributed in good manner and with this type of pattern profile we can say that at the early stage of the evaporation process the sensible heat used was taken from both sources, which were the surrounding and liquid molecules.

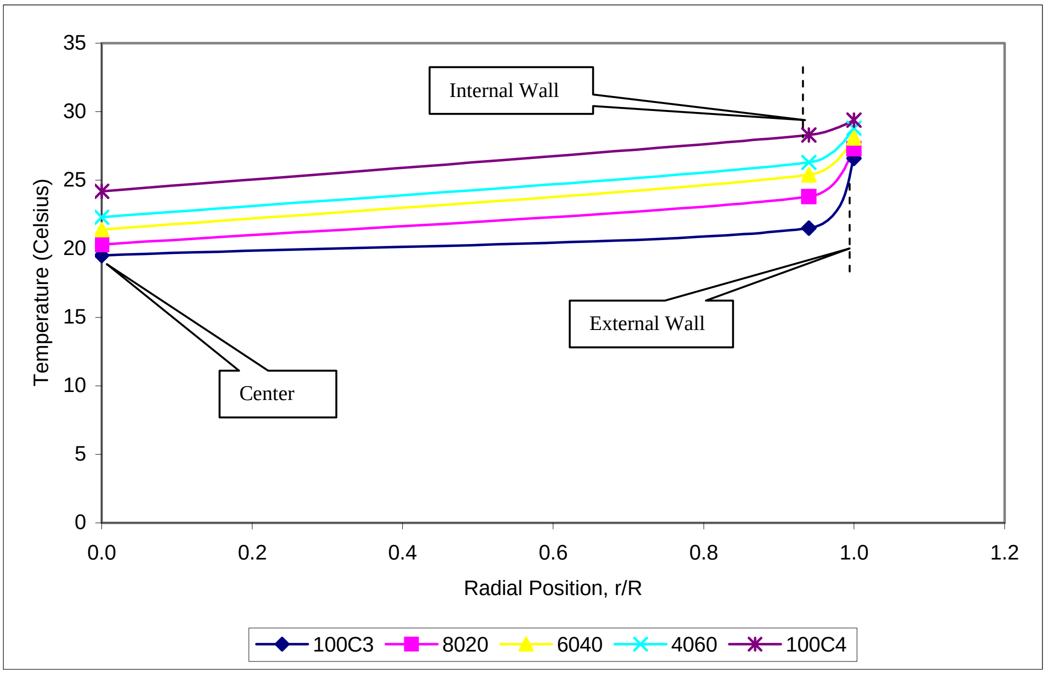

Figure 4.12: Dimensionless Radial Profile of Temperature at Level 6 at 10 Minute of Various Compositions at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

Thirdly, the reductions of temperature among the compositions varies in the gradient drop from commercial butane to commercial propane at location between the external wall and the internal wall. However, the gradient became smaller towards the centre of the cylinder. It means that, the distribution of heat from the surroundings to the internal cylinder was not equal with the heat used for the evaporation process.

Fourthly, for the period of 10 minutes of discharging, the pattern of temperature drop between the composition of 4060 and 6040 was the same from the surroundings to the centre of the cylinder but the composition of 8020 will tend to be like commercial propane towards the centre of the cylinder. However, the temperature difference among all compositions will get closer at the centre of the cylinder. It means that, the sensible heat used for evaporation process was taken mainly at the internal wall so that the heat cannot be distributed into the centre of the cylinder. This reason was proven through observation done during the experiment stage since a lot of bubbles were detached from internal wall.

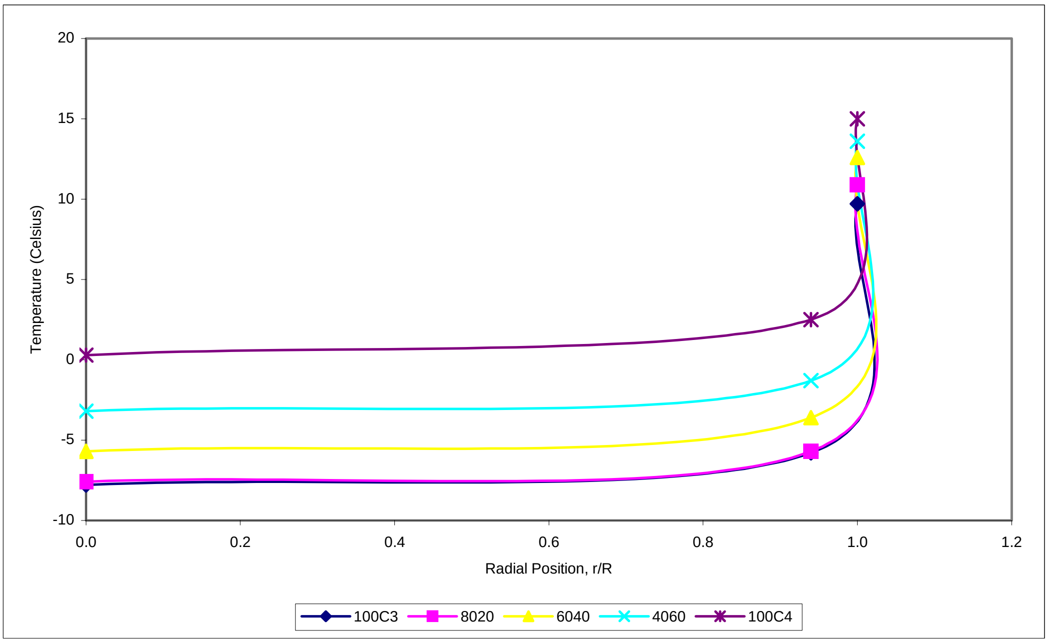

Figure 4.13: Dimensionless Radial Profile of Temperature at Level 6 at 120 Minute of Various Compositions at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

The usage of sensible heat at the internal wall can be clearly explained when the discharge was further proceeded as shown in Figure 4.13. Figure 4.13 shows the temperature profile of sensor at level 6 of radial direction with effects to the variation in composition after 120 minutes of discharging period. Based on Figure 4.13, there were a few characteristics that can be observed. Firstly, the reduction of temperature from external wall to the internal wall was very high compared to temperature drop from the internal wall to centre of the cylinder. This is proves that, the heat derived as a sensible heat for the evaporation process was not enough from surrounding.

Secondly, the pattern of temperature reductions for all the compositions were almost the same, which is very high from the external wall to the internal wall and became stagnant towards the centre of the cylinder. As previously explained, this is due to the fact that, the sensible heat used for evaporation process was taken mainly from the internal wall so that the heat cannot be distributed much into the centre of the cylinder. In others word, there were no heat added at the centre of the cylinder from surrounding when it was derived during evaporation process. It means that, the distribution of heat from the surrounding to the internal cylinder was not equal with the heat used for the evaporation process. Therefore, the liquid temperatures kept decreasing towards the end of the discharging process. However, the liquid temperature will keep increasing and become equal to the surrounding temperature when the discharging process stopped.

Thirdly, the temperature level of commercial propane and 8020 is almost the same at all locations compare to others compositions. However, the temperature level of composition 4060 has more tendencies to behave like commercial butane compared to composition of 6040 that has more tendencies to behave like commercial propane. As previous explained, we can conclude that the minimum amount of propane component in liquefied petroleum gas mixture should be 60 percent since commercial propane is used as a referred composition.

Others dimensionless analysis of temperature for all compositions on the basis of axial and radial flow for the different periods of time also give the same pattern and are illustrated in Figure A199 to Figure A291.

4.1.2 Pressure Profile

The patterns of fall in pressure were similar in all experiments in that fall was continuous up to zero psig. The pressure plot shows that the fastest fall in pressure occurred at the beginning of gas discharging and the slowest fall at late stage of experiment. This was because at initial stage of discharging, the rate of production was maximum and more repulsive forces resulting from pressure were needed (Jensen, 1983), compared to when the rate of vaporization was minimum.

However, there existed a linear and non-linear relationship between the rate of pressure and temperature decrease. As in the case of the rate of temperature fall, this was due to the fact that at initial discharging although heat was much required, it came from two sources, i.e. the liquid and the surroundings (Jensen, 1983). Therefore the fall of temperature to low levels could be prevented. If there was an outer resistance the source of heat was only from the liquid and the fall would be sudden. An example of the relationship between pressure and temperature is as in Figure 4.14, readings for the composition of 80/20 at flowrate 48 liter per minute and the surrounding temperature of 30^{o}C. Based on Figure 4.14, there were three characteristics that can be observed.

Firstly, the gradient of temperature drop was small if there is no outside resistance onto the cylinder wall, which is from A to B. This section was providing a linear relationship between temperature and pressure. It can be seen that the gradient was almost the same for the sensor inside the cylinder. However, the outside sensor has the smallest gradient compared to the inside sensors. This is due to the fact that, the heat was not used for evaporation process but the reduction was due to the heat distributed into the cylinder through conduction process. The reduction showed that the heat supply to the cylinder is not equal with the heat distributed into the cylinder.

Secondly, the gradient of the temperature drop was big when an ice layer insulated the outer wall of the cylinder, which illustrated at point B to point C. This section was also providing a linear relationship between pressure and temperature. Both sections showed that the center sensor indicated the lowest temperature compared to the sensor at internal wall. This proved that the more heat was utilized during the evaporation process of the liquid and also the heat from the surrounding might not reach the liquid at the center.

Thirdly, the sensor in vapor phase and outside of the cylinder was providing a non-linear relationship between temperature and pressure. This section was illustrated from point C to point D. This is because the sensor was in vapor phase so that the heat was not used for evaporation process. This was due to the increase in temperature while pressure decreased in the cylinder. However, the temperature outside the cylinder showed a different pattern compared to others. Generally, this pattern is useful for us to estimate the amount of heat that exists on the cylinder wall as a heat source that can be distributed into the liquid LPG for evaporation process. It showed that the amount of heat supplied into the liquid LPG had decreased.

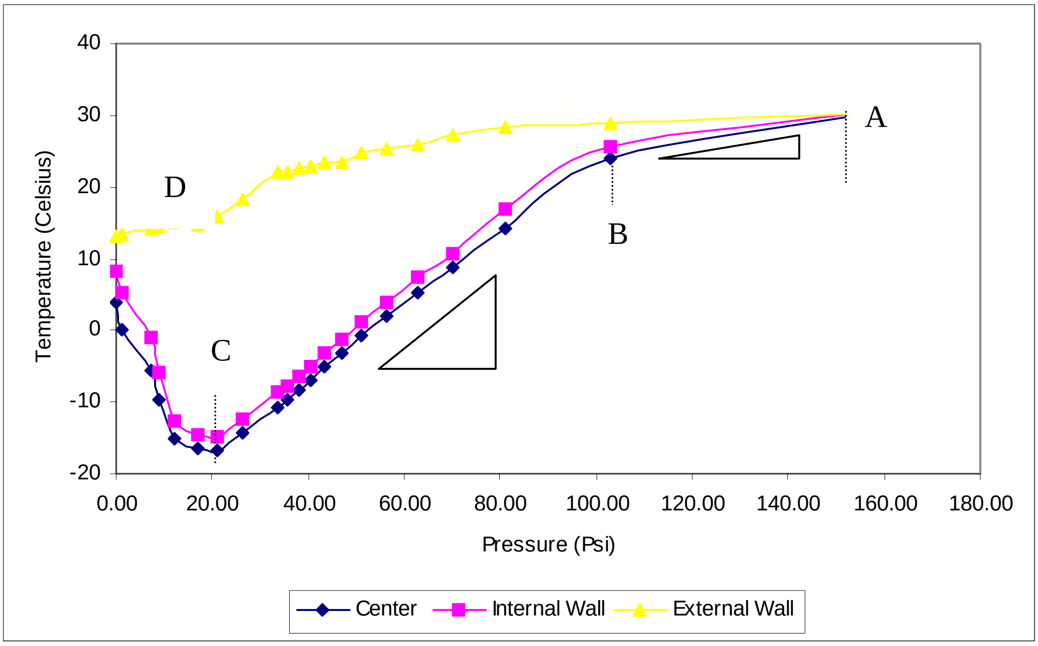

Figure 4.14 The Relationship between Temperature and Pressure of Composition 80/20 in the Cylinder at Flowrate of 48 Liter/Minute and Surrounding Temperature of 30°C

When propane content increased, the rate of pressure fall was slow even at low temperatures. This was because propane had high vapor pressure or in other words propane molecules still possessed high kinetic energy acquired from butane molecules to escape into the vapour phase and thus gave rise to pressure (Conrado and Vesovic, 2000). Figure 4.15 was chosen to illustrate the rate of pressure fall of various compositions at flowrates 48 liter per minute and at surrounding temperature of 30°C. Other flowrates and surrounding temperatures are as shown in Figures B1 to B6.

Based on the Figure 4.15, three important characteristics can be observed. Firstly, commercial propane had the highest degree of resistance to pressure fall followed with a less degree by compositions with increasingly less propane content. The fastest rate of fall was shown by commercial butane. For example, for a period of 90 minutes, pressures recorded were 34.49 psig, 26.47 psig, 18.79 psig, 12.77 psig and 7.51 psig for commercial propane to commercial butane respectively.

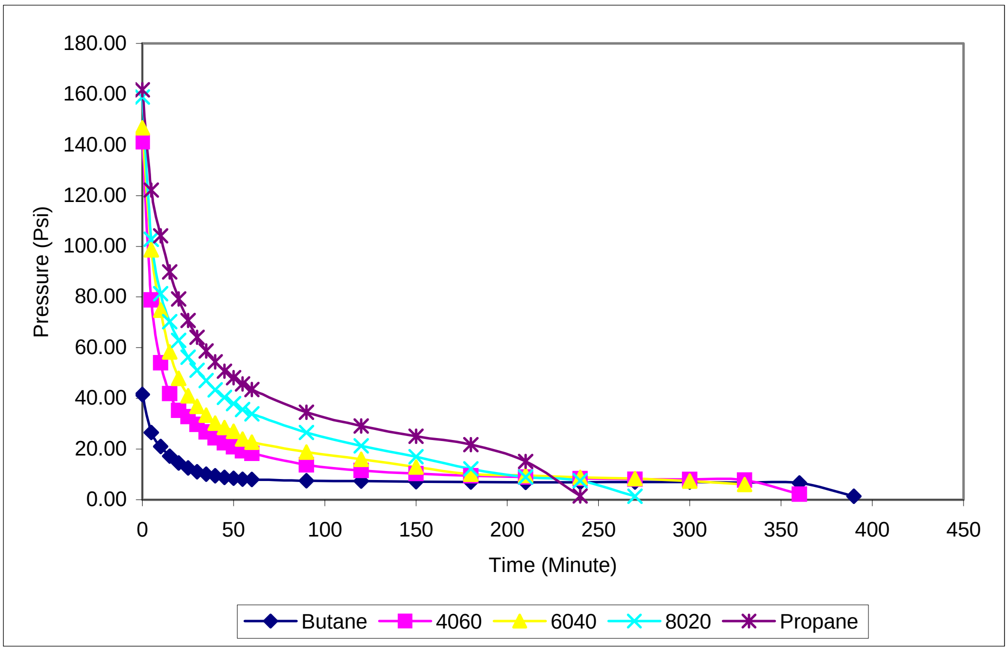

Figure 4.15. Cylinder Pressures of Various Compositions at Flowrate of 48 Liter/Minute and Surrounding Temperature of 30^{o}C

Secondly, at the beginning of the experiment the difference in the rate of pressure fall was proportional to the amount of propane content but with time the rate became smaller at the end of the experiment. For example, for a period of 180 minutes, the pressures recorded were 21.77 psig, 12.21 psig, 10.06 psig, 9.46 psig and 6.99 psig for commercial propane to commercial butane respectively. This showed that for that period, according to kinetic theory, this condition occurred when equal content of propane molecules was present in compositions 8020 and 6040, and in commercial butane and composition 4060. However, the quantity of propane molecules was very high in commercial propane compared to other compositions.

Thirdly, for the period at the end of the experiment, the fall in pressure for compositions 4060 and commercial butane were similar. According to kinetic theory, this condition occurred when the content of propane or butane molecules was equal (Mackay *et al*., 1980). However, the fast period to empty the cylinder was the higher propane content and followed by the lesser propane content. This is because, the higher propane content posed a higher vapor pressure used for transferring phase.

Therefore, the choice of more than 60% content of propane molecules in liquefied petroleum gas is recommended. At that composition, propane molecules will be able to assist in increasing the kinetic energy or pressure of butane molecules that coexist in the cylinder because the characteristics of both in fall of pressure are almost similar. However this is only true for flowrate which is not too high, which is less than $15m^3$/hour since at the higher flowrate the characteristics of fall in pressure in LPG cylinder with 50 kg water capacity were similar for all compositions and surrounding temperatures, except for commercial propane (Zainal, 1994 & Muhammad Noorul Anam, 2002).

4.1.3 Ice Layer Formation

The height of ice layer formed on the outer cylinder wall depended on the level of the liquid in the cylinder. All the height of the ice layer formation is slightly above the liquid level, which is 4 cm to 6 cm. This is due to the distribution of cool temperature (Waite *et al.*, 1983) in the cylinder wall. It means that, the effect of cool temperature distribution will extent up to 6 cm from the liquid level. Figure 4.16 to Figure 4.18 illustrated the ice formation on the cylinder at the condensation, forming and liquefaction stage respectively.

However, the height decreased when the level of the liquid fell but the ice became thicker at the base of the cylinder. The thickness of the ice layer is varied from 1 mm to 2 mm from the top to the bottom part. This was because heat required was from the wetted area and the largest area was at the most bottom part of the cylinder due to the influence

Figure 4.16: The Early Stage of Ice Layer Formation Due to Condensation of Water Vapor

Figure 4.17: Final Stage of Ice Formation Layer

Figure 4.18: Liquefaction of Ice Formation Layer

of gravity on the condensed water (Raj, 1981). The formation of ice on the outer cylinder wall showed that the temperature of the wall was below 0^oC. When temperature of cylinder wall attained 0^oC, this meant that the cylinder did not have the capacity to support the need for vaporization to occur (Turner, 1955 & Thomas *et al*, 1965). However, atmospheric humidity too influences the formation of ice layer (Turner, 1946).

The rate of condensation or ice formation occurs at a faster rate with faster fall in temperature (Waite *et al.*, 1983) in the cylinder wall. This was true with increase in propane content whereby there was an increase in height of ice formed around the cylinder and the thickness of ice at the base. This disturbed the efficiency of heat transfer process between the surrounding and the liquid gas and thus the efficiency of the process of vaporization (Auracher and Marquardt, 2002). Although propane needed less heat theoretically, heat intake was not limited because propane possessed high temperature content and very low boiling point. Therefore any composition with high butane, for example, commercial butane, showed very thin ice formation and sometimes only condensation exist.

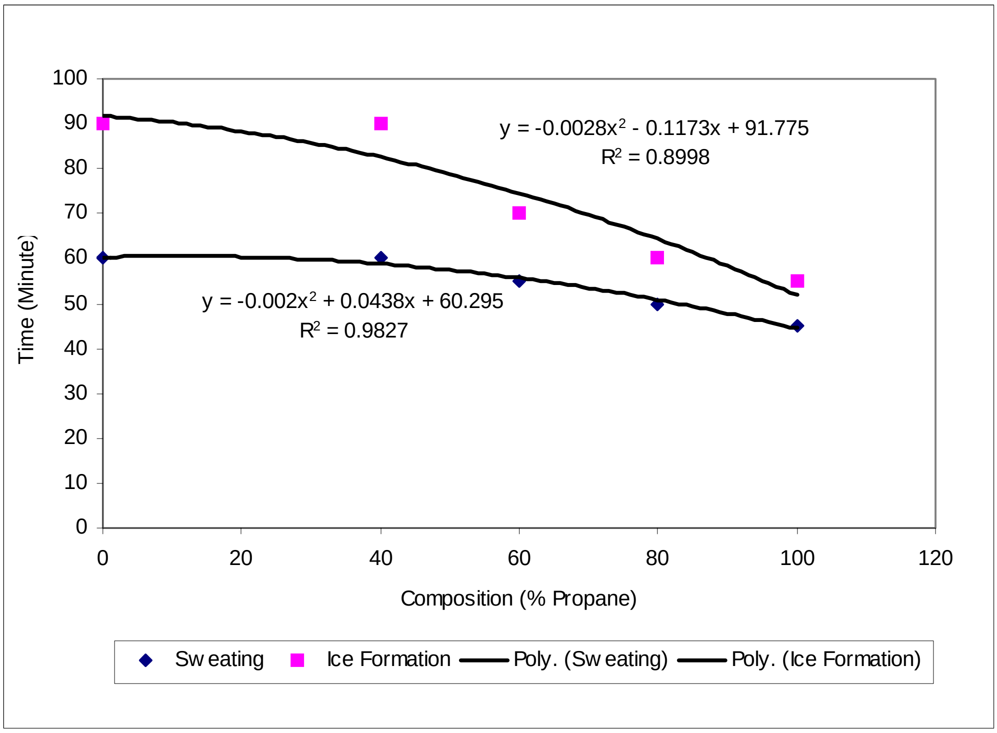

Figure 4.19. Sweating and Ice Formation Layer on the Cylinder Wall for Various Compositions at Flowrate of 48 Liter/Minute and Surrounding Temperature of 30^{o}C

Figure 4.19 illustrated the sweating and ice forming of various compositions at flowrates of 48 liter per minute and surrounding temperature of 30^{o}C. Based on Figure 4.19, there were a few characteristics that can be observed.

Firstly, there existed a non-linear relation ship between the time of sweating and ice forming and composition of Liquefied Petroleum Gas. The fastest time for condensation and ice forming on the cylinder wall was the LPG with higher percentage of propane and the slowest time was with the higher percentage of butane. Secondly, the time required for the ice layer to be formed after condensation also followed the same behavior, which is fastest with the LPG with higher percentage of propane content. This due to the fact that, LPG with higher percentage of propane content is capable to greater fall in temperature level since it has a very low boiling point and evaporation process further exist (Muhammad Noorul anam *et al.*, 1999, Chang and Reid, 1982 & Mackay *et al.*, 1980). In spite of that, the rate of evaporation process was also high with the one of the higher percentage of propane content.

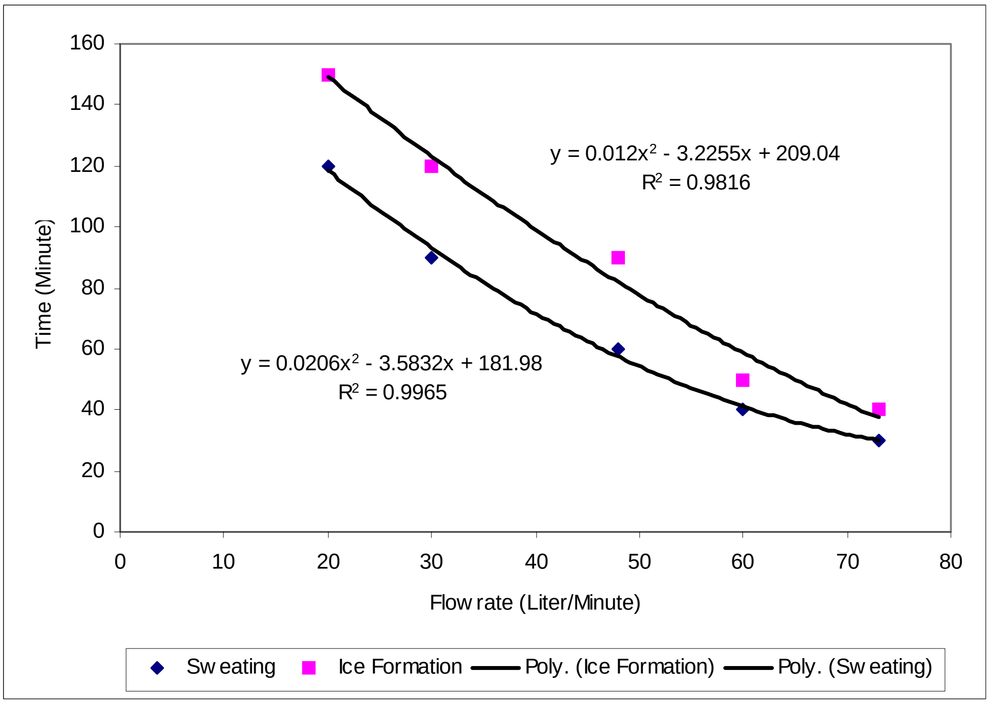

Figure 4.20. Sweating and Ice Formation Layer on the Cylinder Wall for Various Flowrate at Compositions of 4060 and Surrounding Temperature 30°C

Figure 4.20 shows the sweating and ice forming of various flowrates at composition of 4060 and surrounding temperature of 30°C. Based on Figure 4.20, there were a few characteristics that can be observed.

Firstly, there existed a non-linear relation ship between the time of sweating and ice forming and initial setting of discharging flowrate. The fastest time for condensation and ice forming on the cylinder wall was with the higher discharging flowrate. Secondly, the time required for the ice layer to be formed after condensation also followed with the same behavior, which is fastest with the higher discharging flowrate. However, the graph illustrated that, the time to began for condensation and ice layer to form will be constant at the bigger discharging flowrate since the profile of the graph is kept horizontal for further increase in discharging flowrate. This means that, the discharging flowrate need to be estimated in a good manner in order to avoid the problem of ice formation layer (Waite *et al.*, 1983).

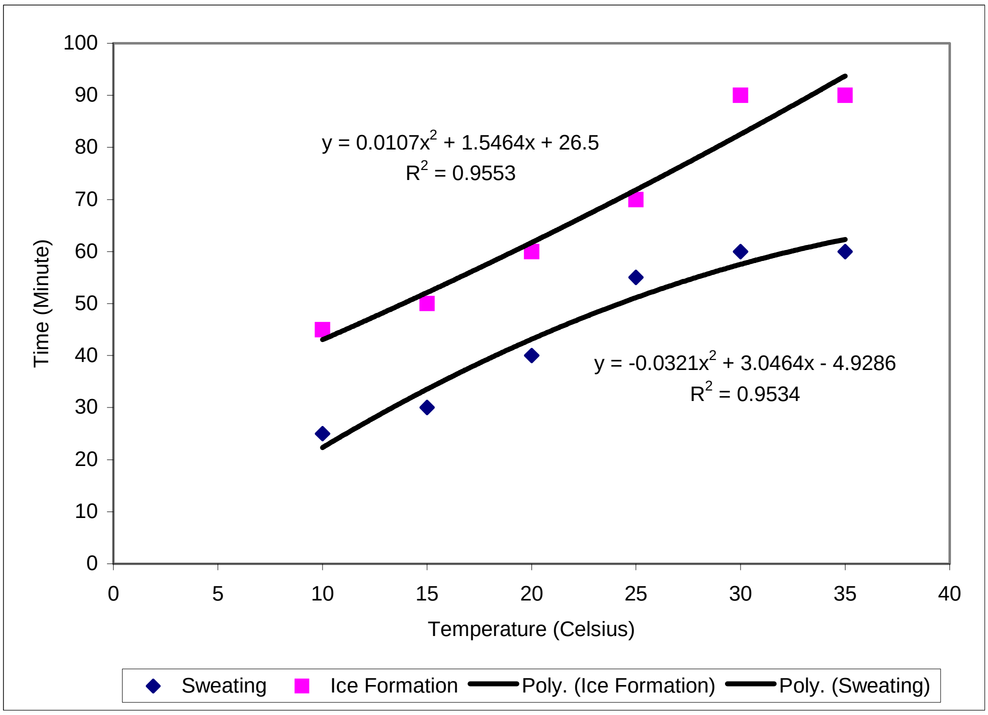

Figure 4.21. Sweating and Ice Formation Layer on the Cylinder Wall for Various Surrounding Temperatures at Flowrate 48 Liter/Minute and Compositions of 4060

Figure 4.21 shows the sweating and ice forming of various surrounding temperatures at flowrates 48 liter per minute and composition of 4060. Based on Figure 4.21, there were a few characteristics that can be observed.

Firstly, there existed a non-linear relation ship between the time of sweating and ice forming and the surrounding temperature. The fastest time was for condensation and ice forming on the cylinder wall with the lowest surrounding temperature. Secondly, the time required for the ice layer to be formed after condensation occurred also followed the same behavior, which is the fastest with the lowest surrounding temperature. However, the graph illustrated that, the period of time for the condensation water to form an ice layer will be constant at the lowest surrounding temperature but at the higher surrounding temperature the period of time became bigger. That means, it shows that at the higher surrounding temperature the problem due to the ice formation layer had reduced.

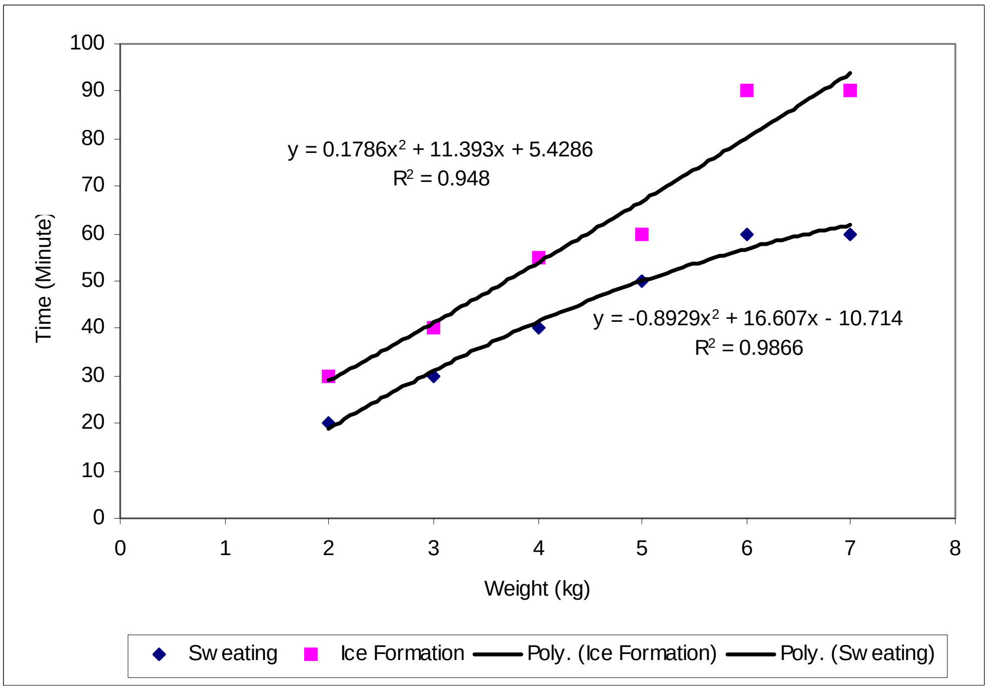

Figure 4.22. Sweating and Ice Formation Layer on the Cylinder Wall for Various Weight at Flowrate 48 Liter/Minute, Compositions of 4060 and Temperatures of 30°C

Figure 4.22 shows the sweating and ice forming of various surrounding temperatures at flowrates 48 liter per minute and composition of 4060. Based on the Figure 4.22, there were a few characteristics that can be observed.

Firstly, there is a non-linear relationship between the time of sweating and ice forming and weight of initial filling. The fastest time for condensation and ice forming on the cylinder wall was with the little weight of initial filling. Secondly, the time required for the ice layer to be formed after condensation also followed the same trend, which is fastest with the little weight of initial filling. However, the graph illustrated that the period of time for the condensation water to form an ice layer will be constant at the small weight of initial filling but at the bigger weight of initial filling the period of time is longer. That means it shows that at the bigger weight of initial filling the problem due to the ice formation had reduced. This is due to the fact that, sensible heat required is enough for the evaporation process for the liquid LPG from the surrounding since the amount of heat is proportional to the wetted area of the vessel or cylinder as well as liquid level (Hisham Supree, 1996 & Normizura Yusof, 1994).

There were a few methods identified to overcome or minimize the forming of the ice layer. The first method is to use a bigger cylinder or increase the number of cylinders by “manifold” installation. Manifold installation can overcome the occurrence or formation of this thickness of ice because the amount of heat was uniformly emitted from each cylinder thus the amount emitted from each cylinder is reduced (Turner, 1955). Although manifold installation can overcome this problem, the responsible authority in the gas industry had implemented regulations that the maximum number of cylinders that can be installed by this system is limited depending on the point of view of safety (Leary, 1980).

The second method is by installing the sheets of metal plates or metal tubes that possessed high heat transfer efficiency. The metals sheets or tubes were installed at the base of the cylinder and arranged accordingly for the most efficient heat transfer (Nor Maizura, 1994 & Wolley, 1980). By this method heat could be transferred to the middle section of the cylinder and the super cooling that occurred could be reduced. Therefore, it is capable to slow down the rate of temperature fall and in turn increases the rate of vaporization.

The third method is by insertion of coil in a spiral shape at the bottom part of the cylinder. By this method, heat from warmer vapor at the top of the cylinder is circulated through the spiral coil that is install at the coolest region (Muhammad Noorul Anam, 2002). The warmer vapor will transfer the heat to the cool liquid by the convection process so that it will minimize the level of temperature fall.

The last method is by insertion of absorbent material like non-woven fabric up to 80% of the cylinder height (Mizuno, 1994). Through this method, liquid LPG will suck up into the vapor phase that possessed a warmer temperature. The warmer temperature at the vapor phase is due to the sensible heat that might be supplied from the surrounding and also heat is not used for the evaporation process so that it will minimize the level of temperature fall.

4.1.4 Composition of Discharging Vapor

Figure 4.23 is an example of the composition of discharged vapors of various filling compositions at flowrates of 48 liter per minute and the surrounding temperature of 30°C. Based on the figure, three characteristics can be observed.

Firstly, the vapor discharged was influenced by the filling compositions where 80/20 showed the largest difference of percentage ratio, followed by compositions 60/40 and the smallest, 40/60. For example, for the period of 60 minutes, the percentage ratio of vapor composition of propane and butane were 100/0, 60/40 and 55/45 for compositions 80/20 to 40/60 respectively.

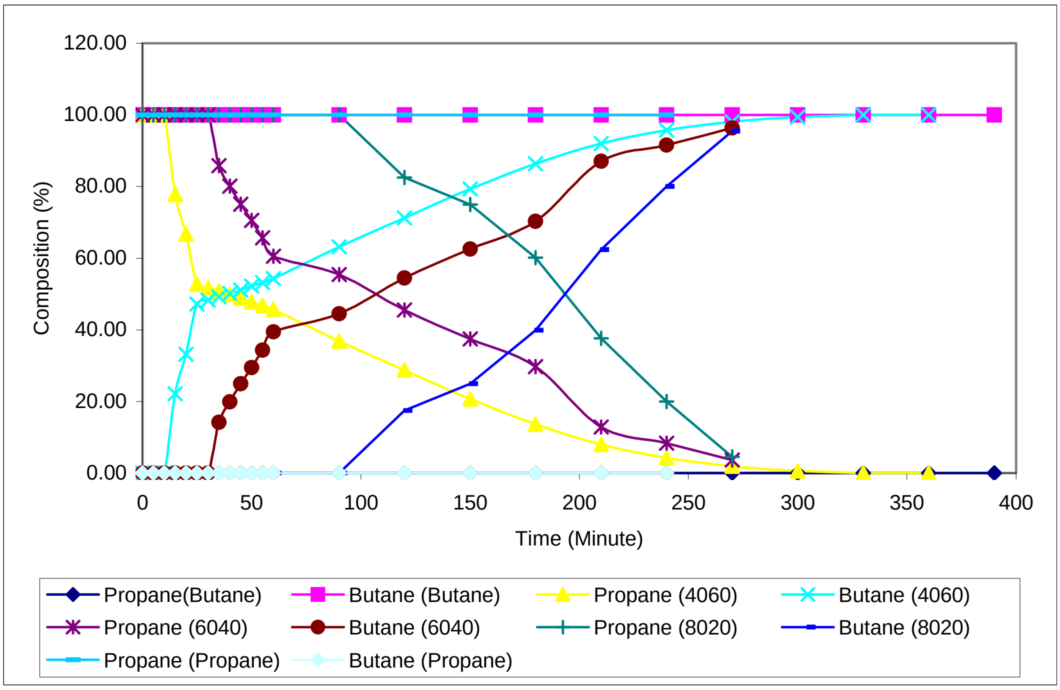

Figure 4.23. The Difference in Vapor Compositions of Various Compositions at Flowrate of 48 Liter/Minute and Surrounding Temperature of 30°C

Secondly, the period of percentage equivalent (the ratio between propane and butane was 50/50) too was according to filling compositions whereby composition 80/20 was the slowest and the fastest, 40/60. The equivalent periods for compositions 80/20 to 40/60 were 190 minutes, 110 minutes and 30 minutes respectively. However, the difference in percentage ratio became smaller after the point of percentage equivalent especially between compositions 60/40 and 40/60. For example, for a period of 210 minutes the percentage ratios were 14/86 and 9/91 for compositions 60/40 and 40/60. In planning to implement a compositional design, the factor of how fast high and low energy molecules could attain percentage equivalent must be considered.

Thirdly, at the initial stage of discharging, there is no butane molecules discharged and the time taken depended on the percentage of propane content. The highest percentage of propane content will take the longest time. This shows that butane molecules would take some time to discharge together with propane molecules.

Fourthly, the line between propane and butane molecules for compositions 80/20 and 6040 was convex while concave for composition 40/60. This gave an early indication that compositions 40/60 were still not able to distribute the energy compared to composition 80/20 and 6040. Other flowrates and surrounding temperatures showed similar behavior as shown in Figures C1 to C6.

4.1.5 Composition of Remaining Liquid

Figure 4.24 is an example of the composition of remaining liquid of various compositions at flowrates of 48 liter per minute and the surrounding temperature of 30^{o}C. Based on the Figure 4.24, two characteristics can be observed.

Firstly, liquid remaining was influenced by the filling compositions where 80/20 showed the largest difference of percentage ratio, followed by compositions 60/40 and the smallest, 40/60. For example, for the period of 60 minutes, the percentage ratio of remaining liquid composition of propane and butane were 68/32, 42/58 and 17/83 for compositions 80/20 to 40/60.

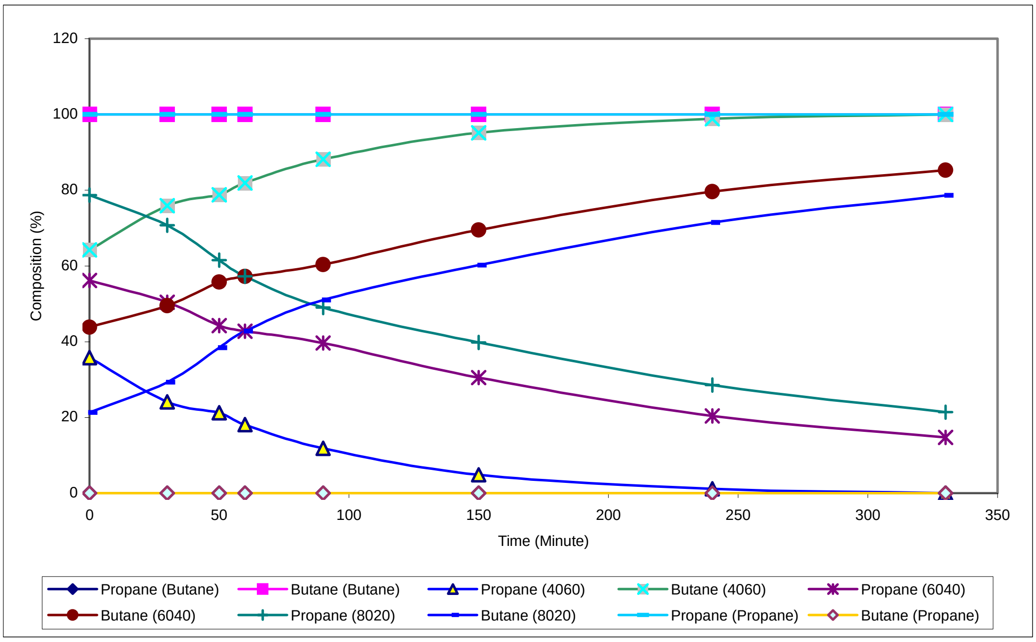

Figure 4.24. The Difference in Liquid Compositions of Various Compositions at Flowrate of 48 Liter/Minute and Surrounding Temperature of 30°C

Secondly, the period of percentage equivalent (the ratio between propane and butane was 50/50) too was according to filling compositions whereby composition 80/20 was the slowest and the fastest was 6040. However, there is no percentage equivalent for the composition 4060 since the percentage of propane is already less than 50 percent. The equivalent periods for compositions 80/20 and 60/40 were 80 minutes and 30 minutes respectively. However, the difference in percentage ratio became smaller after the point of percentage equivalent especially between compositions 8020 and 6040. For example, for a period of 240 minutes the percentage ratios were 28.56/71.44 and 20.42/79.58 for compositions 8020 and 6040.

Based on the result, it shows that the possibility of the optimum design of compositional is 60 percent of propane should be filled up in the liquefied petroleum gas. This was due to the fact that, with the 40 percent of propane remaining in liquid phase, it is too little compared to both two components therefore the driving force is that required to transfer phase is small (Leorenzo *et al.*, 2003). With this result, it proves that the existing composition used in market is insufficient.

4.1.6 Discharging Mass Profile

Figure 4.25 was chosen as an example to illustrate the remaining weight of the various compositions at flowrate 48 liter per minute and the surrounding temperature of 30^{o}C. The characteristics that can be observed based on Figure 4.25 are as follows.

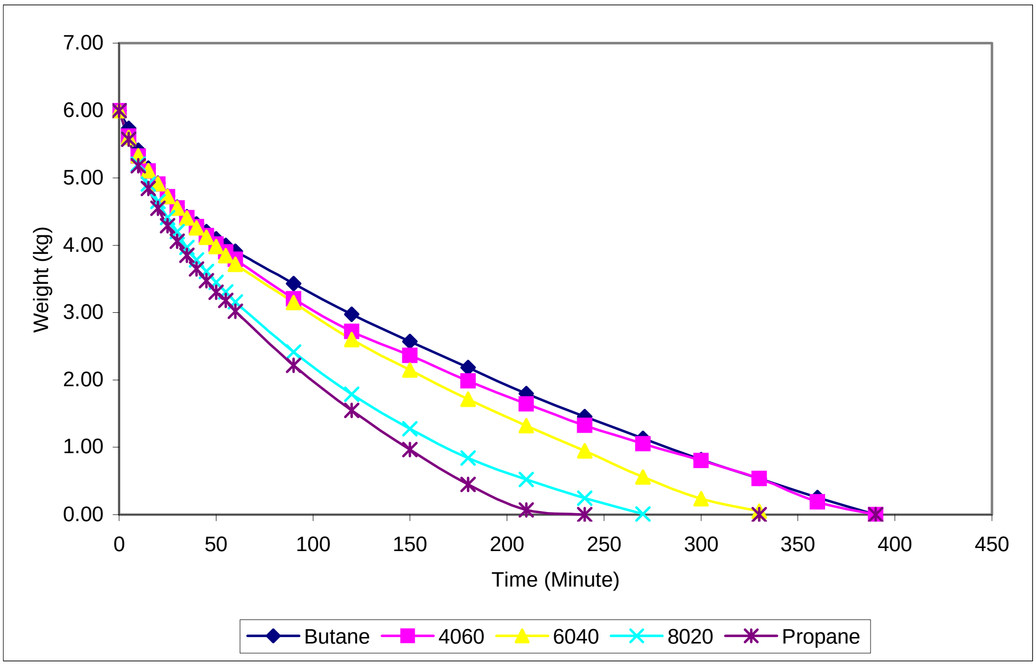

Figure 4.25. Weight Remaining Profile of Various Compositions at Flowrate 48 Liter/Minute and Surrounding Temperature 30^{o}C

Firstly, all compositions showed similar pattern of production. The composition with the largest number of propane molecules showed the highest production, followed by compositions with other percentages of propane and commercial butane with the lowest production. Secondly, the production rate (slope of graph) of composition 40/60 and commercial butane was almost similar on the overall experiment period except at the end of the experiment. Thirdly, the pattern of composition 60/40 is similar to the composition 8020 compared to composition 4060. Fourthly, both compositions 80/20 and commercial propane had similar production rate especially at the end of the experiment period and did not show such sudden decrease in production rate till the end of the production. This characteristic depended on the total propane molecules still available in the cylinder as explained in the previous section, that is the role of propane molecules on pressure. This is because pressure is the main function in the process of mass production (Kwangsam *et al.,* 2004).

Based on the characteristics above, once again an indication that 60 percent or more of propane content must be considered in the planning of compositional design. Other conditions also showed similar behavior as shown in Figures D1 to D9.

4.1.7 Discharging Flowrate Profile

The patterns of fall in flowrate were similar in all experiments in that fall was continuous up to zero. Another thing is that the pattern shown was similar with the pattern shown by pressure fall. Flowrate plotted shows that the fastest fall in pressure occurred at the beginning of gas discharging and the slowest fall at late stage of experiment. This was because at initial stage of discharging, the pressure level is maximum. Therefore, there existed a non-linear relationship between the flowrate and time. Figure 4.26 was chosen as an example to illustrate the flowrate profile of the various compositions at flowrate 48 liter per minute and the surrounding temperature of 30^{o}C. The characteristics that can be observed based on Figure 4.26 are as follows.

Firstly, commercial propane had the highest degree of difficulty in flowrate fall followed with a less degree by compositions with increasingly less propane content. The fastest rate of fall was shown by commercial butane. For example, for a period of 60 minutes, flowrate recorded were 12.2 liter/minute, 11.5 liter/minute, 9.7 liter/minute and 7.8 liter/minute and 6.9 liter/minute for commercial propane to commercial butane.

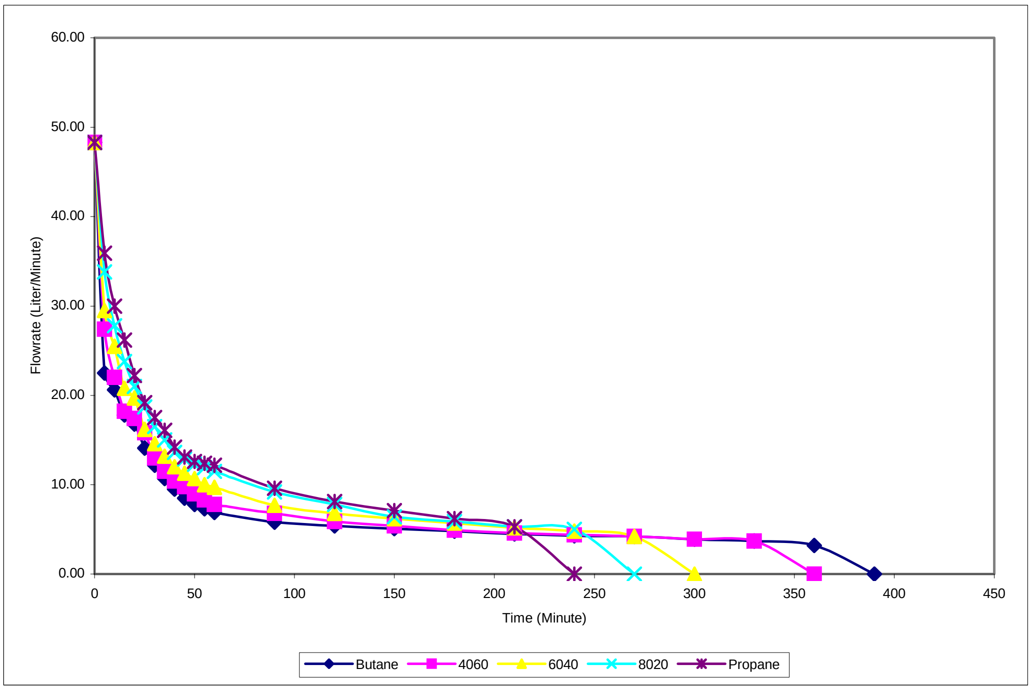

Figure 4.26. Discharging Flowrate Profile of Various Compositions at Flowrate 48 Liter/Minute and Surrounding Temperature 30°C

Secondly, at the beginning of the experiment the difference in the rate of flowrate fall was proportional to the amount of propane content but with time the rate became smaller to the end of experiment. For example, for a period of 210 minutes, the flowrate recorded were 5.3 liter/minute, 5.3 liter/minute, 5.2 liter/minute, 4.6 liter/minute and 4.5 liter/minute for commercial propane to commercial butane. This shows that for that period, according to kinetic theory, this condition occurred when equal content of propane molecules was present in compositions of commercial propane, 8020 and 6040, and in commercial butane and composition 4060.

Thirdly, for the period to the end of the experiment, the fall in flowrate for compositions 4060 and commercial butane were similar. According to kinetic theory, this condition occurred when the content of propane or butane molecules was equal. However, the fast period to empty the cylinder was the higher propane content and followed by the lesser propane content. This is because, the higher propane content poses a higher vapor pressure and have a better chance to escape from the cylinder (Waite *et al.*, 1983).

Therefore, the choice of more than 60% content of propane molecules in liquefied petroleum gas was recommended. At that composition, propane molecules will be able to assist in increasing the kinetic energy or pressure of butane molecules that coexist in the cylinder because the characteristics of both in the fall of flowrate are quite close either to sustain the flowrate level or time to empty the cylinder. Other conditions also showed similar behavior as shown in Figures E1 to E9.

4.1.8 Liquid Level Profile

Figure 4.27 was chosen as an example to illustrate the liquid level of the various compositions at flowrate 48 liter per minute and the surrounding temperature of 30^{o}C. The characteristics that can be observed based on Figure 4.27 are as follows.

Firstly, all compositions showed similar pattern of liquid level in the cylinder. The composition with the largest number of propane molecules showed lowest liquid level, followed by compositions with other percentages of propane and commercial butane with the height liquid level. Secondly, the slope of graph of composition 40/60 and commercial butane was almost similar on the overall experiment period except at the end of the experiment. Thirdly, the pattern of composition 60/40 is similar to the composition 8020 compared to composition 4060. Fourthly, both compositions 80/20 and commercial propane had similar liquid level except at the end of the experiment period. This characteristic depended on the total propane molecules still existed in the cylinder as explained in previous section, that is the role of propane molecules on pressure. This is because pressure is the main function in the process of mass production so that it will influence the liquid level.

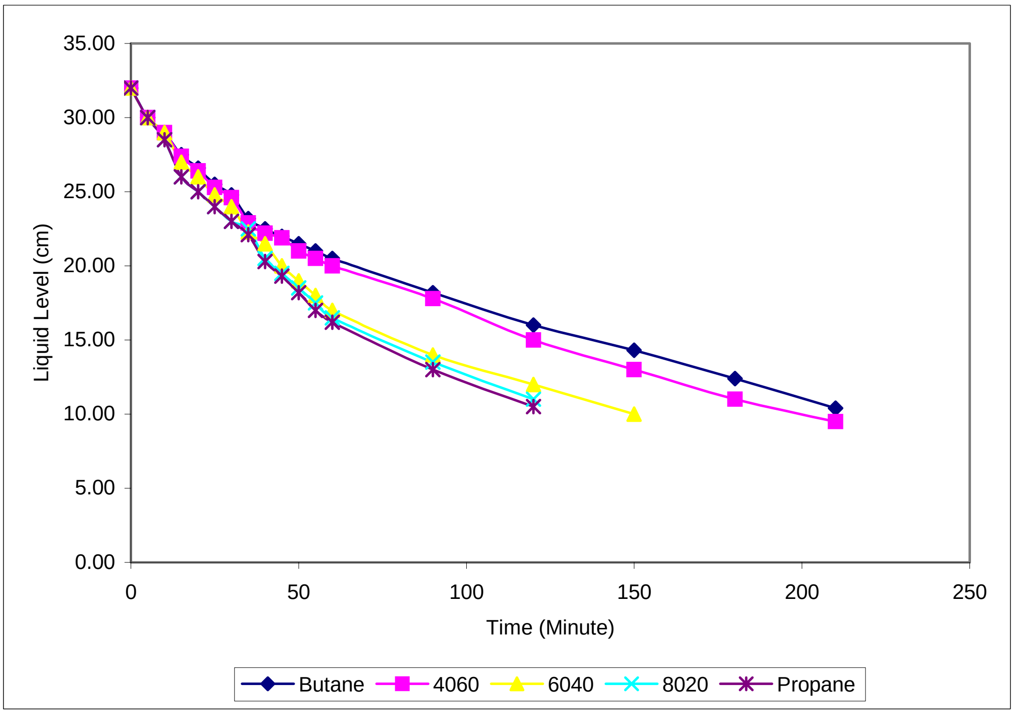

Figure 4.27. Liquid Level Profile of Various Compositions at Flowrate 48 Liter/Minute and Surrounding Temperature 30°C

Based on the characteristics above, once again an indication that 60 percent or more of propane content must be considered in the planning of compositional design. Other conditions also showed similar behavior as shown in Figures F1 to F9.

4.2 Effect of Variation in Flowrate

The flowrate were varied to five values while other parameters such as compositions, initial weight and surrounding temperatures were constant. They were 20 liter/minute, 30 liter /minute, 48 liter/minute, 60 liter/minute and 73 liter/minute.

4.2.1 Temperature Distribution Profile

An example of the influence of flowrate on the fall of temperature at the center of cylinder is as shown in Figure 4.28, with composition of 40/60 and surrounding temperature of 30°C. Based on the Figure 4.28, three important factors can be presented.

Firstly, the higher the flowrate, the larger was the fall in temperature even reaching low temperatures. That means, at flowrate 78 liter per minute, it showed the lowest temperature. However, the temperature readings were almost the same at the flowrate of 70 liter per minute and 60 liter per minute while the difference was so clearly separated for flowrates less than 60 liter per minute. For example, for the period of 150 minutes, the temperatures recorded was -6.70°C, -6.34°C, –3.05°C, 0.32°C and 3.72°C at flowrates 70 liter per minute to 20 liter per minute. Therefore, the optimum flowrate for this cylinder capacity is 60 liter per minute since the amount of heat required to vaporize LPG is influenced by the size of the cylinder (Leary, 1980).

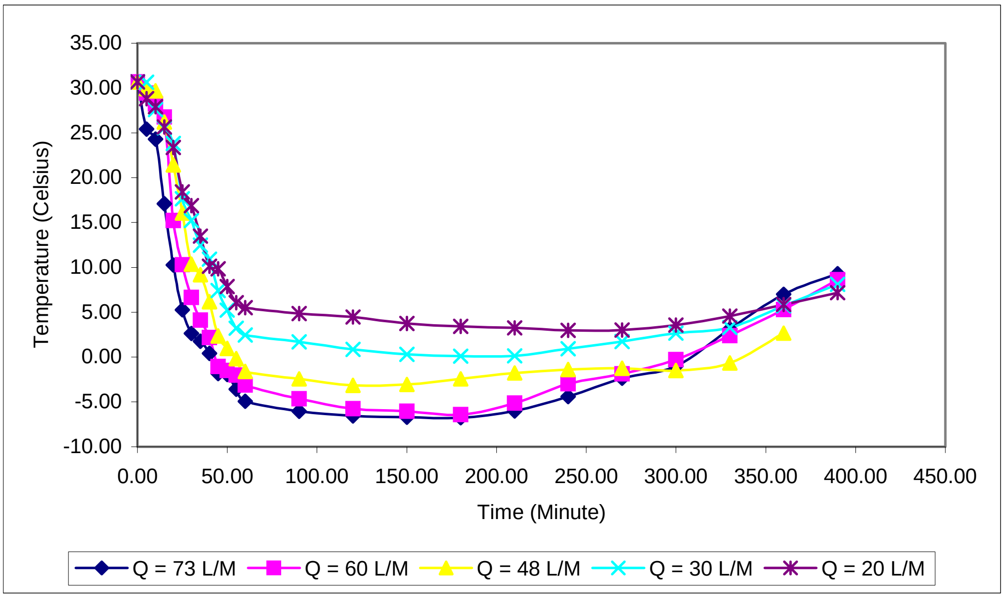

Figure 4.28. Liquid Temperature at Center Sensor for Various Flowrates at Composition 4060 and Surrounding Temperature of 30°C

Secondly, there was a sudden rise in temperature after the thermocouple changed position into the vapor phase. The higher flowrate showed the faster changes in vapor phase and followed by the lesser flowrate. After the change into vapor phase, the increase in temperature at high flowrates was faster. This was different for low flowrates where the rate of decrease and increase in temperature were almost similar. However, as explained, propane possessed a higher heat content compared to butane because more propane content was left in the cylinder at high flowrates compared to at lower flowrates since temperature fall to the most minimum level. High flowrates resulted in more propane molecules being trapped due to extreme cooling. However, low flowrates gave propane and butane molecules more chances to uniformly vaporize from the cylinder and no extreme cooling occurred.

Thirdly, the horizontal line represented the period of phase change of the thermocouple. The thermocouple at low flowrate recorded a longer period of phase change compared to periods at higher flowrate. The difference in the periods of flowrates of 20 liters per minute and 30 liters per minute was very small and might be equal as well as between flowrate of 70 liters per minute and 60 liters per minute. The horizontal period between flowrates of 70 liters per minute to 20 liters per minute were 180 minutes, 200 minutes, 270 minutes, 330 minutes and 330 minutes respectively.

The relationship between flowrate and the horizontal period is a non-linear. This was because at high flowrates, the temperature approaches dew or boiling point temperature faster compared to when at lower flowrates. This resulted in the thickening of the ice formed. With the formation of ice, there was maximum heat intake from the liquid because heat supplied by the surrounding was almost stopped (Kawamura and Mackay, 1987). Therefore, at such conditions, the rate of vaporization was lower compared to that at low flowrates. This is due to the fact that, the faster the cooling rates the smaller the heat flux (Auracher and Marquardt, 2001). At lower flowrates the thickening of ice was not sudden and heat would still be supplied until the liquid level fell below the position of the thermocouple.

The lowest temperature should similarly be recorded by the thermocouple at every flowrate. However, this was not the case since the liquid level at lower flowrates had entered the vapor phase before maximum value was reached which was more gas was discharged compared to at high flowrates. If temperature readings were continuously being recorded in the liquid left in the cylinder, the same readings would eventually be recorded.

Longer period to reach this point will reduce the residue of liquefied petroleum gas. Thus, it is better to use the lower the flowrate is to minimize the left over and for the composition of 4060, the surrounding temperature of 30^{o}C and the initial weight of 6 kg, the optimum design for initial flowrate is 48 liter per minute since the period taken is not too long to empty the cylinder.

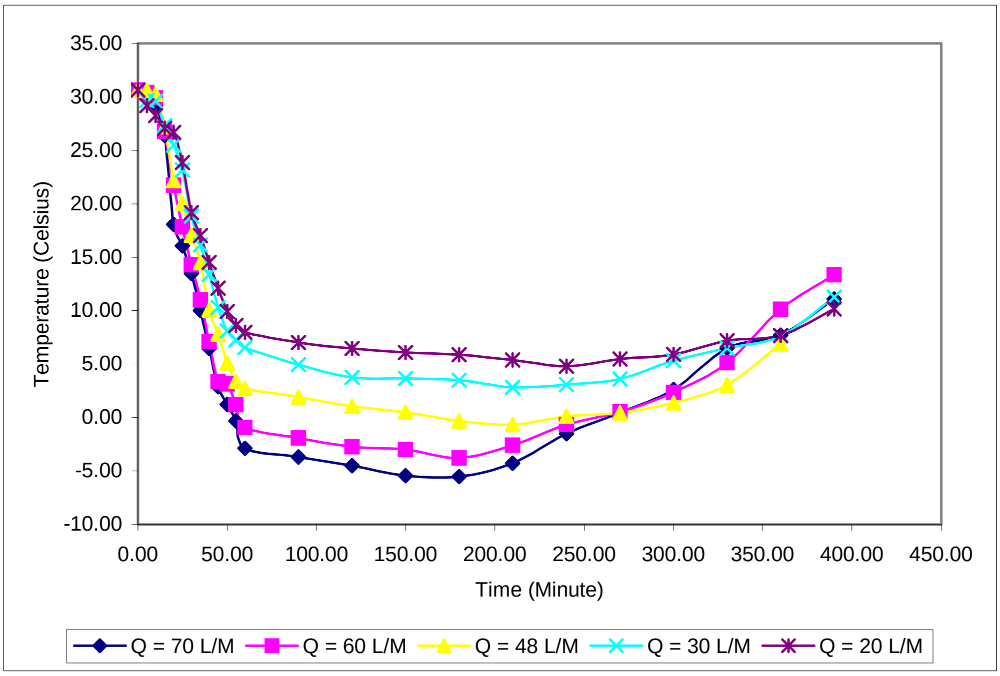

Figure 4.29. Liquid Temperature at Internal Wall for Various Flowrates at Composition 4060 and Surrounding Temperature of 30^{o}C

The pattern of temperature recorded at the internal wall of the cylinder was similar with the sensor located at the center of the cylinder since both sensor were in liquid phase and at the same level as shown in Figure 4.29. However, the pattern of temperature at the external wall of the cylinder was different with the sensor located inside the cylinder as shown in Figure 4.30. Based on Figure 4.30, there were a few characteristics that can be highlighted.

Firstly, at the low flowrate, the temperature decreases until the evaporation stopped or the cylinder was empty of liquefied petroleum gas. However the temperature will increase gradually with increasing flowrate at the end of the evaporation process, which is the fastest change, was flowrate of 70 liters per minute and the slowest was flowrate of 20 liters per minute. Based on this phenomena, which was continuously falling in temperature, it was shown that at low flowrate the heat from surrounding was continuously supplying heat into the cylinder for evaporation process but at higher flowrate the heat used for evaporation was only taken from the liquid itself. This was due to the fact that cylinder wall was surrounded by the ice formation layer (Waite *et al.*, 1983).

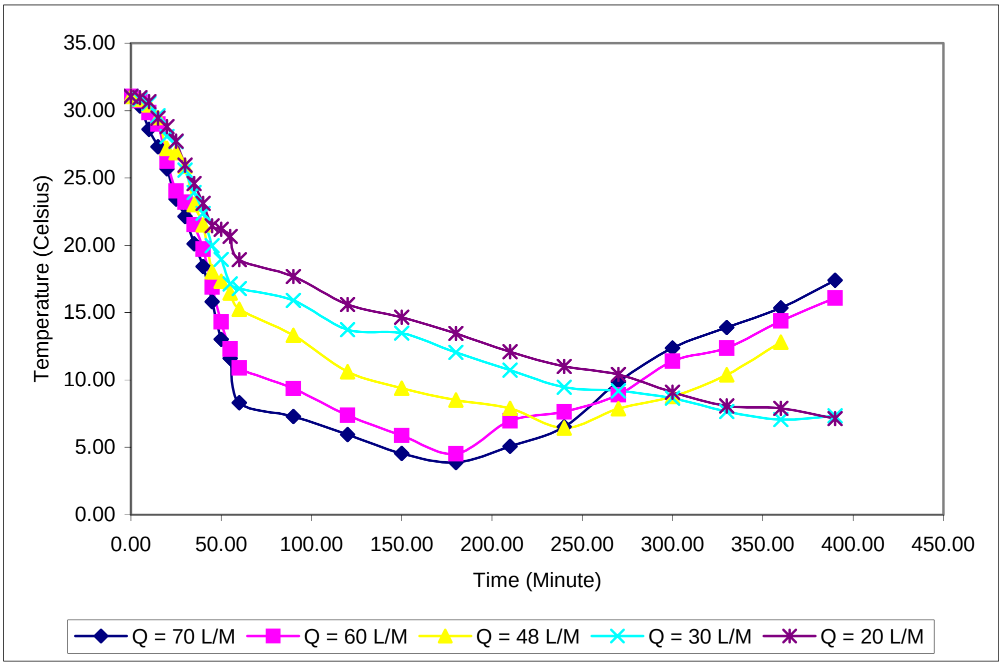

Figure 4.30. Liquid Temperature at External Wall for Various Flowrates at Composition 4060 and Surrounding Temperature of 30^{o}C

Secondly, the temperature at flowrate of 20 liters per minute and 30 liters per minute is quite close as well as at flowrate of 73 liters per minute and 60 liters per minute. It means that, at the designed testing, the most optimum design flowrate is 48 liter per minute. Therefore, the flowrate of more than 60 liters per minute is the maximum and 30 liters per minute is the minimum.

As explained in sub-section 4.1.1, one of the useful methods to analyze heat distribution in cylinder is based on the dimensionless analysis, which is in both directions, axial and radial directions. Through this analysis, the tank thermal behavior will be understood clearly. In order to draw a clear picture on the system, the temperature distribution is illustrated on the basis of axial and radial temperature data. Figure 4.31 shows the temperature profile of centre sensor of the axial direction with effects of variation in flow rate after 10 minutes of discharging period. Based on Figure 4.31, there were a few characteristics that can be observed.

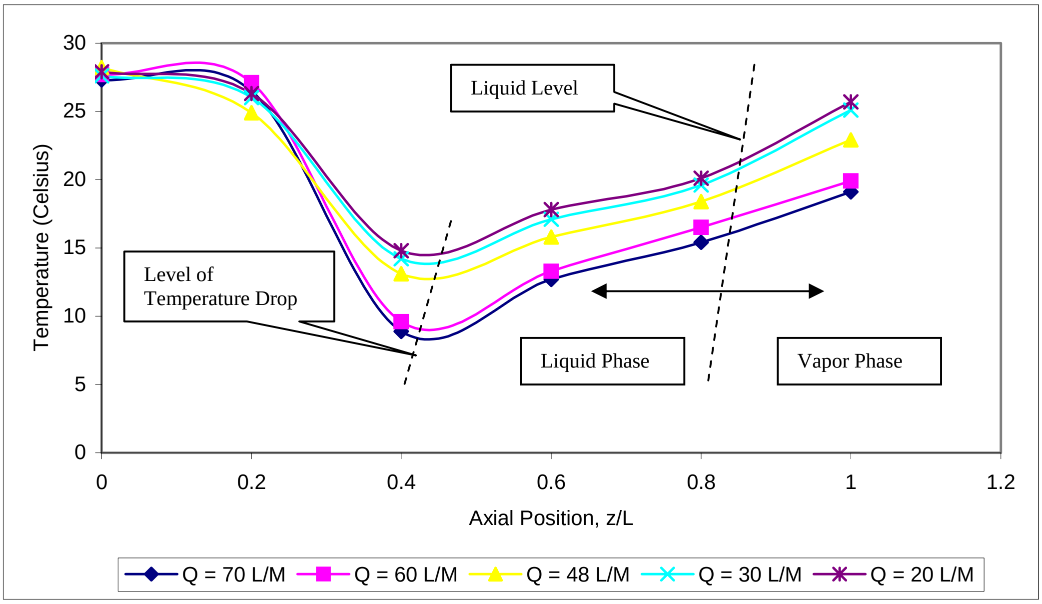

Figure 4.31: Dimensionless Axial Profile of Temperature at 10 Minute at Centre of Various Flow rates at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

Firstly, the higher the flow rate the higher the temperature drop and the sequences of the temperature drop varies from low to high flow rate. However, the rates of temperature drop were not equal with the rate flow rate increments. It shows that, at the period of 10 minutes of discharging, the temperature level of flow rate of 30 liter per minute was quite close with flow rate of 30 liter per minute and flow rate of 60 liter per minute was quite close with flow rate of 70 liter per minute but for the flow rate of 48 liter per minute has more tendency to behave like low flow rate.

Secondly, the reduction of temperature at the period of 10 minutes of discharging was up to 40 to 50 percent of axial direction. Results show that the higher flow rate will influence the lowest level of liquid. However, the influence level of liquid of flow rate of 60 liter per minute is quite close to flow rate of 70 liter per minute meanwhile the low flow rate were also close among each others. It means that, the dominant heat derived as a sensible heat used for evaporation process was by axial direction. Furthermore, the influence of temperature of liquid level was further increased until to the bottom part of the cylinder whenever the discharging process continued as illustrated in Figure 4.32.

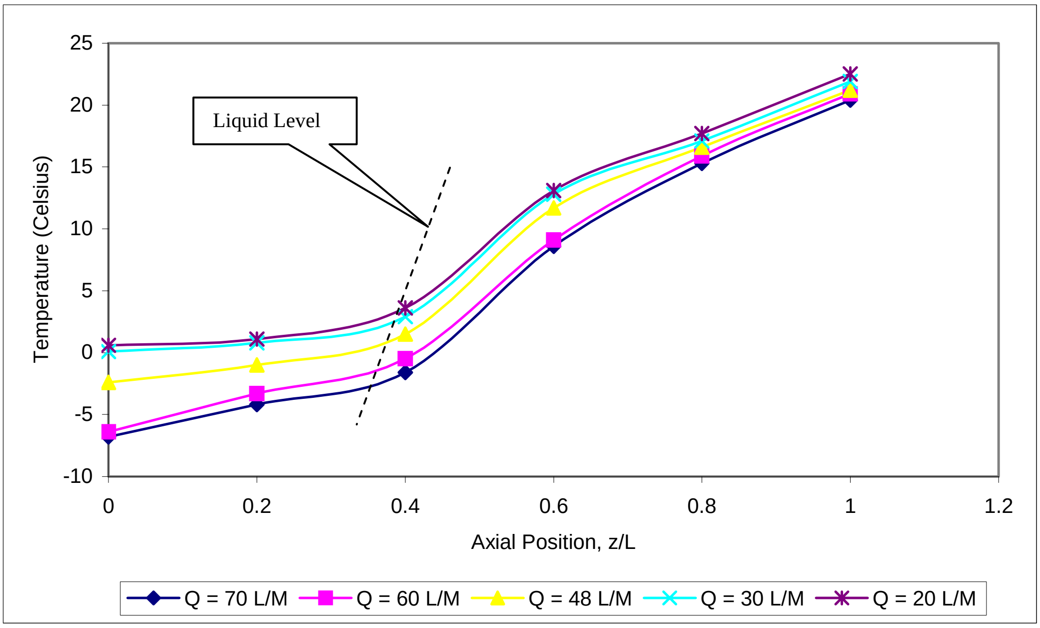

Figure 4.32: Dimensionless Axial Profile of Temperature at 180 Minute at Centre of Various Flow rates at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

Based on Figure 4.32, there were a few characteristics that can be observed. Firstly, at the period of 180 minutes of discharging process, the bottom part of the cylinder was cooled. It means that, the sensible heat was derived from the liquid molecules up to the bottom part of the cylinder and the deriving process will be continued until the evaporation process stopped. In conjunction with that, the liquid temperature will be kept decreasing as the evaporation process further proceeds. This inclination is related to the poor thermal conductivity of the cylinder. High thermal conductivity will show a smaller inclination than for low thermal conductivity. However, the poor conductivity of the cylinder wall presents a large resistance to heat transfer and prevents effective utilization of the energy transfer through the cylinder wall. It is therefore, expected that the profiles would be flat if the heat transfer perform efficiently from the surrounding.

Secondly, the temperature drop in liquid phase of flow rate of 48 liter per minute was slowly moving to the behavior of the higher flow rate compared to the early stage of discharging process. This inclination shows that the relationship between the flow rate and the temperature drop is non-linear. Furthermore, it could be addressed that the optimum flow rate for testing cylinder size was 48 liter per minute since temperature gradient was in the middle, which is the level of the temperature, is not too low.

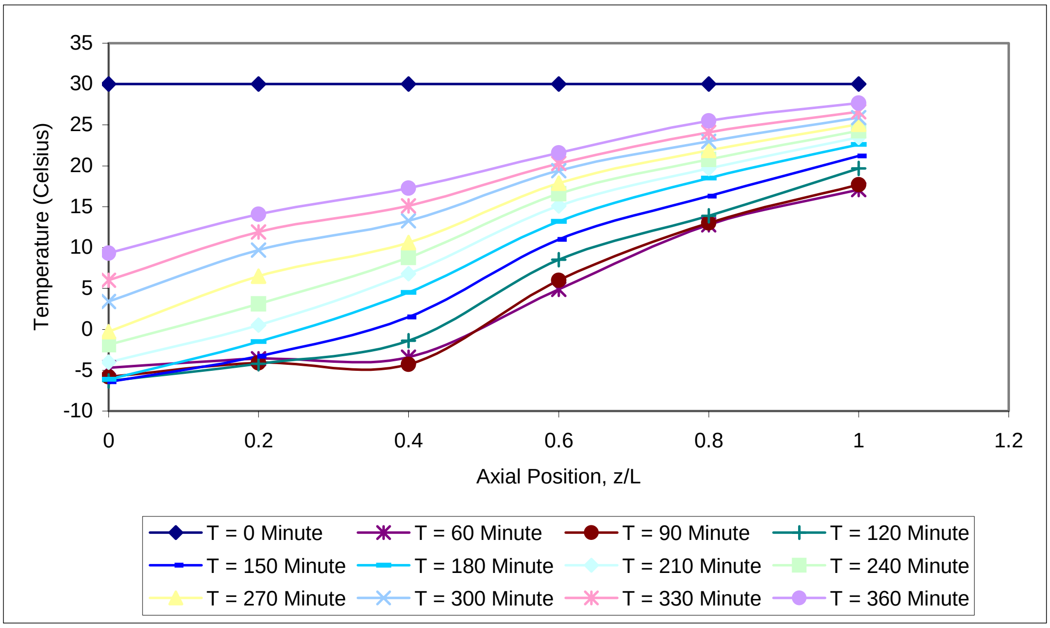

Figure 4.33: Dimensionless Axial Profile of Temperature at Center of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

In all flow rates, it is observed that the behavior of thermal distribution in the cylinder dropped tremendously at the beginning of the discharging compared to the behavior at the end. The behaviors are shown in Figure 4.33 and Figure 4.34 respectively. Based on the both two figures the drop of temperature was tremendous for the first 60 minutes and became smaller towards the end of discharging process.

Figure 4.35 shows that the temperature profile of the sensor at level 6 of radial direction with effect to variation in discharge flow rate after 10 minutes of discharging period. Based on Figure 4.35, the reduction of temperature from external wall to the centre of the cylinder varies from low to high flow rate. However, the reduction of temperature was tremendous from the internal wall to the centre compared from the external wall to the internal wall of the cylinder. This shows that the heat derived as a sensible heat for the evaporation process was not enough from the surrounding. It means that, the sensible heat used for evaporation process was taken mainly at the internal wall so that the heat cannot be distributed into the centre of the cylinder or in other words the heat transfer in the cylinder was occurring in the opposite direction, which is from the centre to the internal wall. This reason was proven through the observation done during the experiment stage since the bubbles detached only occurred at the internal wall. Therefore, the heat was only consumed from the liquid molecules. The higher the flow rate the bigger the heat required for the evaporation process.

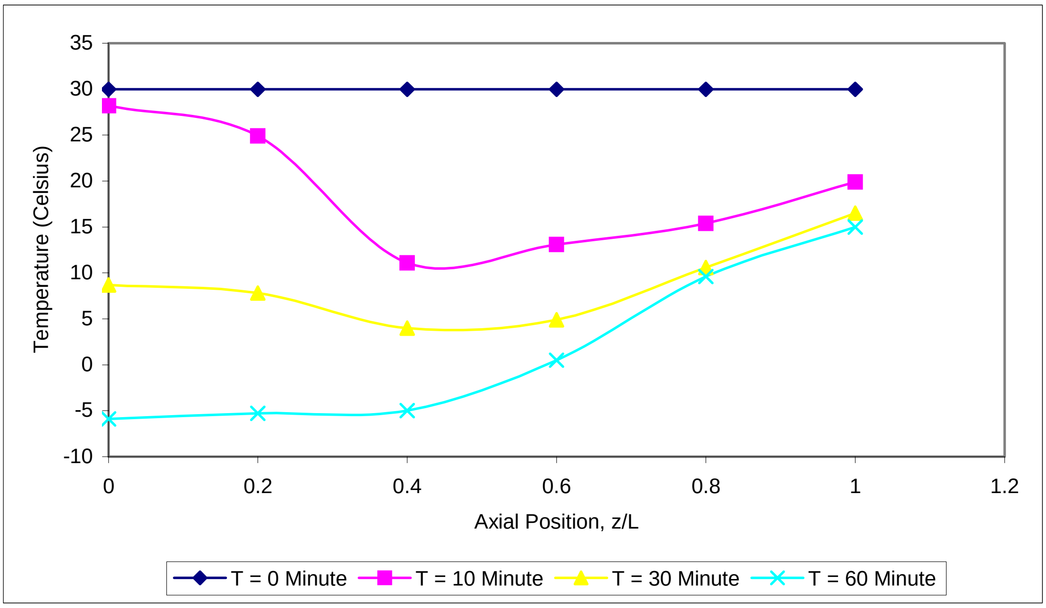

Figure 4.34: Dimensionless Axial Profile of Temperature at Early Stage at Center of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

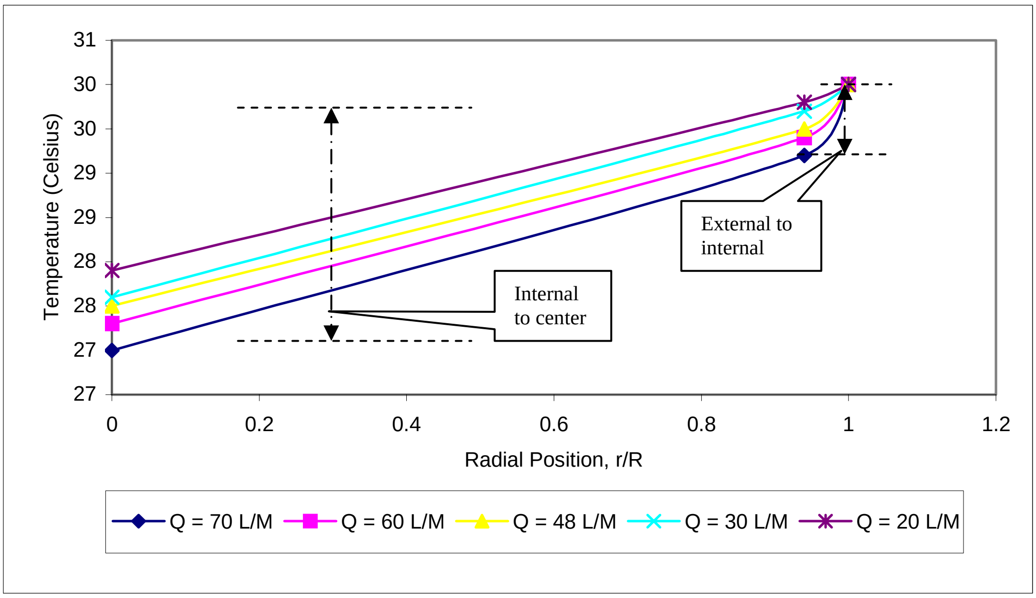

Figure 4.35: Dimensionless Radial Profile of Temperature at Level 6 at 10 Minute of Various Flow rates at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

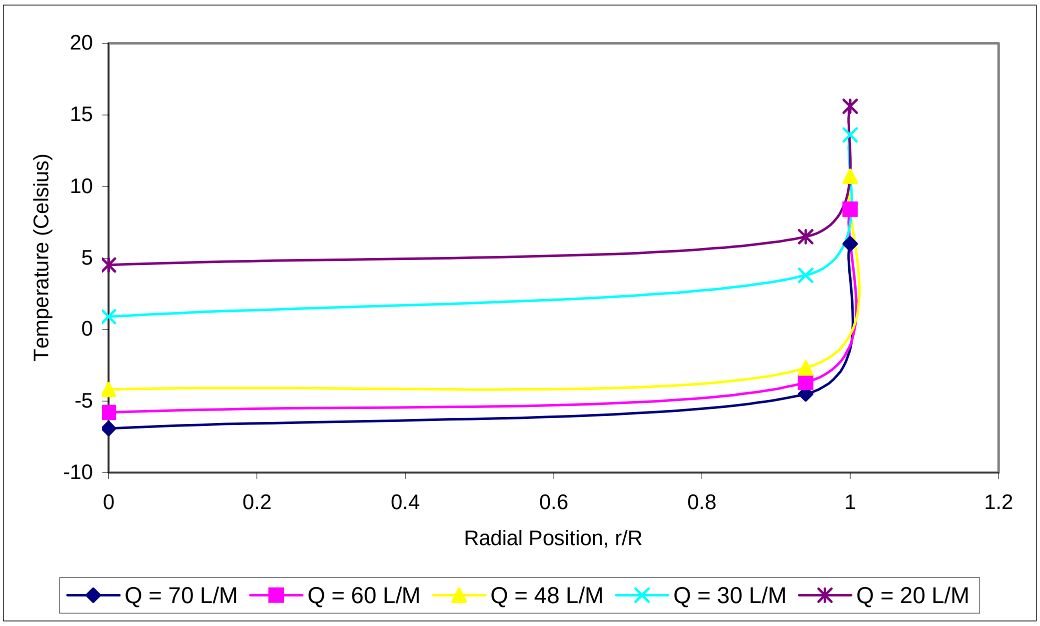

Figure 4.36: Dimensionless Radial Profile of Temperature at Level 6 at 120 Minute of Various Flow rates at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

The pattern of temperature drop became slower in the liquid phase compared with the external wall to the internal wall towards the end of discharging process as shown in

Figure 4.36. It means that, when reached to this period of time the molecules energy at the centre became less and not enough to help liquid molecules at the internal wall to change phase so that the rate of evaporation became slower. With the size of the testing cylinder used, therefore, the optimum flow rate should be less than 48 liters per minute.

Other axial and radial illustrations of all flow rates during discharging process were given in Figure A292 to A387.

4.2.2 Pressure Profile

Figure 4.37 is an example of pressure fall that occurred for composition 4060 at the surrounding temperature of 30^{o}C and at different flowrates. Two important characteristics could be observed based on that figure.

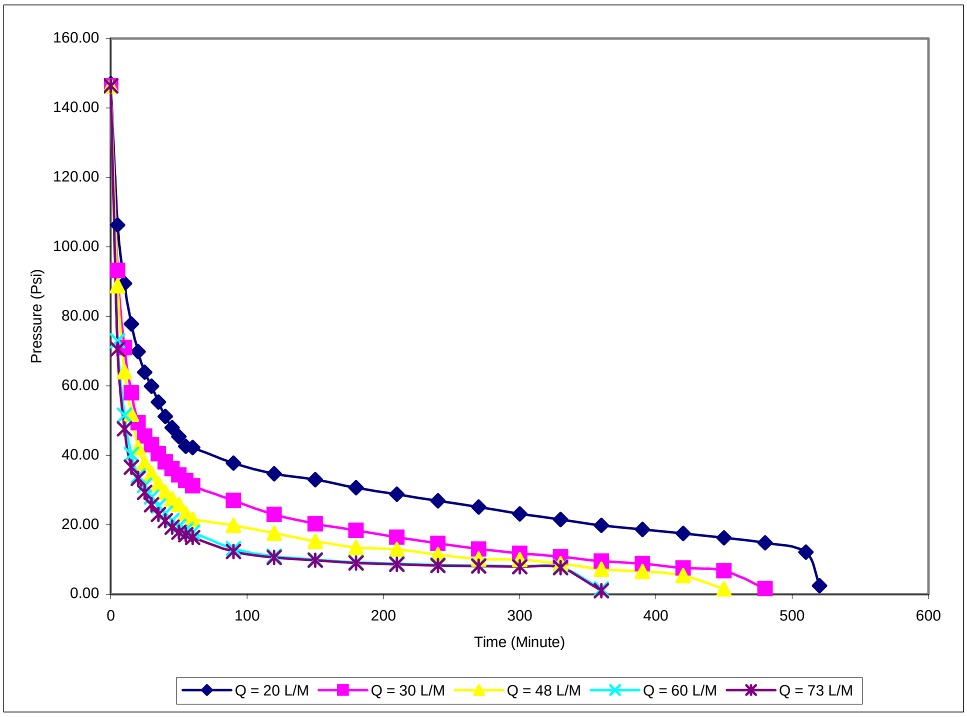

Figure 4.37. The Difference in Pressure Fall for Various Flowrates at Composition 4060 and the Surrounding Temperature of 30^{0}C

Firstly, the higher the flowrate the higher was the fall in pressure and was similar in form to the fall in temperature. This behavior was similar for all compositions and conditions. This was because the higher the flowrate, the greater was the latent heat of vaporization needed for evaporation process as explained in the previous section. Secondly, there was not much difference for flowrate 73 liters per minute and 60 liters per minute but it was very slow for 20 liters per minute.

This means that, at flowrate more than 60 liters per minute, the amount of heat supplied into the cylinder became constant. Therefore, the design of initial flowrate must be related with the cylinder capacity and also the surrounding temperature (Leary, 1980).

4.2.3 Composition of Discharging Vapor

Figure 4.38 is an example of the effect of flowrate on the composition of discharged vapor of composition 4060 at the surrounding temperature of 30^{0}C. Based on Figure 4.38, several characteristics can be observed.

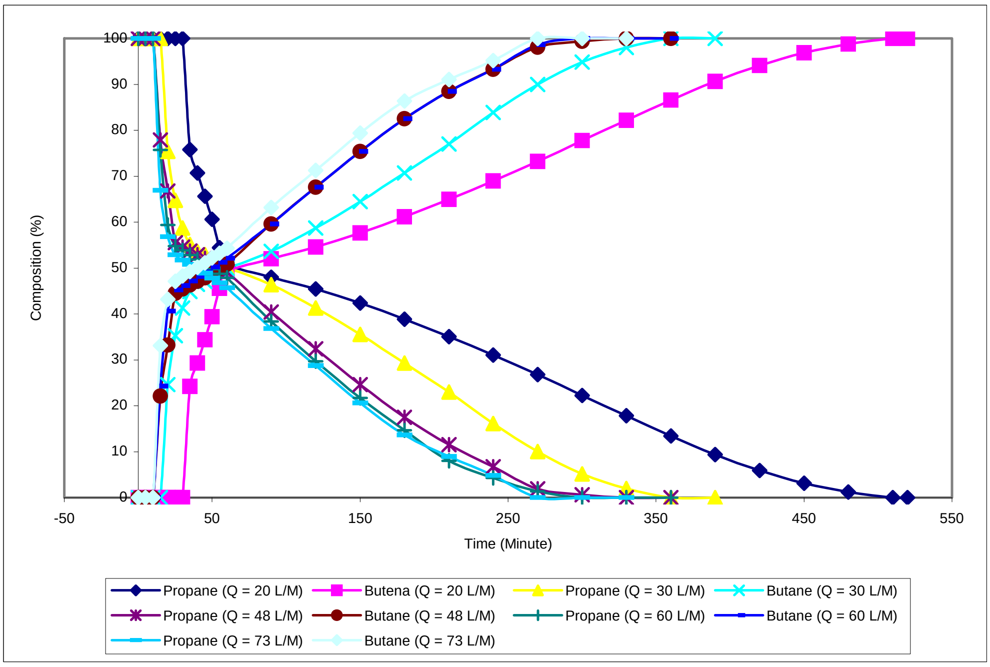

Figure 4.38. The Difference in Vapor Compositions of Various flowrate at Composition 4060 and the Surrounding Temperature of 30^{o}C

Firstly, at all flowrates, the trend of discharge vapor is the same which is at the initial period of discharging all propane component was withdrawn and at the end of the experiment period there were increase and decrease in butane and propane component respectively. Secondly, the flowrates of 73 liters per minute and 60 liters per minute showed an even and almost similar compositional change.

As explained in previous section the temperature fall for both the flowrates did not differ much. Therefore, the maximum flowrate of the system under study is 60 liters per minute and the optimum flowrate is 48 liters per minute. Thirdly, the difference in composition between flowrates of 20 liters per minute, 30 liters per minute and 48 liters per minute became increasingly bigger with time and the difference was only small in the early period of withdrawal. For example, at the period of 60 minutes, the percentage of propane at flowrate from 20 liters per minute to 73 liters per minute was 50.76%, 50.12%, 49.18%, 47.84% and 45.72% while at the period of 270 minutes was 26.77%, 10.05%, 1.87%, 1.37% and 0% respectively.

This was because at high flowrates, the fall in temperature was fast and a large amount of propane and butane molecules were trapped or were not emitted besides a too large production early in the experiment. The researcher predicted that other compositions will show a similar behavior, with almost the same ratios of vapor production percentage for all flowrates. However, the discharging flowrate will be bigger compared to that of other compositions, which is bigger in propane component. The same behavior will be observed if there is an increase in the surrounding temperature. This meant that the propane content of 40% was still unusable although at low flowrates.

4.2.4 Composition of Remaining Liquid

The composition of remaining liquid in the cylinder was related to the composition of discharged vapor. The pattern of the compositions was similar with the composition of discharge vapour, which is if the propane component in the vapor phase is higher then it is higher also in the liquid phase. This is due to the fact that liquid phase act as a supply source to the vapor phase (Conrado and Vesovic, 2000, Stawczyk, 2002 & Durr, 1984). Figure 4.39 is an example of the composition of remaining liquid of the various flowrates at composition 4060 and surrounding temperature of 30°C. Based on the Figure 4.39, three characteristics can be observed.

Firstly, at all flowrate the profile or percentage of remain component in liquid phase was the same, which is propane component, and butane component was being reduced and increased respectively. Secondly, the different amount of component was not in linear relationship between flowrate and percentage of component remaining liquid. It shows that at the flowrate of 48 liters per minute, the system has more tendencies to behave like a bigger flowrate compared to the low flowrate. Thirdly, as highlighted in the components of discharged vapour, since the percentage difference of propane and butane components was quite close for the flowrate of 60 liters per minute and 73 liters per minute so there was nothing much improvement if the flowrate was set higher then 60 liters per minute. It means that, the optimum value of the flowrate for the system under study is 48 liters per minute.

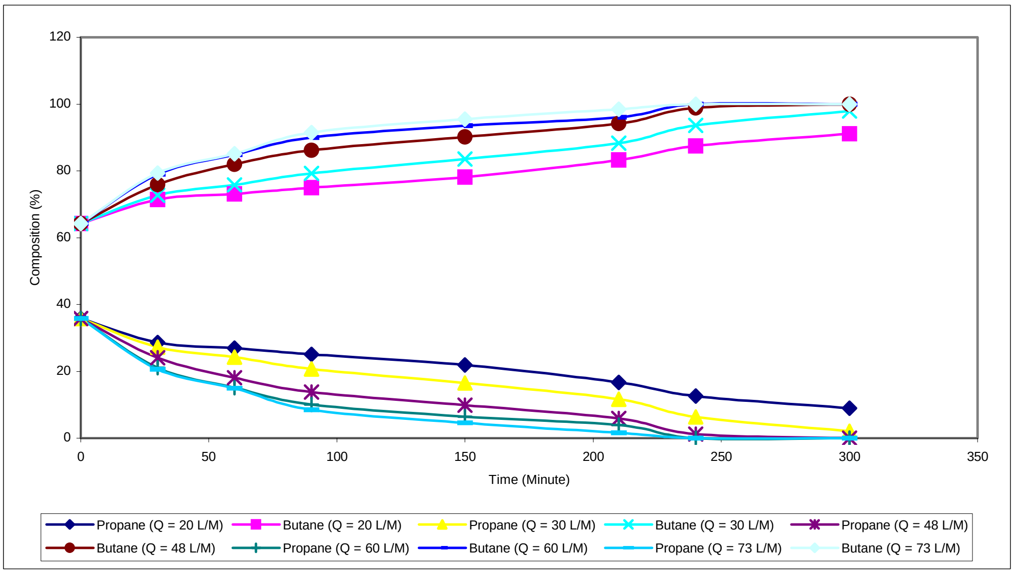

Figure 4.39. The Difference in Liquid Compositions of Various Flowrates at Compositions 4060 and the Surrounding Temperature of 30°C

4.2.5 Discharging Mass Profile

Composition 4060 and surrounding temperature of 30^{o}C were taken as an example to illustrate the influence of the flowrate on the rate of production of mass as shown in Figure 4.40. Based on Figure 4.40, three important characteristics can be elaborated.

Firstly, the higher flowrate showed a high rate of production at the beginning of the experiment but the rate changed abruptly and became similar with the low flowrate after a certain period. Secondly, the mass production for flowrates 73 liters per minute and 60 liters per minute did not differ much. Both these characteristics were due to the effect of temperature fall as explained in previous section.

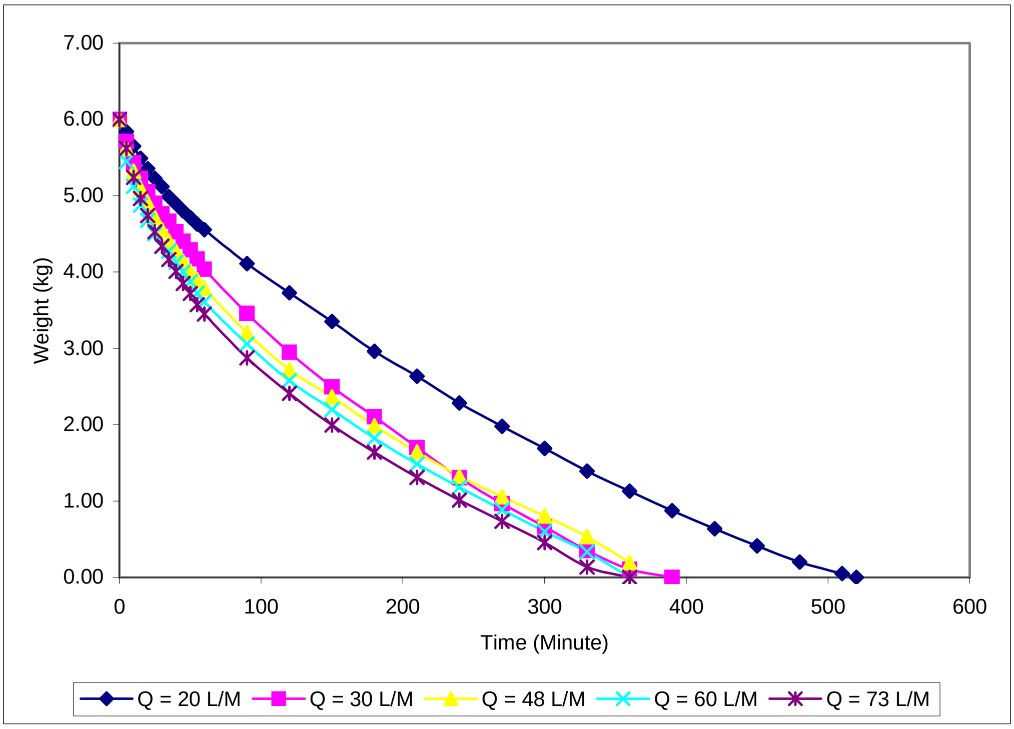

Figure 4.40. Weight Remaining Profile of Various Flowrates at Compositions 4060 and the Surrounding Temperature of 30^{o}C

Thirdly, the time to empty the cylinder was faster at the higher flowrate but the difference of the time period was not proportional to the difference of flowrate. It can be seen that the maximum flowrate for the system under study was 60 liter per minute. However the optimum value of flowrate is 48 liter per minute. Finally, the residue in this conditions was quite small but the variation was according to the value of flowrate which the higher value exist at the higher flowrate (Leary, 1980).

4.2.6 Discharging Flowrate Profile

The patterns of the fall in flowrate were similar in all experiments in that fall was continuous up to zero. Also, the pattern shown was similar with the pattern shown by the pressure fall. Flowrate plotted shows that the fastest fall in flowrate occurred at the beginning of gas discharging and the slowest fall at the later stage of the experiment. This was because at the initial stage of discharging, the pressure level is maximum. Therefore, there is a non-linear relationship between the flowrate and time.

Figure 4.41 illustrated the flowrate profile of the various flowrates at composition 4060 and the surrounding temperature of 30^{o}C. The characteristics that can be observed based on Figure 4.41 are as follows.

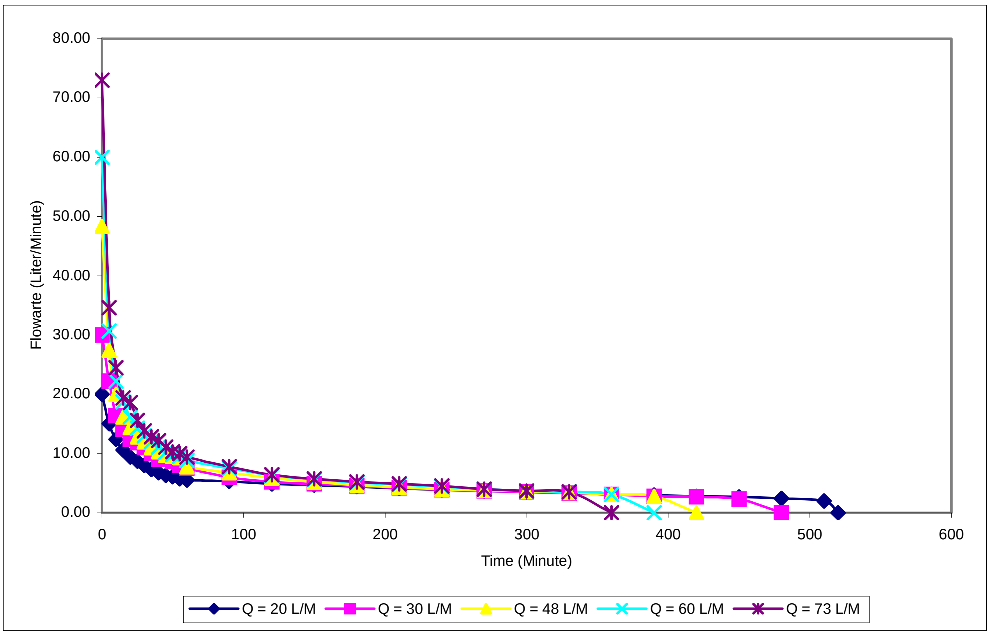

Figure 4.41. Discharging Flowrate Profile of Various Flowrates at Compositions 4060 and Surrounding Temperature 30^{o}C

Firstly, at low flowrates possessed the highest degree of difficulty in flowrate fall followed with a high flowrate which is the fastest rate of fall as shown by the flowrate of 73 liters per minute. For example, for a period of 60 minutes, flowrate recorded were 9.40 liters per minute, 8.80 liters per minute, 7.80 liters per minute, 7.50 liter per minute and 5.10 liters per minute for flowrate of 73 liters per minute to 20 liters per minute respectively. This means that the percentage of reduction of flowrate for that period of time was 87.12 %, 85.33 %, 83.75%, 75.00% and 74.50% for flowrate of 73 liter per minute to 20 liter per minute respectively. Based on those values, the percentage of reduction is almost constant when the flowrate is too high or too low. Therefore, for the system under study, the optimum for the system was 48 liters per minute.
Secondly, at the beginning of the experiment the difference in the rate of flowrate fall was proportional to the set flowrate but with time the rate became smaller to the end of the experiment. For example, for a period of 210 minutes, the flowrate recorded were 4.90 liters per minute, 4.80 liters per minute, 4.30 liters per minute, 4.20 liters per minute and 4.10 liters per minute for flowrate of 73 liters per minute to 20 liters per minute respectively. This showed that for that period, according to kinetic theory, this condition occurred when the liquid temperature or amount of sensible heat was equal for those tested flowrate.

Thirdly, for the period to the end of the experiment, the short period to empty the cylinder was for the higher flowrate and followed by the lower flowrate. However, the difference between the flowrate of 73 liters per minute to flowrate of 48 liters per minute was not big. This was due to the fact that at the higher flowrate the liquid temperature will tend to boiling point faster compared to the lesser flowrate so that at that condition the evaporation rate became minimum. Among those flowrate, the reasonable reduction was the flowrate of 48 liters per minute.

Therefore, the choice of the flowrate of 48 liter per minute for the system under study is recommended. At that flowrate, the liquid temperature or source of sensible heat will be able to assist in increasing the kinetic energy or pressure (Dezellus *et al.*, 2002 & Dick and Timms, 1970) of propane and butane molecules that coexist in the cylinder since the characteristics of fall in flowrate are quite close either to sustain the flowrate level or time to empty the cylinder with the flowrate of 73 liter per minute and 60 liter per minute.

4.2.7 Liquid Level Profile

Figure 4.42 illustrated the liquid level of the various flowrate at composition 4060 and the surrounding temperature of 30°C. The characteristics that can be observed based on Figure 4.42 are as follows.

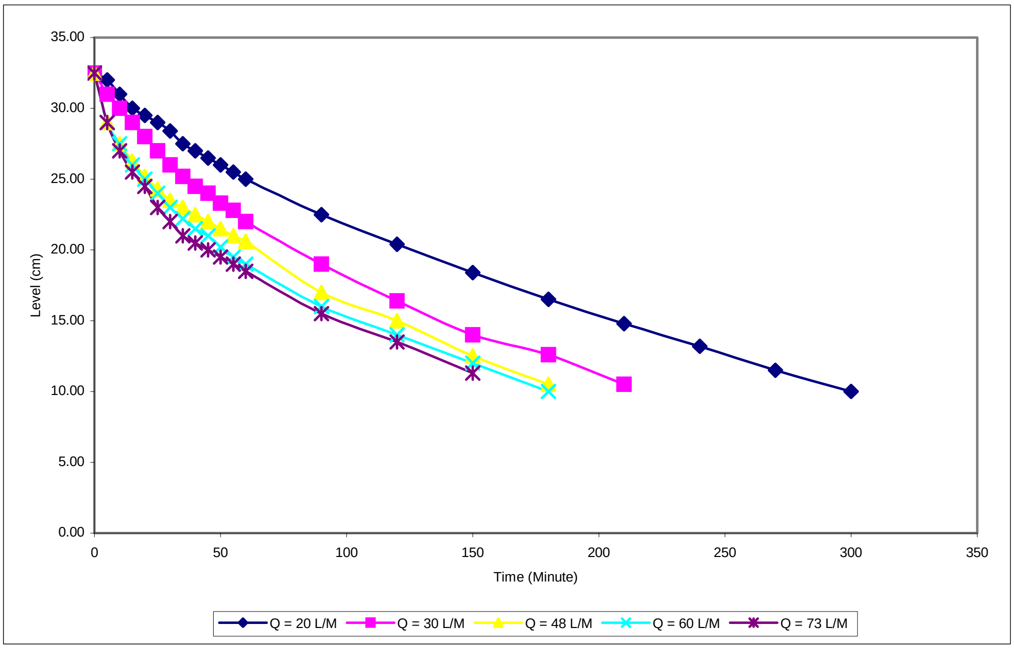

Figure 4.42. Liquid Level Profile of Various Flowrate at Compositions 4060 and Surrounding Temperature 30°C

Firstly, all compositions show similar pattern of liquid level in the cylinder. The liquid level with the largest flowrate show the lowest in liquid level, followed by the lower flowrate. Secondly, the falling slope of the among flowrate of 73 liter per minute to flowrate of 48 liters per minute is almost similar at the initial stage of discharging process except at the end of the experiment. However, the difference between the flowrate of 73 liters per minute and flowrate of 60 liters per minute is not much for the whole period of the experiment. Thirdly, the flowrate of 48 liters per minute has more tendencies to achieve the liquid level of flowrate of 60 liters per minute at the end of the experiment period. This characteristic shows that at the end of the experiment period the amount of liquid sensible heat of flowrate 60 liter per minute and 48 liter per minute is approximately equal so that the rate of evaporation process is also equal. This is because the liquid temperature or amount of sensible heat is proportional to pressure which is the main function in the process of evaporation so that it will influence the liquid level. Based on the above explanation, again the flowrate of 48 liter per minute is the optimum flowrate for the system under study.

4.3 Effect of Variation in Surrounding Temperature

The surrounding temperature are varied i.e. 10^{o}C, 15^{o}C, 20^{o}C, 25^{o}C, 30^{o}C and 35^{o}C. The effects of the surrounding temperature on the fall of the cylinder temperature, pressure, discharge vapor composition, remaining liquid composition and production weight, discharging flowrate and liquid level are discussed in the following sub-chapter.

4.3.1 Temperature Distribution Profile

The difference in temperature fall between the surrounding temperatures of 15^{o}C to 35^{o}C and all tested conditions were clearly seen as shown in Figure 4.43 for the composition of 4060 and flowrate 48 liter per minute which is the temperature profile that happen at the center and the most bottom part of the cylinder. The characteristics that can be observed from the Figure 4.43 are as follows.

Firstly, the lowest temperature was recorded by the lowest surrounding temperature and followed by the higher surrounding temperature. For example, for a period of 60 minutes the liquid temperatures were -14.10^{o}C, -12.55^{o}C, -7.95^{o}C, -4.57^{o}C, -3.14^{o}C and –0.02^{o}C for the surrounding temperature of 10^{o}C to the surrounding temperature of 35^{o}C respectively. This is because at the higher surrounding temperature more heat can be supplied into the cylinder (Shebeko *et al.*, 1995) since the ability of the liquid to wet the surface decreases (Auracher and Marquardt, 2002). Therefore the reduction of liquid temperature during the evaporation process reaches a minimum. That means, at low surrounding temperature, since the supplied heat from the surrounding was limited or small then for liquid to vaporize, the heat is probably derived from the liquid itself (Vai and Chun, 2004).

Another factor that contributes to the level of the surrounding temperature is the possibility of the forming of a layer of ice on the cylinder wall. As we all know, the lower the surrounding temperature the faster and the thicker of the ice layer formed (Shebeko *et al.*, 1995). Therefore, the higher the surrounding temperature the smaller the resistance of the temperature to distribute into the cylinder since the ice layer is one of the bad conductors.

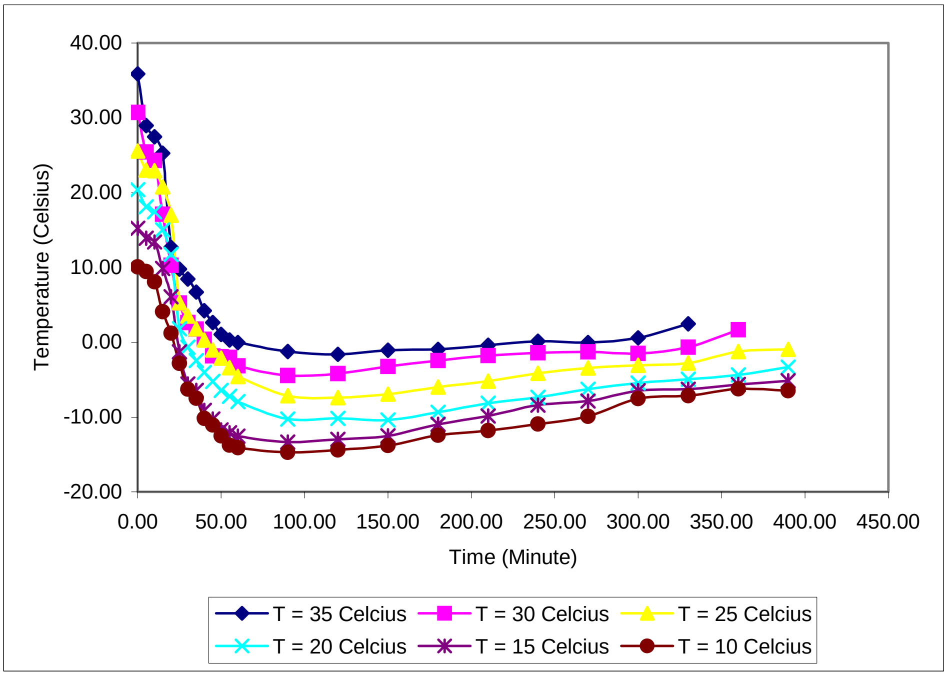

Figure 4.43. Liquid Temperatures at Center for Composition 4060 at Flowrate of 48 Liter Per Minute and at Different Surrounding Temperatures

Secondly, all the surrounding temperature gave an approximately equal differences compared to others starting from the midway to the end period of experiment. However, even though the interval between the surrounding temperatures is 5 degree but the deviation of the temperature recorded are categorized into two groups which is for the surrounding temperature of 25°C, it has tendency to close up to the surrounding temperature of 30°C and 35°C and for the surrounding temperature of 20°C there is a tendency to close up to the temperature of 10 and 15°C. Therefore, the minimum surrounding temperature for LPG in order to minimize reduction of temperature is 25°C. Thirdly, after the occurrence of phase change, the higher surrounding temperature shows faster increase in temperature compared to the lowest surrounding temperature. This is because at higher temperatures, more heat are absorbed by the liquid LPG.

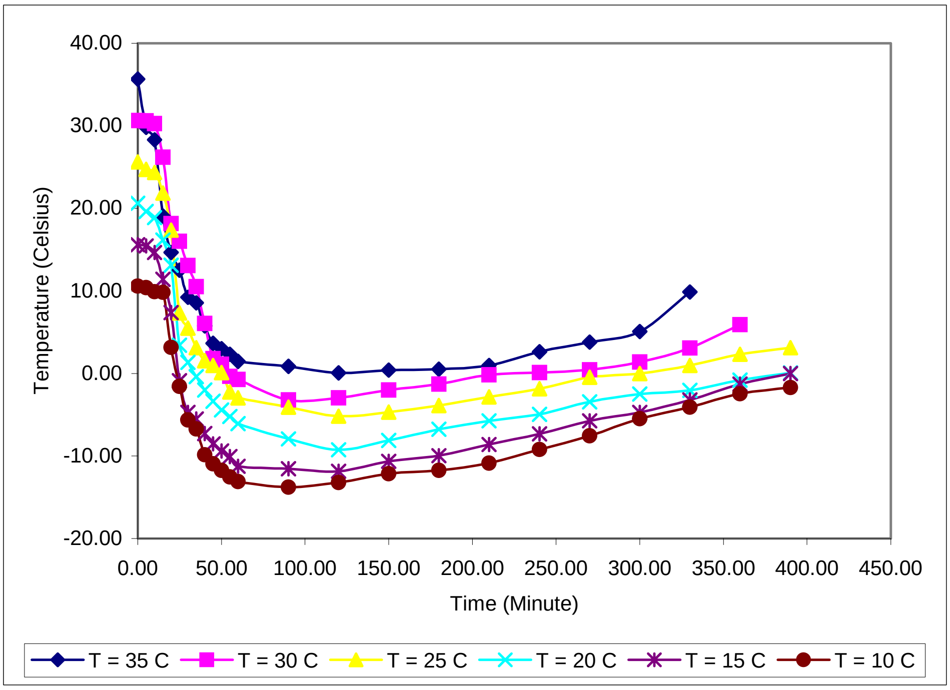

Figure 4.44. Liquid Temperatures at Internal Wall for Composition 4060 at Flowrate of 48 Liter/Minute and at Different SurroundingTemperatures

The pattern of profile of the temperature at the center of the cylinder is also similar with the sensor located at the internal and external wall of the cylinder as shown in Figure 4.44 and Figure 4.45 respectively.

The difference among those figures only the medium of temperature measured since in Figure 4.45, the temperature recorded is not in liquid phase. However, even though the pattern is similar but the differences among the surrounding temperature is quite big compared to the reading recorded in the liquid phase or inside the cylinder. For example, for a period of 60 minute the temperatures are 2.50°C, 3.86°C, 5.62°C, 9.84°C, 15.27°C and 17.13°C for the surrounding temperature of 10°C to surrounding temperature of 35°C respectively.

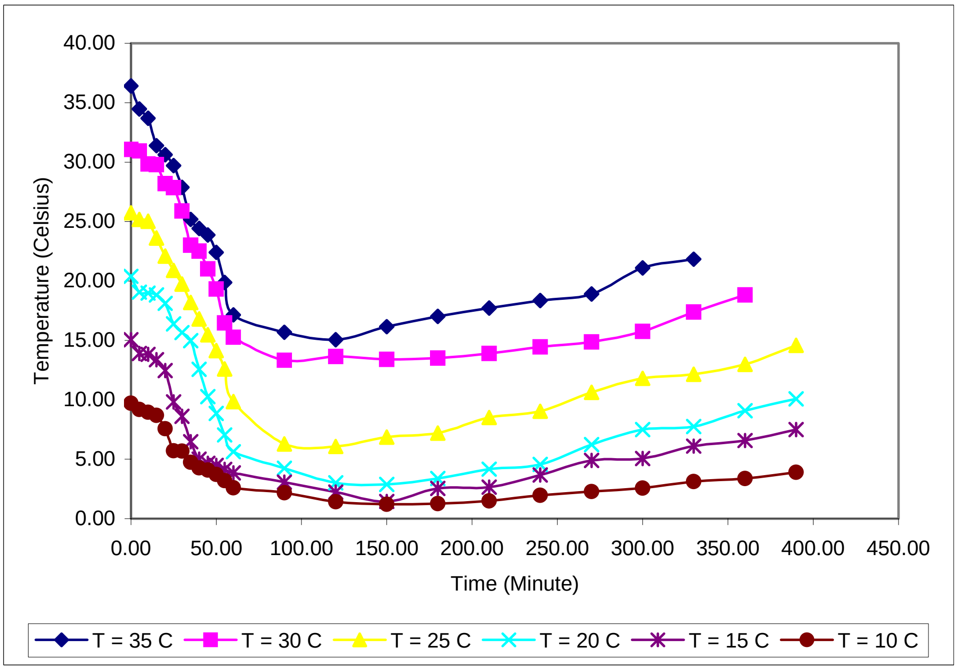

Figure 4.45. Temperatures at External Wall for Composition 4060 at Flowrate of 48 Liter/Minute and at Different Surrounding Temperatures

Furthermore, weather change in Malaysia does not bear any importance on the liquid temperature of liquefied petroleum gas since the lowest Malaysia temperature is always above 25°C (Yue, 1999) except for the highland area such as Genting Highland, Cameron Highland and Frazer Hill.

As previously explained in above sub-section, the dimensionless analysis on the basis of axial and radial temperature data should be discussed in further detail in order to get detail understanding on the tank thermal behavior. Therefore, discussion will start with axial and followed with radial temperature data. Figure 4.46 shows the temperature profile at the centre sensor of axial direction with effect of variation in surrounding temperature after 10 minutes of discharging period. Based on Figure 4.46, there were a few characteristics that can be observed.

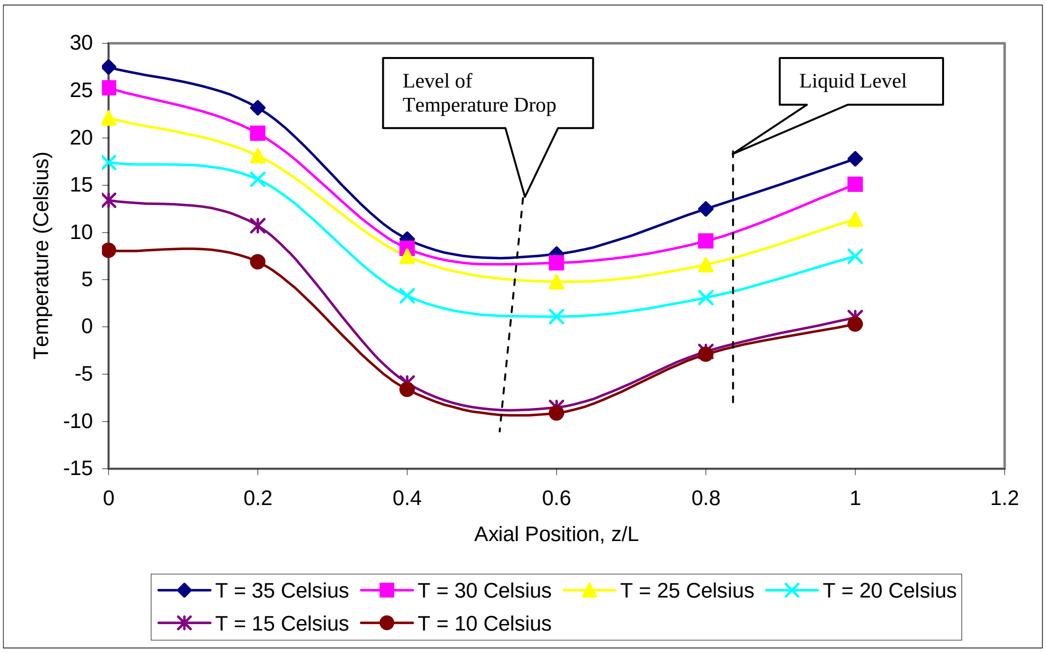

Figure 4.46: Dimensionless Axial Profile of Temperature at 10 Minute at Centre of Various Surrounding Temperatures at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg

Firstly, the higher the surrounding temperature the lower the temperature drop and the sequences of the temperature drop varies from high to low of surrounding temperature level. However, the rates of temperature drop were not equal with the range of surrounding temperature decreases. It shows that, at the period of 10 minutes of discharging, the temperature level of surrounding temperature of 15°C was quite close to the surrounding temperature of 10°C and surrounding temperature of 30°C was quite close to the surrounding temperature of 35°C but the surrounding temperature of 25°C has more tendency to behave like higher surrounding temperature level.

Secondly, the lowest temperature drop among all the surrounding temperatures were occurring at the surrounding temperature of 10°C and the highest was at the surrounding temperature of 35°C and the order of drop was 10°C, 15°C, 20°C, 25°C, 30°C and 35°C. It means that, the higher the surrounding temperature the more heat derived from the liquid molecules for the evaporation process since more heat is supplied into it. Therefore, the tendency for liquid temperature to drop at the higher surrounding temperature is less so that the evaporation process becomes stable.

Thirdly, the reduction of temperature at the period of 10 minutes of discharging was up to 50 to 55 percent at the centre of the cylinder. Results show that the lower the surrounding temperature will influence the most bottom level of liquid level. However, the influence level of liquid of the surrounding temperature of 10°C was quite close to the surrounding temperature of 15°C. Furthermore, the influence of temperature of liquid level was further increased up to the bottom part of the cylinder whenever the discharging process continued as illustrated in Figure 4.47.

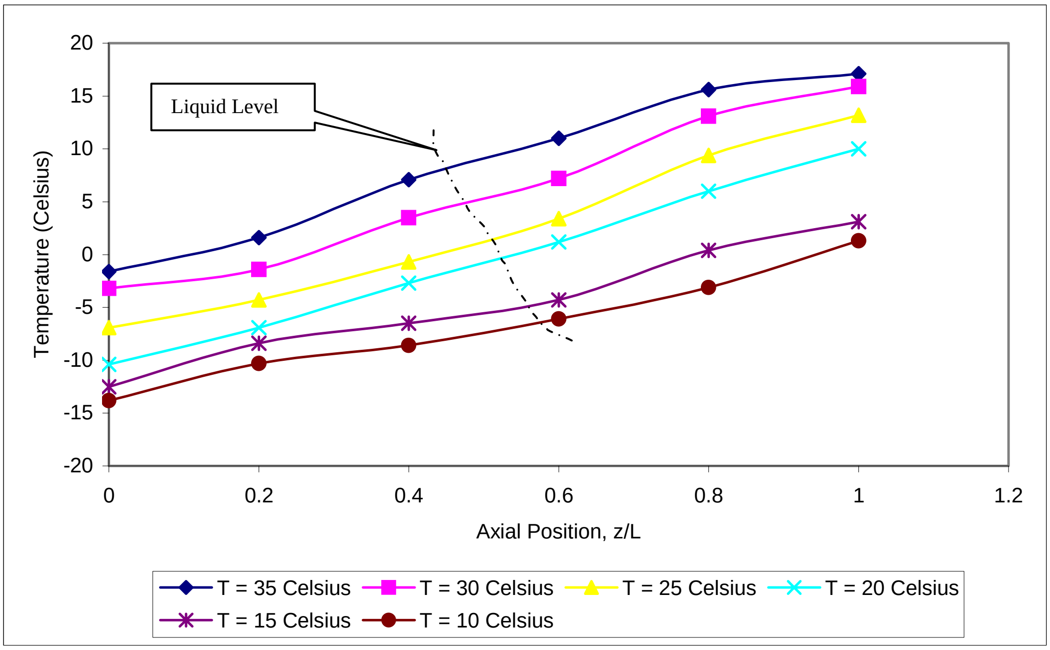

Figure 4.47: Dimensionless Axial Profile of Temperature at 150 Minute at Centre of Various Surrounding Temperatures at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg

Based on Figure 4.47, after the period of discharging reached 150 minutes the whole liquid in the cylinder showed a reduction of temperature for all levels of surrounding temperatures. The pattern of temperature reduction was maintained at early period of discharging which is the lowest surrounding temperature level that showed the lowest temperature level in the cylinder either in liquid or vapor. The average temperature reduction gradient among all surrounding temperatures was quite the same except for the surrounding temperature below 20^{o}C. This is because, some deviation occurred to the surrounding temperature of below 20^{o}C at the level above 40 percent of the cylinder high. The temperature difference towards the bottom part of the cylinder of all the surrounding temperature was smaller. It means that, the possible amount of energy from the bottom liquid molecules to transfer to the liquid molecules at the surface becomes smaller due to insufficient energy available. However, the liquid molecules at the bottom part of the cylinder will be continuously supplying the energy to the liquid molecules at the surface until it reaches its boiling point.

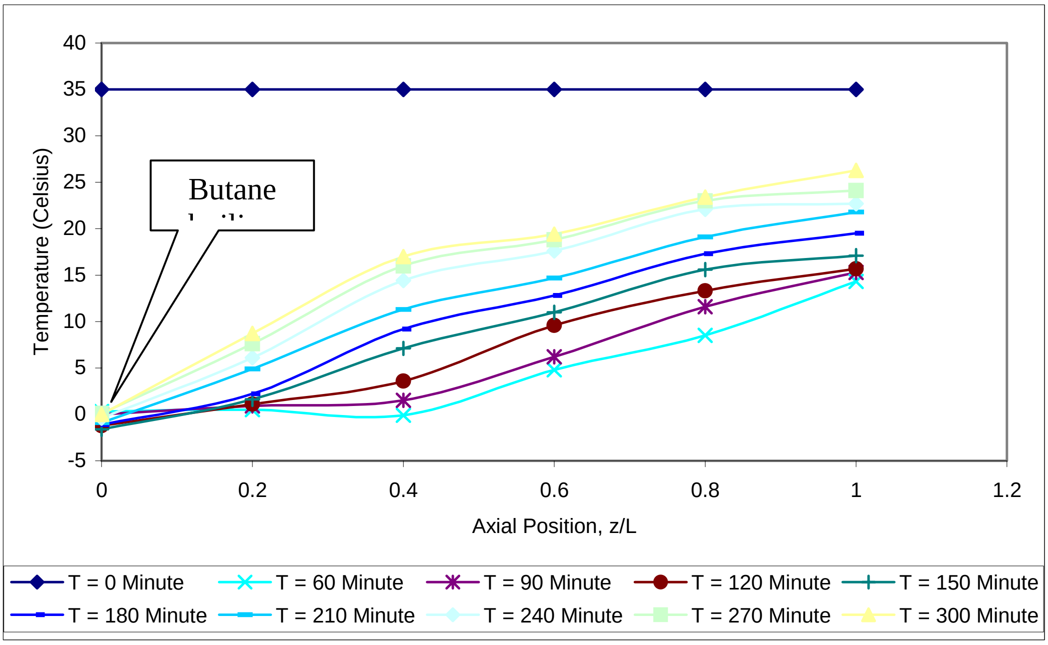

Figure 4.48: Dimensionless Axial Profile of Temperature at Centre of Surrounding Temperature of 35^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg

With reference to the boiling point of propane and butane, it means that butane and propane will stop to vaporize or transfer phase when it reaches the temperature of -0.5^{o}C and –42^{o}C respectively. This was proven as highlighted in Figure 4.48, which is at the bottom part of the cylinder the temperature level was almost close to the boiling point of butane. Therefore, it proves as highlighted in the literature, which is almost the component remaining in cylinder is butane (Badrul Hisham, 1993).

In all surrounding temperatures, it is observed that the behavior of thermal distribution in the cylinder dropped tremendously at the beginning of the discharging process compared towards the end like other tested parameters as explained in sub-section 4.1.1 and 4.2.1.

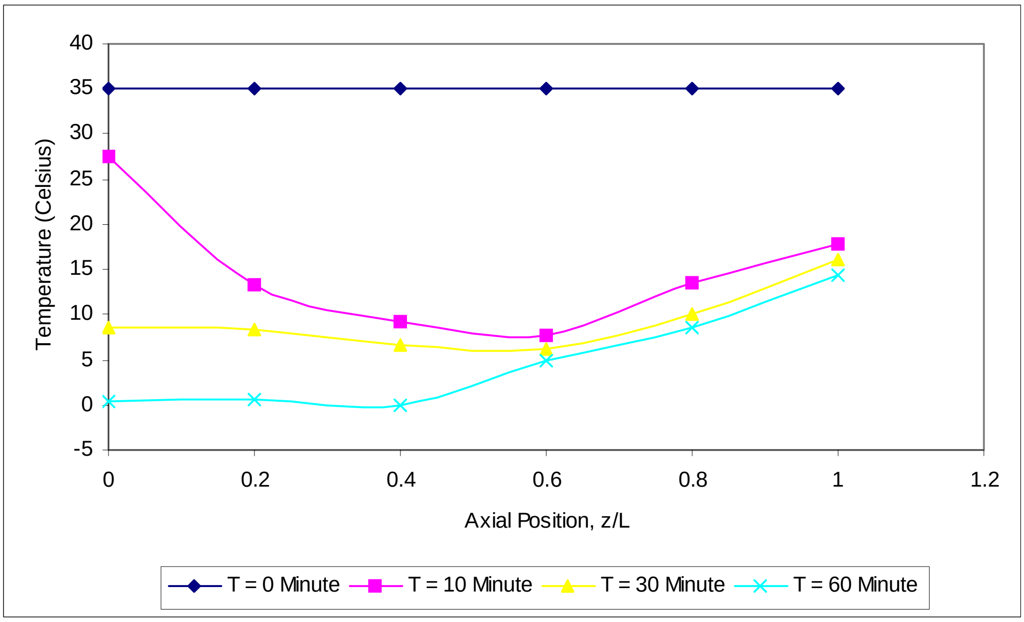

Figure 4.49: Dimensionless Axial Profile of Temperature at Early Stage at Centre of Surrounding Temperature of 35°C Commercial at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg

The behaviors were shown in Figure 4.48 and Figure 4.49 respectively. As explained previously, based on the both figures the drop of temperature was tremendous for the first 60 minutes and became slower towards the end of the discharging process.

Figure 4.50 shows the temperature profile of sensor at level 6 of radial direction with effects to the variation in the surrounding temperatures after 10 minutes of discharging period. Based on Figure 4.50, the reduction of temperature from external wall to the centre of the cylinder varies from low to high of surrounding temperatures. However, the reduction of temperature was tremendous from internal wall to the centre compared from the external wall to the internal wall of the cylinder except for the surrounding temperature of below 20°C. This is because, at the surrounding temperature of below 20°C, the temperature inside the cylinder was stagnant.

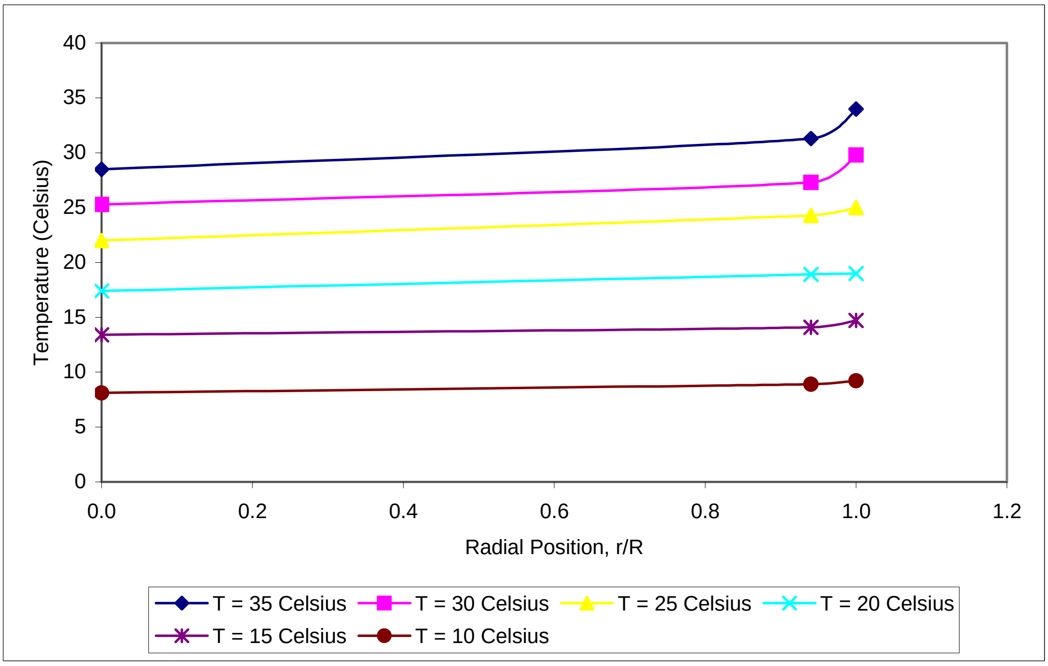

Figure 4.50: Dimensionless Radial Profile of Temperature at Level 6 at 10 Minute of Various Surrounding Temperatures at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg

This shows that the heat derived as sensible heat for the evaporation process was insufficient supplied from the surroundings, therefore, all locations contributed the heat. However, the sensible heat used for the evaporation process at the surrounding temperature of above 20°C was taken mainly at the internal wall so that the heat cannot be distributed into the centre of the cylinder or in other words the heat transfer in the cylinder occurred in opposite direction with is from the centre to the internal wall. Since the additional heat supplied into the centre is almost nil so that the liquid temperature will continuously drop. Therefore, the heat was only consumed from the liquid molecules. The higher the surrounding temperature the bigger the heat supplied by the liquid molecules for the evaporation process. Furthermore, the surrounding temperature of below 20°C should be avoided in order to minimize the problem that is related to the cylinder system.

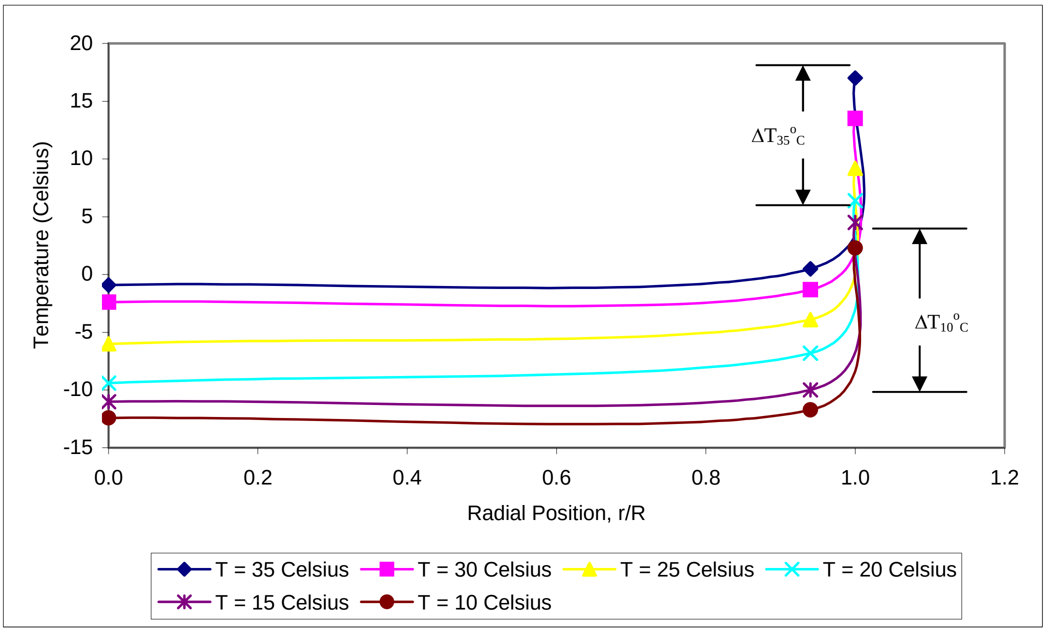

Figure 4.51: Dimensionless Radial Profile of Temperature at Level 6 at 180 Minute of Various Surrounding Temperatures at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg

The pattern of temperature drop was become slower in the liquid phase but increases from external wall to the internal wall towards the end of discharging process as shown in Figure 4.51. It means that, when it reached this period of time the molecules energy at the centre is also less and not enough to help liquid molecules at internal wall to transfer phase so that the rate of evaporation is slower. In other words, the surrounding temperature was not enough to supply heat into the cylinder system even at higher surrounding temperatures. However, the higher the surrounding temperature the lower the temperature drops between the external wall and the internal wall. So that, in the process of evaporation of liquefied petroleum gas in cylinder the most dominant heat was supplied from the liquid molecules itself. With reference to the tested surrounding temperature, therefore, the optimum surrounding temperature should be more than 20^{o}C since it tends to behave like lower surrounding temperature level especially towards the centre of the cylinder.

Other axial and radial illustrations of all flow rates during discharging process were given in Figure A388 to A489.

4.3.2 Pressure Profile

The pattern of fall in pressure were similar for the whole surrounding temperature which is bigger reduction at the early period of discharging and keep gradually decreasing until the end of the experiment as highlighted in sub-section 4.1.2 and 4.2.2. Figure 4.52 illustrates the difference in pressure fall of various surrounding temperature at composition of 4060 and flowrate of 48 liter per minute. Based on Figure 4.52, the biggest difference only occurred after a time period of 0 to 90 minutes. For example, for a period of 90 minutes, the pressures were 1.60 psig, 13.05 psig, 14.02 psig, 16.11 psig, 17.77 psig and 18.97 psig from the surrounding temperatures of 10°C to 35°C respectively, but after that period to the end of experiment, the fall became almost similar or similar. This was because during that period all conditions were close to the boiling or dew point. When this condition occurred, the rate of vaporization would be always similar for surrounding temperatures of 10°C to 35°C.

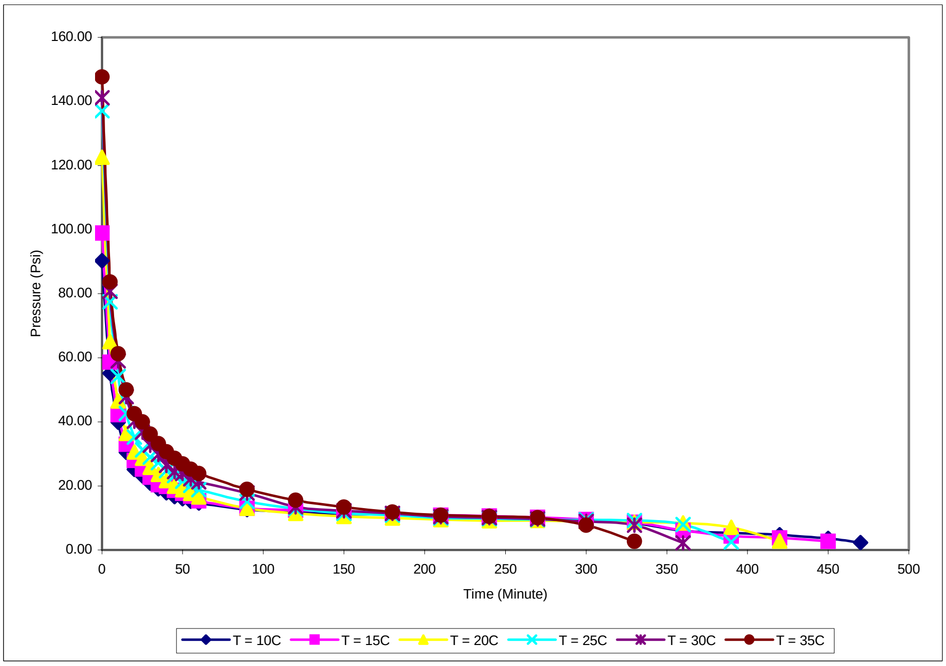

Figure 4.52. The Difference in Cylinder Pressure for Various Surrounding Temperature at Composition 4060 and Flowrate of 48 Liter/Minute

The lowest pressure level was at the surrounding temperature of 10°C and followed by the next higher and will continued to the surrounding temperature of 35°C. However, the difference of pressure fall between the surrounding temperature of 25°C and 30°C was not too obvious or in other word both of them are quite close or similar. Therefore, the weather of Malaysia with a range of above 25°C will result in a similar temperature fall and thus the choice of composition based on this study which is the propane content of 60% or more and flowrate of 48 liters per minute can be practiced or applied.

4.3.3 Composition of Discharging Vapor

The composition of discharging vapor at various surrounding temperature is important since it will influences of the flame or burner characteristics. Therefore based on the experimental result, it is very useful to those people that related to the designing of the gas burner (Wijayatunga and Attaloge, 2002). Figure 4.53 illustrated the effect of the discharging vapor to the various surrounding temperature. Based on Figure 4.53, there were a few characteristics that can be observed.

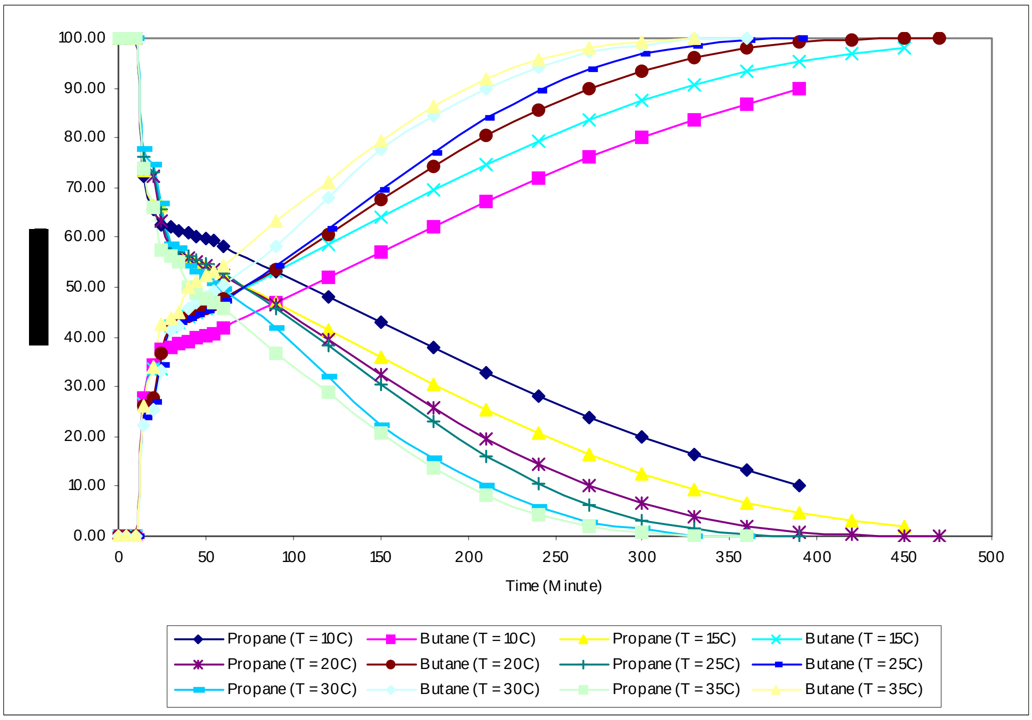

Figure 4.53. The Difference in Vapor Compositions of Various Surrounding Temperatures at Composition 4060 and flowrate 48 Liter/Minute

Firstly, at high temperatures, the production of vapor composition either may it be propane or butane was more but the difference among the surrounding temperature at the early period of time was small. Secondly, the difference in composition of discharged vapour became increase with time of experiment. For example, for a period of 150 minutes, the propane component was 42.89%, 35.90%, 32.58%, 30.34%, 22.45% and 20.64% while for the period of 240 minutes the propane content was 28.14%, 20.57%, 14.57%, 10.38%, 5.88% and 4.25% at surrounding temperature of 10^oC to 35^oC. This showed that temperature stimulated was only shown the influences to the system from the midway to the end of the experiment period since at the early period of time the difference in composition of discharge vapor was quite close.

However, that behavior only valid for the surrounding temperature less than 25^oC since at the higher temperature the differences was quit small. For example, at the surrounding temperature of 30^oC and 35^oC, they were almost the same. In spite of that, the temperature of 25^oC was also more tendencies to get close to the profile of surrounding temperature of 30^oC and 35^oC. Therefore, based on the characteristics above, any change of the weather of Malaysia does not have much influence on the behavior of the composition of discharged vapor. So that, the composition was recommended as the design, which is propane content of 60% or more and flowrate of 48 liters per minute can be practiced to the system under study.

4.3.4 Composition of Remaining Liquid

The composition of the remaining liquid in the cylinder was shown the similar pattern with the influence of variation in composition and flowrate as previously discussed in the sub section 4.1.4 and 4.2.4 respectively. However, the influence of the surrounding temperature into the composition of the remaining liquid was not too obvious since the differences was quite small as illustrated in Figure 4.54 which is the composition of remaining liquid of various surrounding temperature at composition 4060 and flowrates 48 liters per minute.

However, the result shows that the lower the surrounding temperature more propane or butane component remains in the cylinder. For example, at the initial stage of the experiment, which is the system in equilibrium, the propane component was 35.11%, 34.55%, 34.05%, 33.83%, 33.76% and 33.09% respectively for the surrounding temperature of 10°C to 35°C. The result of the surrounding temperature of 20°C to 35°C were really close through out the period of discharging process except for the surrounding temperature of 20°C since there was a slight deviation. Therefore, the minimum surrounding temperature for the LPG to behave as at the higher temperature was 25°C.

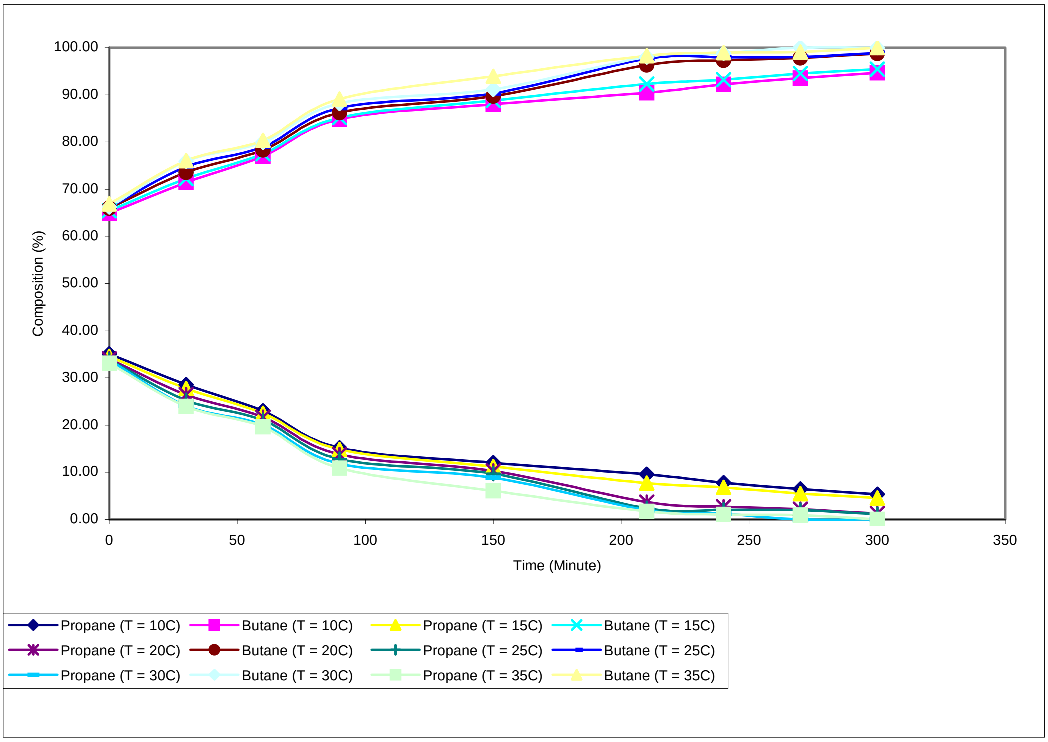

Figure 4.54. The Difference in Liquid Compositions of Various Surrounding Temperatures at Composition 4060 and flowrate 48 Liter Per Minute

4.3.5 Discharging Mass Profile

Figure 4.55 shows the difference in mass for composition of 40/60 at flowrate of 48 liters per minute. Some of the characteristics that can be observed from Figure 4.55 are as follows.

Firstly, a high surrounding temperature will result in a smaller remaining weight. Secondly, the rate of production or slope of graph for all the surrounding temperatures give the same pattern of profile, which is higher reduction of weight at the beginning and gradually decreasing throughout the experiment period. Thirdly, the surrounding temperature of 25^{o}C gave a quite close value to the remaining weight of the surrounding temperature of 30^{o}C. However, the surrounding temperature of 20^{o}C has more tendencies to behave as that of low surrounding temperature.

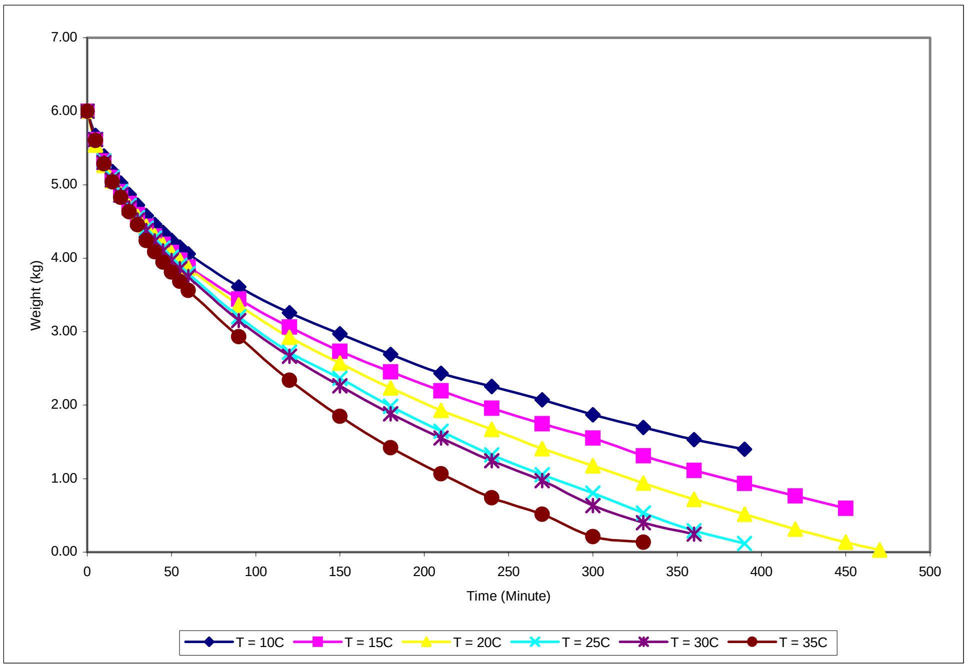

Figure 4.55. Weight Remaining Profile of Various Surrounding Temperatures at Compositions 4060 and Flowrate 48 Liter Per Minute

4.3.6 Discharging Flowrate Profile

Figure 4.56 illustrates the profile of discharging flowrate profile at various surrounding temperatures for composition of 4060 and flowrate of 48 liters per minute. The pattern of the profile is similar with the pattern that has been discussed in sub section 4.1.6 and 4.2.6.

As discussed earlier, the results shows that the reduction of the flowrate was big at the early period of discharging process and keep gradually decreasing until to the end of the experiment period. The reduction of the flowrate was the biggest for the surrounding temperature of 10^{o}C and increase with the increased in the surrounding temperature. The sequence of the reduction is in ascending order, which is from 10^{o}C to 35^{o}C. The total period for LPG to empty cylinder was faster at the higher surrounding temperature and decrease gradually with the lower surrounding temperature.

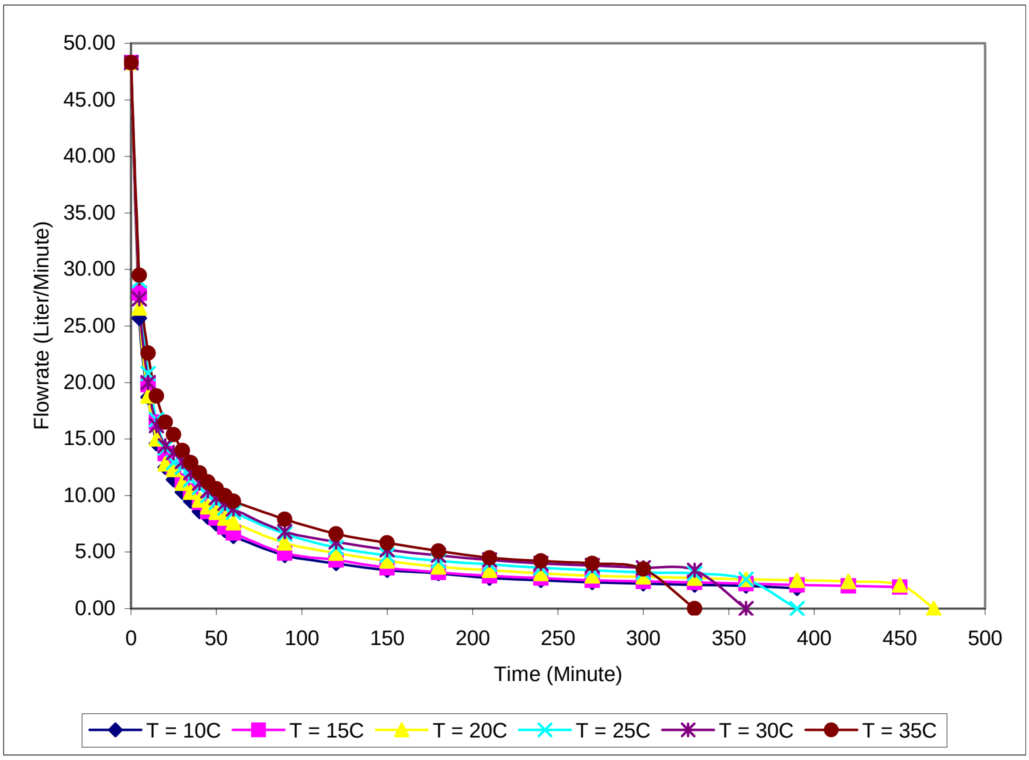

Figure 4.56. Discharging Flowrate Profile of Various Surrounding Temperatures at Compositions 4060 and Flowrate 48 Liter Per Minute

The above behavior discussed is due to the fact that at higher temperature the LPG component possessed a higher energy than the increase of the rate of evaporation process so that it will be faster to empty the cylinder. In spite of that, it shows that the reduction of liquid temperature would be compensated with the sensible heat that is being supplied from the surrounding (Yang, 2003, Verforndern and Dienhart, 1997 & Waite, 1983). However, based on the flowrate recorded, only at surrounding temperature of 25^{o}C is capable of achieving minimum compensation.

4.3.7 Liquid Level Profile

The effect of the surrounding temperature to the liquid level is not much different with the effect of the composition and flowrate to the liquid level as discussed in sub section 4.1.8 and 4.2.7.

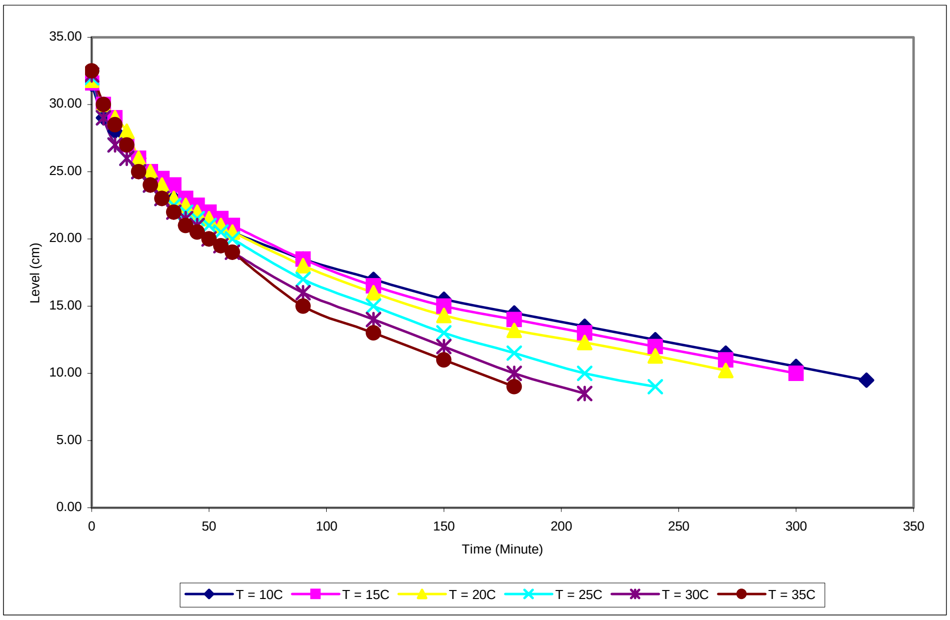

Figure 4.57. Liquid Level Profile of Various Surrounding Temperatures at Compositions 4060 and Flowrate 48 Liter Per Minute

Figure 4.57 illustrates the effect of the liquid level to the various surrounding temperatures for the composition of 4060 and flowrate of 48 liter per minute. Based on Figure 4.57, at the initial condition there is a little difference of liquid level since LPG was expanded (Thyer, 2003 & Reid *et al.*, 1984). For example, at equilibrium condition the liquid level was 31.5 cm, 31.6 cm, 31.8 cm, 32.0 cm, 32.2 cm and 32.5 cm for the surrounding temperatures of 10^{o}C to 35^{o}C.

However, the liquid level different gradually increased towards the end of the experiment period. For example the liquid level at the period of 60 minutes was 21.0 cm, 20.50 cm, 20.50 cm, 20.0 cm, 19.0 cm and 19.0 cm while at the period of 180 minutes was 14.5 cm, 14.0 cm, 13.2 cm, 11.5 cm, 10.0 cm and 9.5 cm for the surrounding temperature of 10^{o}C to 35^{o}C. It shows that the influence of the surrounding temperature to the liquid LPG after a certain period of time of evaporation process. Therefore, the result proves that the minimum level of the surrounding temperature in order for LPG to minimize the problem which associated with the left over is 25^{o}C. This is based on the graph pattern that shows which has more tendencies to achieve the behavior of the surrounding temperature of 30^{o}C and 35^{o}C.

4.4 Effect of Variation in Weight

The initial weight of liquefied petroleum gas fill in testing cylinder was varied which were 2kg, 3kg, 4kg, 5kg, 6kg and 7kg. The effects of liquefied petroleum gas weight on the fall of the cylinder temperature, pressure, discharge vapor composition, remaining liquid composition, mass of production, discharging flowrate and liquid level were discussed in detail in section 4.4.1 to 4.4.7. Other parameters were constant such as composition, the surrounding temperature and flowrate.

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4.4.1 Temperature Distribution Profile

The difference in temperature fall for all weights at the surrounding temperature 30^{o}C and flowrate 48 liters per minute were very small different as illustrated in Figure 4.58.

The characteristics that can be observed from Figure 4.58 are as follows. Firstly, increasing the weight will increase the period of phase change. The result shows that the time of phase change were 55 minutes, 75 minutes, 120 minutes, 180 minutes, 240 minutes and 300 minutes for the weight of 2 kg to 7 kg. This is due to the level of the liquid, which is proportional to the weight of LPG. Therefore, the higher the weight is, the higher the volume, and the bigger the distance of temperature sensor to the surface of the liquid.

Secondly, the higher weight of LPG will provide a higher liquid temperature. For example, for the period of 50 minute, the liquid temperature at the center of the cylinder was –7.98°C, -3.49°C, -1.24°C, -0.75°C, 0.36°C and 1.5°C for the weights of 2 kg to 7 kg. This is due to the fact that heat supplied to the liquid was more at higher weight of LPG since the amount of heat distributed into liquid LPG is influent by the wetted area (Shebeko *et al.*, 1995). Therefore, higher wetted area will provide more heat to be absorbed by propane or butane molecules. This means that when the weight of LPG is low, the resistance to heat transfer at cylinder becomes greater. Thirdly, the weight of 7 kg gave a slightly higher reading of temperature compared to that of 6 kg. Therefore, the minimum weight of LPG for the system under study was 5 kg since the reduction of the temperature was not too high and also a slightly below the temperature of weight of 6 kg.

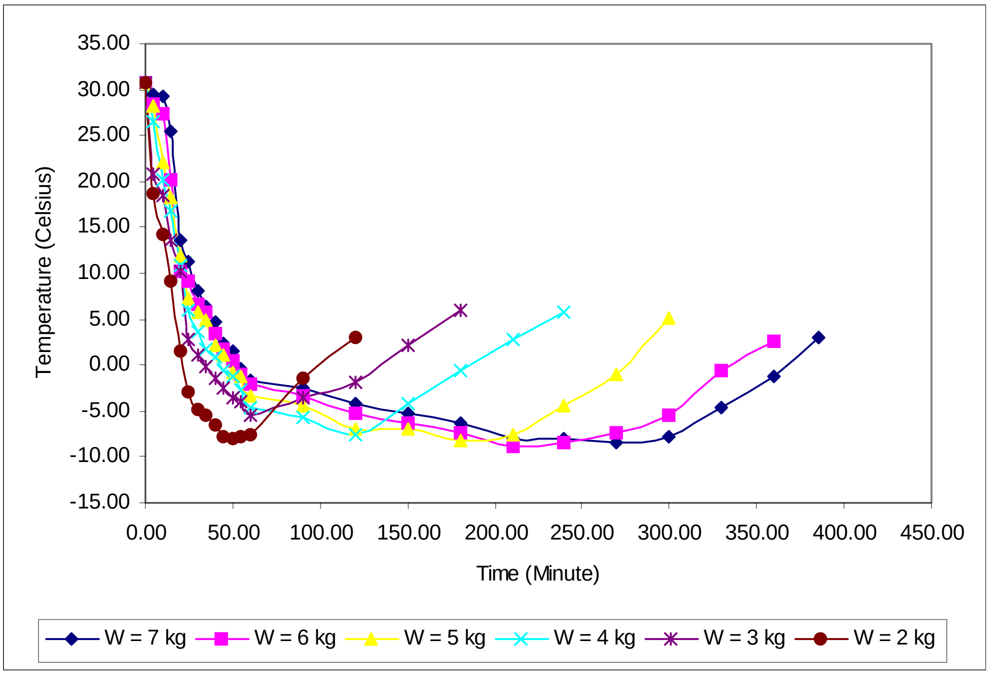


Figure 4.58. Liquid Temperature at Center Sensor for Various Weights at Composition 4060 and Surrounding Temperature of 30°C

Therefore, the weight of LPG must be properly identified in order to minimize the residue problem due to the fall in liquid temperature. However, the maximum percentage of the LPG was limited due to the safety reason (SIRIM, 1984 & William, 1982).

As previously explained in the above three sub-sections, the dimensionless analysis on the basis of axial and radial temperature data should be discussed in further detail in order to get detailed understanding of the tank thermal behavior. Figure 4.59 shows the temperature profile at the centre sensor of axial direction with effects of variation in filling weight after 10 minutes of discharging period. Based on Figure 4.59, there were a few characteristics that can be observed

Firstly, the pattern of thermal behavior in the cylinder was different compared with other tested parameter as previously discussed. The difference in filling weight showed a different pattern of thermal behavior. There were two different patterns of behaviors related to the filling weight, which showed a curve shape line and straight line. At the filling weight of more than 4 kg, it gave the same pattern like other test parameters, which is the curve shape line and vice versa at below it. It means that, with the small amount of liquid petroleum gas in the cylinder than the total energy that was required, it was not enough so that it will further taken from the most bottom part. So that the minimum-filling amount of liquefied petroleum gas into the cylinder should be given consideration in order to achieve the cylinder efficiency at the optimum level, which is more than 53 percent.

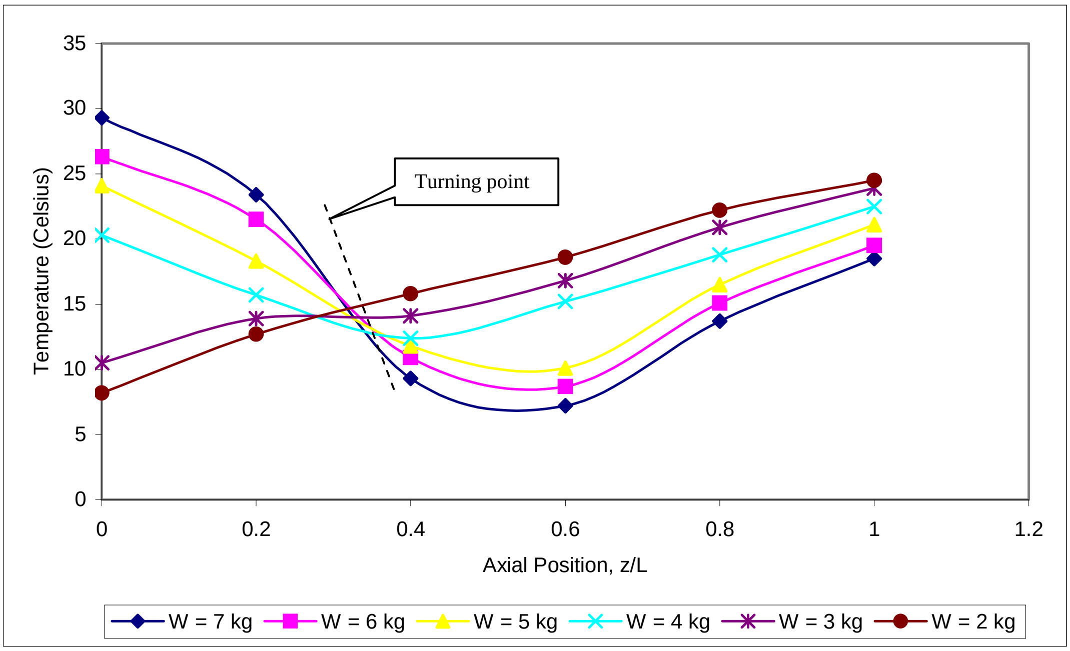


Figure 4.59: Dimensionless Axial Profile of Temperature at 10 Minute at Centre of Various Weights at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C

Secondly, at the beginning of the discharging process, the higher the filling weight gave the lower the temperature reading at the upper part of the cylinder and vice versa at the bottom part. It means that, at the higher filling weight the liquid molecules at the upper level are enough to supply the energy, therefore, the contribution from the molecules at the bottom is not required. In other words, the higher the fillings weight the better. However, in actual practice, the maximum of filling weight should follow the appropriate percent that is required by the code of practice due to safety reasons (SIRIM, 1984).

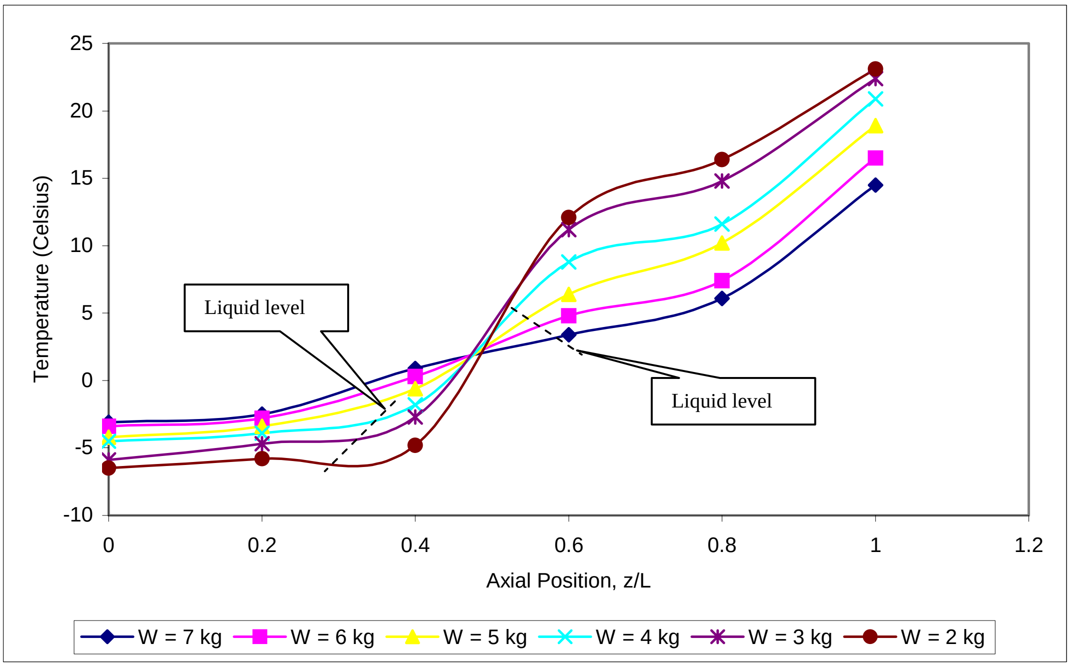


Figure 4.60: Dimensionless Axial Profile of Temperature at 120 Minute at Centre of Various Weights at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C

Similar to other test parameters, the influence of temperature of liquid level was further increased up to the bottom part of the cylinder whenever the discharging process continued as illustrated in Figure 4.60. The higher the filling weight the lower the temperature in vapor phase and vice versa in liquid phase. The difference of temperature level in vapor phase was bigger compared to liquid phase among all of filling weight. This was due to the fact that, in liquid phase energy was continuously taken for the purposes of liquid transfer phase but nothing in the process in the vapor phase. Therefore, the temperature in vapor phase was continuously increasing towards the end of the discharging process.

However, the different temperature of both phases will be getting closer towards the end of the discharging process as illustrated in Figure 4.61. This is because; in the vapor phase the temperature of all filling weights tried to reach the surrounding temperature level. It means that, at the final stage all of filling weights will be having the same temperature as the surrounding temperature. In liquid phase of all filling weights tend to reach boiling point of residue compound. It means that, at 180-minute discharge period, the residue compound will be having propane component since the lowest temperature detected was less than –0.5°C. At this temperature level there were none of butane component vaporized unless supported by energy provided by the propane component.

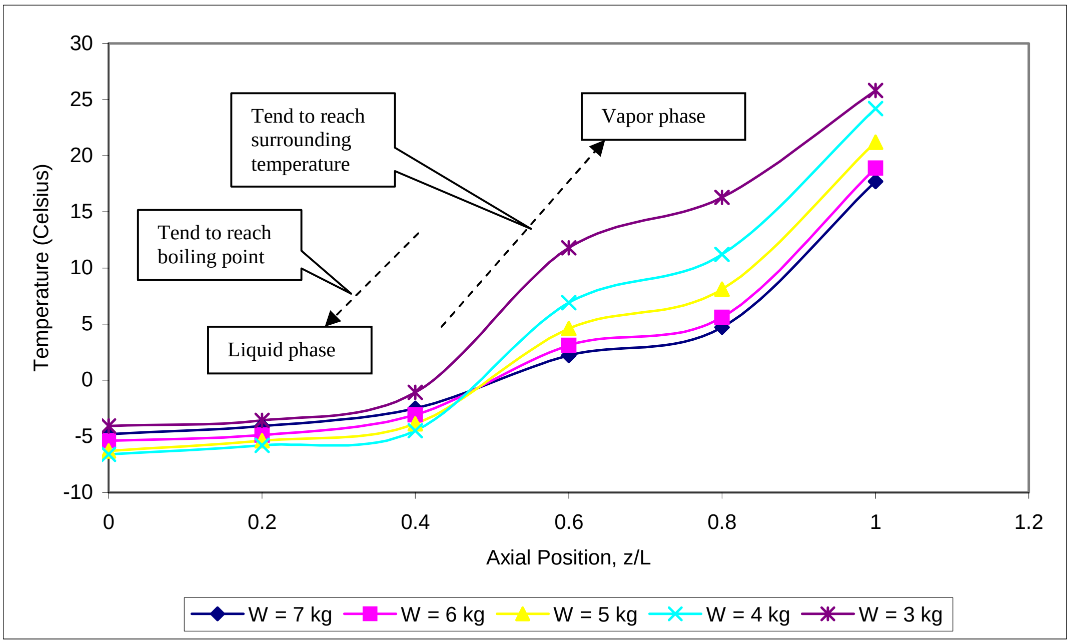


Figure 4.61: Dimensionless Axial Profile of Temperature at 180 Minute at Center of Various Weights at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C

Figure 4.61 also illustrated the inconsistencies of temperature levels in liquid phase among all of filling weights. This pattern shows that, the filling weight of 4 kg gave the lowest temperature level and the filling weight of 3 kg gave the highest reading respectively. This pattern shows that, the liquid of filling weight of 3 kg was almost completely transferred into the vapor phase. This type of pattern will be followed by the next minimum filling weight towards the end of the discharging process. As explained, the more the filling weight the slower the reduction of liquid temperature since the more the contributor of the energy, therefore, the reduction of the temperature level becomes difficult.

In all filling weights, it is observed that the behavior of thermal distribution in the cylinder dropped tremendously at the beginning of the discharging process compared to the end like other tested parameter as explained in sub-section 4.1.1, 4.2.1 and 4.3.1. The behaviors are shown in Figure 4.62 and Figure 4.63 respectively. As explained previously, based on the both figures the drop of temperature was tremendous for the first 60 minutes and became slower towards the end of discharging process.

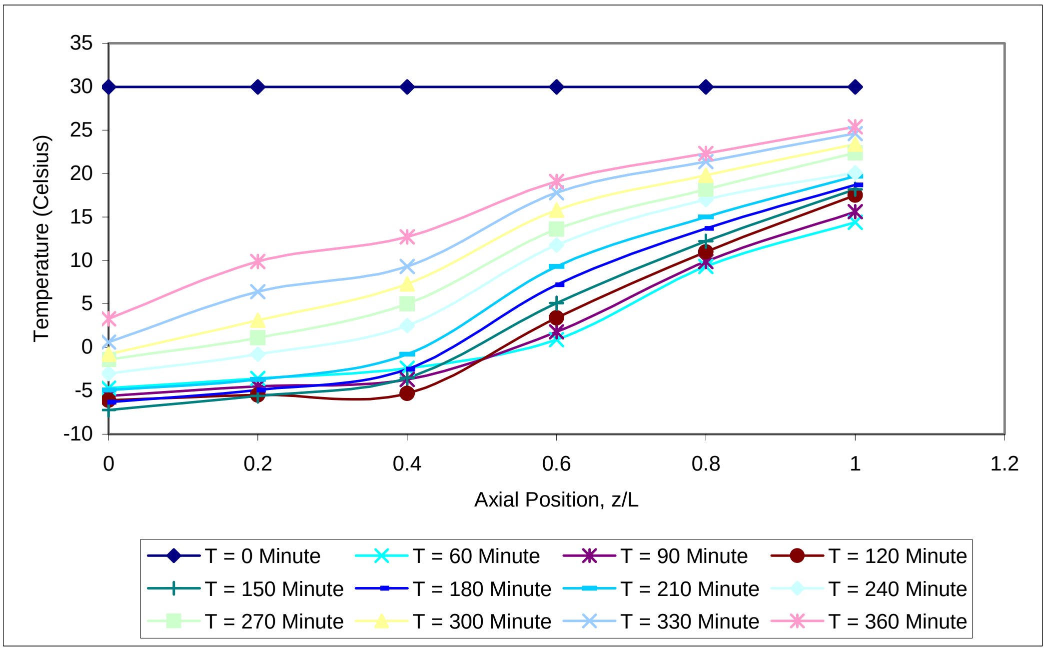


Figure 4.62: Dimensionless Axial Profile of Temperature at Centre of Weight of 7 kg at Surrounding Temperature of 30^{o}C, Flow rate of 48 liter/minute and Composition of 4060

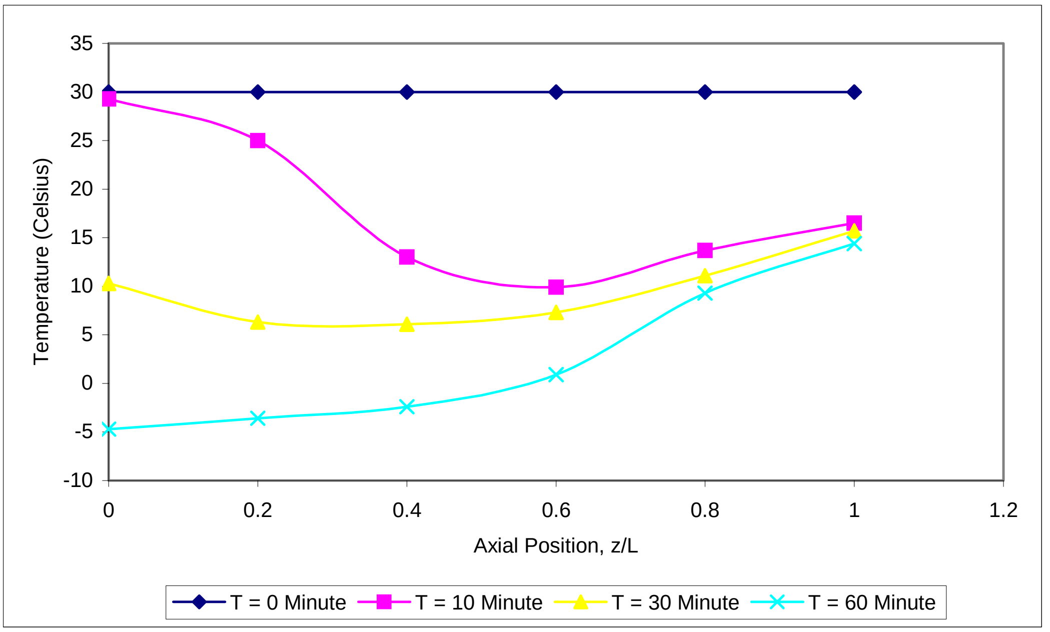


Figure 4.63: Dimensionless Axial Profile of Temperature at Early Stage at Centre of Weight of 7 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

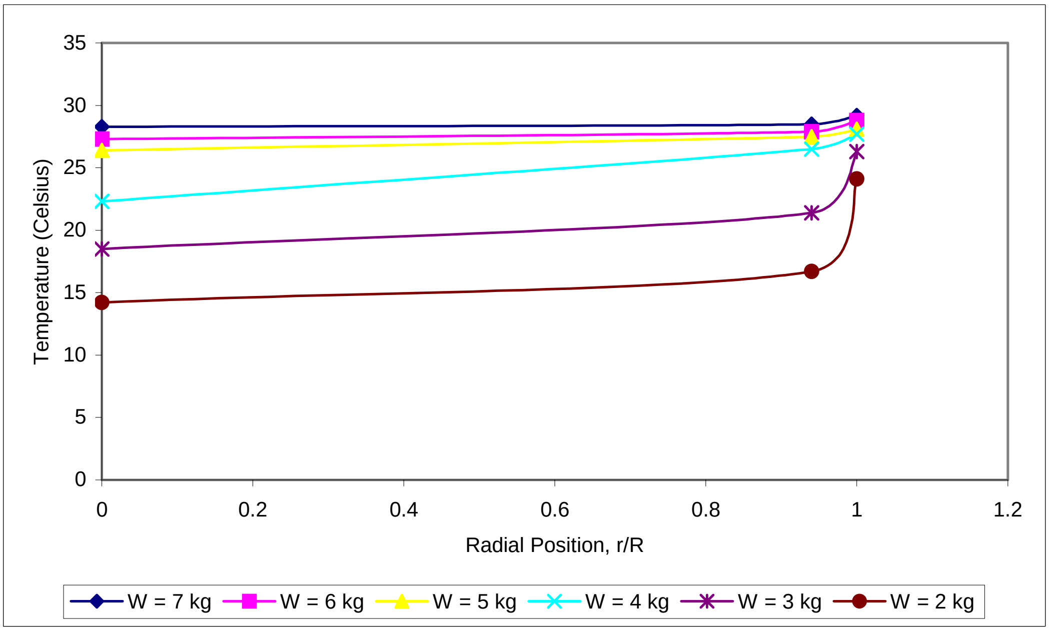


Figure 4.64: Dimensionless Radial Profile of Temperature at Level 6 at 10 Minute of Various Weights at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C

Figure 4.64 shows the temperature profiles of sensor at level 6 of radial direction with effects to variation in filling weight after 10 minutes of discharging period. Based on Figure 4.64, the reduction of temperature from external wall to the centre of the cylinder varies from low to high of filling weight. However, the reduction of temperature was tremendous from the external wall to the centre of the cylinder except for the filling weight of above 4 kg. This is because, at the filling weight of above 4 kg, the temperature inside the cylinder was stagnant.

This shows that, the heat derived as a sensible heat for the evaporation process was not enough supplied from the surrounding, therefore, all locations contributed the heat. However, the sensible heat used for the evaporation process at the filling weight of below 4 kg was taken mainly from the internal wall so that the heat cannot be distributed into the centre of the cylinder or in other words the heat transfer in the cylinder occurred in the opposite direction with is from centre to the internal wall. Since the additional heat supplied into the centre is almost nil, the liquid temperature will continuously drop. Therefore, the heat was only consumed from the liquid molecules. The higher the filling weight the bigger the heat supplied by the liquid molecules for the evaporation process. Furthermore, the filling weight of below 53 percent of total capacity should be avoided in order to minimize the problem related to the cylinder system due to high reduction of temperature level.

As explained previously concerning the influences of other factors to the temperature drop, the pattern of temperature drop became slower in the liquid phase but became bigger from the external wall to the internal wall towards the end of discharging process as shown in Figure 4.65. It means that, at this period of time the molecules energy at the centre is less energy and not enough to help liquid molecules at internal wall to transfer phase so that the rate of evaporation is slower. In other words, the surrounding temperature was not enough to supply heat into the cylinder system even at higher filling weight. However, the higher the filling weights the lower the temperature drop between the external wall and the internal wall. So that, in the process of evaporation of liquefied petroleum gas in cylinder the most dominant heat was supplied from the liquid molecules itself. With reference to the tested filling weight, therefore, the optimum filling weight should be more than 53 percent of cylinder capacity since it tends to behave like maximum allowable filling capacity especially towards the centre of the cylinder.

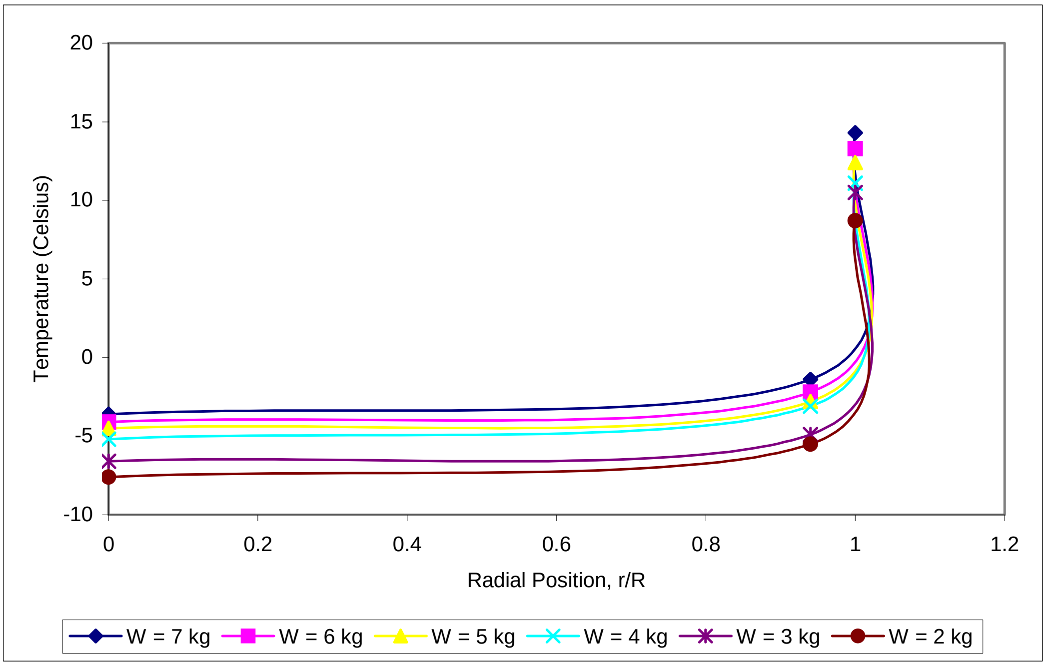


Figure 4.65: Dimensionless Radial Profile of Temperature at Level 6 at 90 Minute of Various Weights at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C

If the liquid was transferred into vapor phase, which is towards the end of the discharging process, the temperature started to increase. This is because, the heat contained in vapor phase was not used for evaporation process so that the vapor temperature will continuously increase to equalize with the surrounding temperature. This phenomenon is illustrated in Figure 4.66 and Figure 4.67 respectively. Based on Figure 4.66, the filling weight of 2 kg changed the position of the temperature from the most bottoms to the most upper part and similar with the filling weight of 4 kg that is illustrated in Figure 4.67. The sequences of temperature increases of filling weight in ascending order was 2 kg, 3 kg, 4 kg, 5 kg, 6 kg and 7 kg.

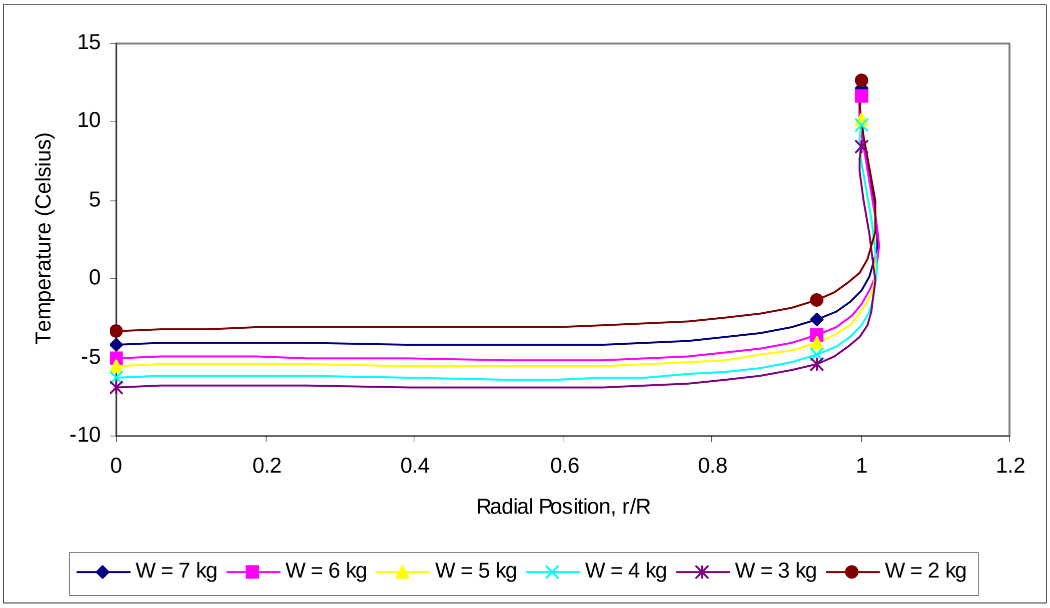


Figure 4.66: Dimensionless Radial Profile of Temperature at Level 6 at 120 Minute of Various Weights at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C

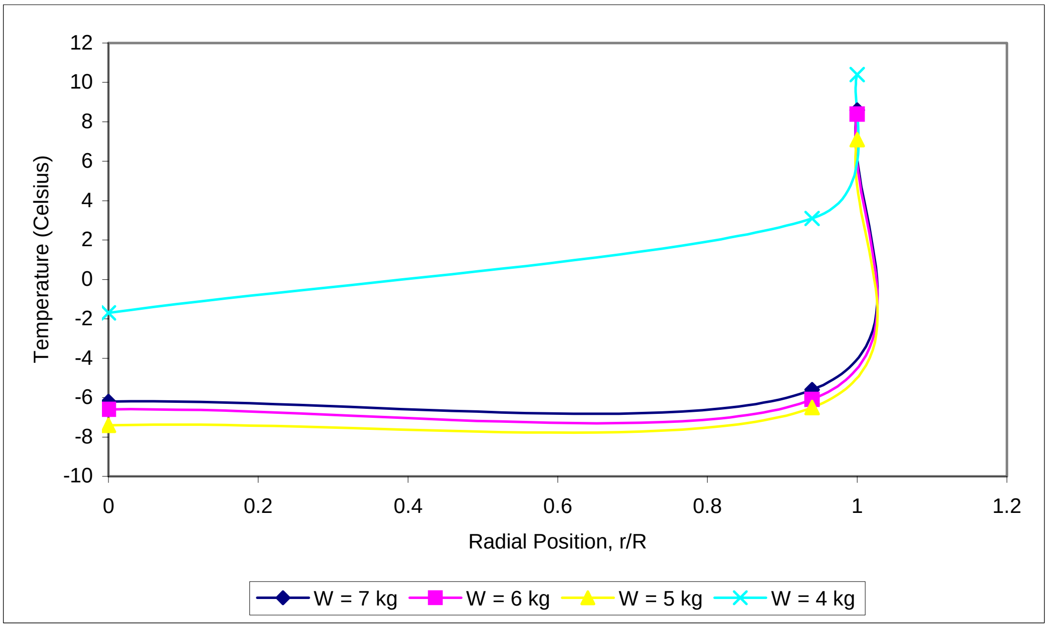


Figure 4.67: Dimensionless Radial Profile of Temperature at Level 6 at 240 Minute of Various Weights at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C

Other axial and radial illustrations of all flow rates during discharging process are given in Figure A490 to A588.

4.4.2 Pressure Profile

The difference in pressure fall between weight of 2 kg to 7 kg gives a similar pattern of profile with the effect of the surrounding temperature, composition and flowrate that has been discussed in section 4.1.3, 4.2.2 and 4.3.2 respectively. Figure 4.68 illustrates the difference in pressure fall for the variation of the initial weights of 2 kg to 7 kg at the composition of 4060, flowrate of 48 liters per minute and the surrounding temperature of 30^{o}C.

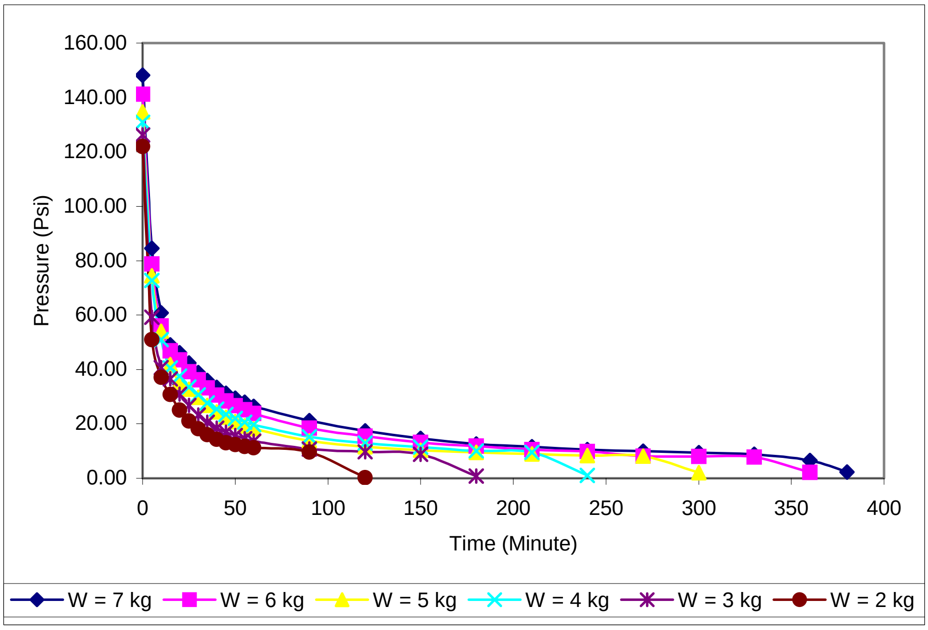


Figure 4.68. The Difference in Cylinder Pressure of Various Weights at Composition 4060 and Flowrate 48Liter Per Minute

Based on Figure 4.68, the initial pressure is influenced by the initial weight. For example, at equilibrium condition the pressure level was 121.98 psi, 126.24 psi, 130.92 psi, 134.64 psi, 141.18 psi and 148.15 psi. This is due to the factor of liquid expansion since the vapor space above the liquid level decreases with the increases in weight or volume (SIRIM, 1984 & Turner, 1946). The pressure difference gives a smaller difference if further evaporation continues. For example, at the period of 30 minutes the pressure was

18.16 psi, 23.30 psi, 29.75 psi, 30.69 psi, 36.17 psi and 38.88 psi while at the period of 90 minutes the pressure was 9.57 psi, 10.74 psi, 13.77 psi, 15.24 psi, 18.49 psi and 21.17 psi for the weights of 2 kg to 7 kg.

The time required to empty the cylinder was also varied according to the weight, which is 115 minutes, 165 minutes, 230 minutes, 280 minutes, 360 minutes and 380 minutes respectively from weights of 2 kg to 7 kg. It seems that, there were not much difference between the weights of 7 kg and 6 kg. Therefore, the optimum weight for the system under study was 6 kg.

4.4.3 Composition of Discharging Vapor

The effect of initial weight to the pattern of composition of discharging vapor profile is similar with the effect of composition, flowrate and the surrounding temperature that had been discussed in section 4.1.4, 4.2.3 and 4.3.3. Figure 4.69 illustrates the effect of initial weight to the profile of discharge vapor composition at composition of 4060, flowrate of 48 liters per minute and the surrounding temperature of 30^{o}C.

Based on Figure 4.69, the lowest weight shows the faster percentage change of propane or butane. In order words, the lowest initial weight fill in cylinder showed the lowest composition compared with the higher weight. For example, for the period of 120 minutes the component of propane was 1.45%, 13.45%, 19.85%, 29.78%, 33.72% and 37.57% for the weights of 2 kg to 7 kg.

The period of percentage equivalent which is the ratio of propane and butane was 5050 was according to the initial weight. The equivalent periods for the initial weights of 2 kg to 7 kg were within a period of 30 minutes to 60 minutes respectively, which is the fastest occurrence in the system having less weight. The result shows that the minimum weight for the system under study was 5 kg since the profile is quite close with the weight of 6 kg.

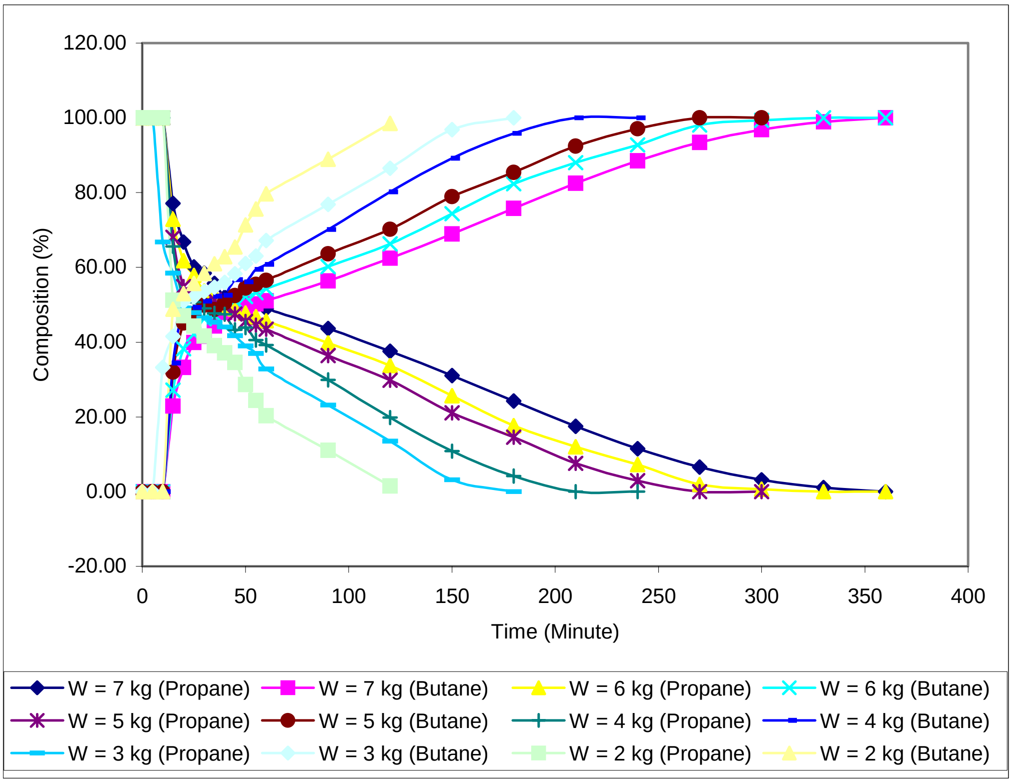


Figure 4.69. The Difference in Vapor Composition of Various Weights at Composition 4060, Flowrate 48 Liters Per Minute and Surrounding Temperature 30^{o}C

4.4.4 Composition of Remaining Liquid

Figure 4.70 illustrates the composition of remaining liquid various initial weights of filling at composition 4060, flowrates 48 liters per minute and the surrounding temperature of 30^{o}C.

Based on Figure 4.70, there is not much difference with the pattern that had been discussed in section 4.1.5, 4.2.4 and 4.3.4. During the process of discharging or evaporation the component of propane decreases if the process further proceeds. However, the decreases in propane component is influenced by the initial weight of filling which is the lowest percentage resulted at the lesser weight of filling. As discussed earlier, the composition of liquid remaining also proves that the minimum weight of 5 kg is the optimum weight for the system under study since its profile is close to the pattern of 6 kg.

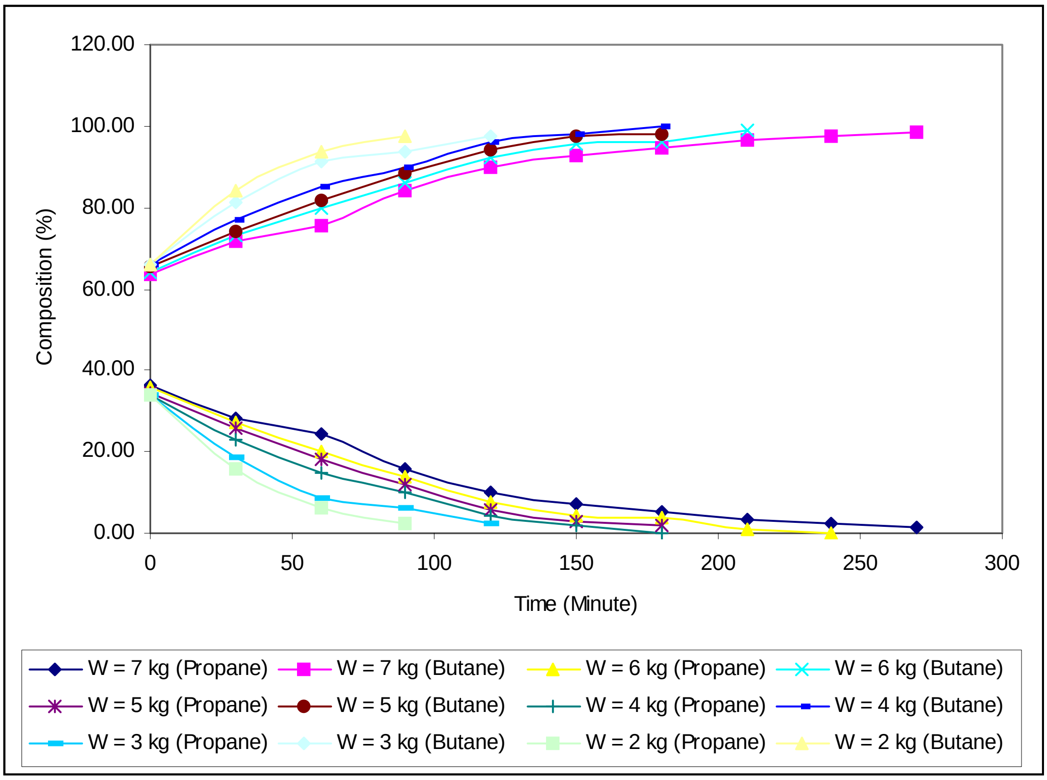


Figure 4.70. The Difference in Liquid Composition of Various Weights at Composition 4060, Flowrate 48 Liters Per Minute and Surrounding Temperature 30°C

4.4.5 Discharging Mass Profile

Figure 4.71 shows the difference in production of mass of various weights for composition of 40/60, flowrate of 48 liter per minute and the surrounding temperature of 30°C. Some of the characteristics that can be observed from Figure 4.71 are as follows.

Firstly, a high of initial weight of filling will result in a larger production of mass. This is observed on the graph gradient. Therefore, the sequences of the mass production in ascending order were 7 kg to 2 kg. This is due to the higher the initial weight then the higher the pressure system since pressure will provide a driving force during the phase change. However, all the slop of the graph keeps gradually decreasing when the discharging process proceeds further. Secondly, towards the end of the experiment period the rate of production was almost similar. Thirdly, a small difference in the rate of production between the weight of 6 kg and 7 kg and both weights tend to be similar towards the end of the experiment period. This is showes that, the optimum weight for the system under study was 6 kg.

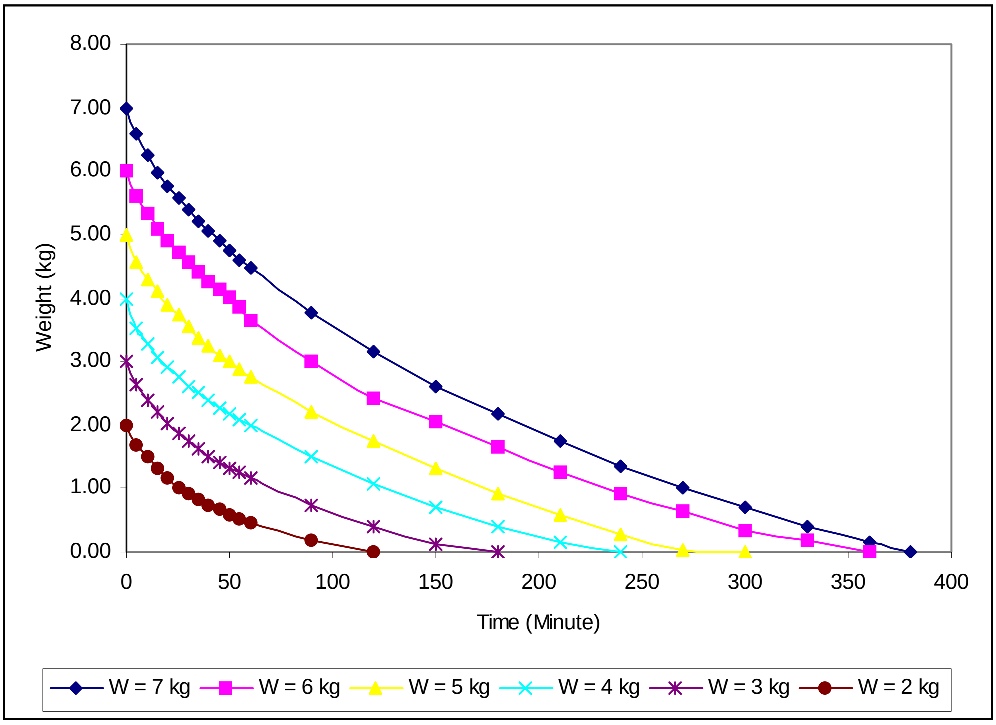


Figure 4.71. The Difference in Weight Remaining of Various Weights at Composition 4060 and Flowrate 48 Liters Per Minute

4.4.6 Discharging Flowrate Profile

The profile of discharging flowrate has the same trend with the discharging mass which is the higher rate of flowrate reduction was observed at the early period of discharging process and becomes smaller when the process further proceeds. However, the highest rate of the reduction was the weight of 2 kg and the lesser was the weight of 7 kg.

The rate of reduction of flowrate was getting similar and smaller towards the end of the experiment period. For example, at the period of 60 minutes, the flowrate was 4.5 liters per minute, 5.9 liters per minute, 7.0 liters per minute, 8.4 liters per minute, 8.8 liters per minute and 8.7 liters per minute while at the period of 150 minutes the flowrate was 0 liter per minute, 3.2 liters per minute, 4.1 liters per minute, 5.0 liters per minute, 5.2 liters per minute and 6.5 liters per minute for the weights of 2 kg to 7 kg. The discharging flowrate would be similar or close towards the end for the weights of 5 kg to 7 kg. Therefore, the optimum weight for the system under study was 6 kg. The rate of reduction of flowrate of various initial weights at composition of 4060, flowrate of 48 liters per minute and the surrounding temperature of 30°C is illustrated in Figure 4.72.

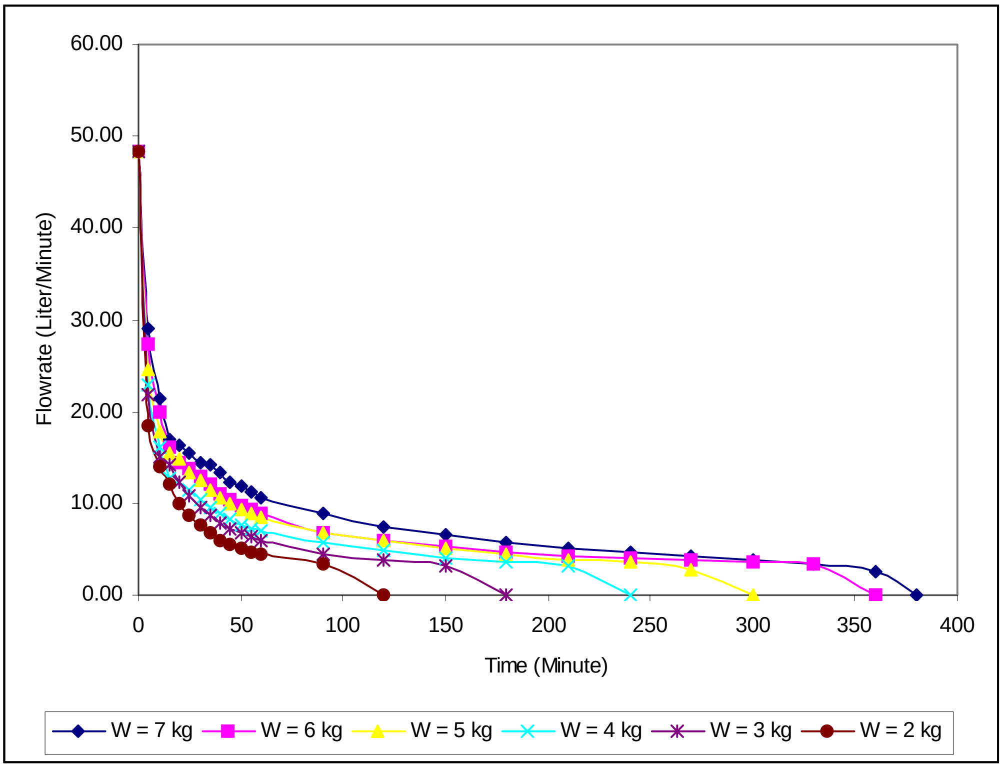


Figure 4.72. The Difference in Flowrate of Various Weights at Composition 4060 and Flowrate 48 Liter/Minute

4.4.7 Liquid Level Profile

Figure 4.73 shows the liquid level in cylinder of various initial weights of filling at composition of 4060, flowrate of 48 liters per minute and the surrounding temperature of 30^{o}C. However, the result shown is not completed except for the weight of 3 kg to 7 kg since the glass window installed is not capable to measure the weight less than 3 kg.

Based on Figure 4.73, it is similar with the previous pattern, which is the rate of reduction was high for the early period of discharging and keeps gradually decreasing towards the end of the process.

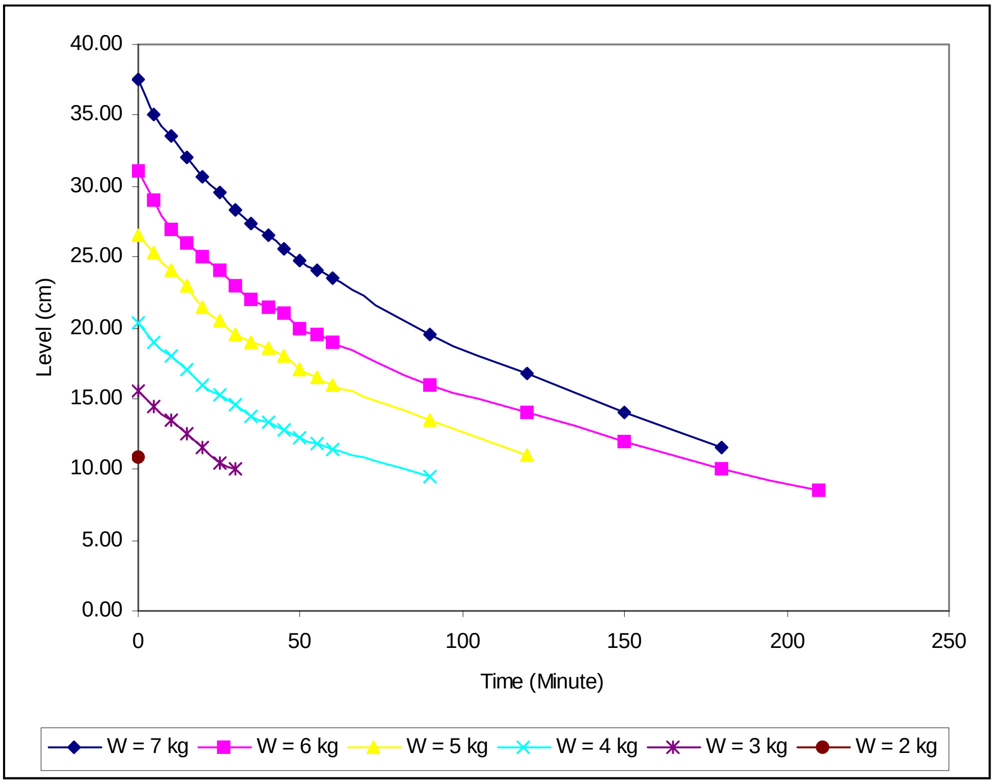


Figure 4.73. The Difference in Liquid Level of Various Weights at Composition 4060 and Flowrate 48 Liters Per Minute

However, among the initial weight of tested, the lowest rate of reduction of the liquid level was 3 kg and the highest was 7 kg. This is due to the heat absorbed by the liquid is higher for the bigger weight since they received extra heat from the surrounding. As discussed earlier, since the level was dropped then the supplied of heat to the liquid also dropped, therefore, the rate of liquid level reduction also decreased. The result shows that the optimum weight for the system under study was 6 kg and the minimum weight was 5 kg since the pattern of both weights are getting similar towards the end of experiment.

4.5 Left Over of Liquefied Petroleum Gas

All conditions of liquefied petroleum gas studied could not completely empty the cylinder. Table 4.1 illustrates the results obtained from various conditions of studies. The residue in the cylinder is influenced by factors such as the surrounding temperature, flowrate, weight and composition, as elaborated in the previous sections, besides cylinder capacity which is not included in the research scope. Data form Table 4.1 is used to develop a relationship between amounts of residue and tested parameter such as composition, flowrate, the surrounding temperature and the amount of filling.

Table 4.1. Weight of Gas Residue in Cylinder at Various Conditions

Comp = 4060 W = 6 kg T = 30°C		Comp = 4060 W = 6 kg Q = 48 L/M		W = 6 kg T = 30°C Q = 48 L/M		Comp = 4060 T = 30°C Q = 48 L/M	
Flowrate (L/M)	Residue (kg)	Temperature (Celcius)	Residue (kg)	Composition Propane (%)	Residue (kg)	Weight (kg)	Residue (kg)
20.00	0.05	10.00	1.40	100.00	0.01	7.00	0.20
30.00	0.11	15.00	0.60	80.00	0.05	6.00	0.18
48.00	0.18	20.00	0.32	60.00	0.07	5.00	0.16
60.00	0.34	25.00	0.25	40.00	0.18	4.00	0.12
73.00	0.46	30.00	0.18	0.00	0.36	3.00	0.10
		35.00	0.04			2.00	0.00

Figure 4.74 to 4.77 illustrate the relationship between the amounts of the residue to all above mentioned parameters. The relationship developed shows that it is quite accurate since all the square values of R are above 0.9 (Kwangsam *et al.*, 2004).

Figure 4.74 shows the relationship between amount of residue and flowrate that was measured at the surrounding temperature of 30°C, composition 4060 and filling amount of 6 kg. Based on the figure, it shows the polynomial relationship between the amount of residue and the flowrate. This relationship is based on the curve fit method. Therefore, with the equation developed, the amount of residue can be predicted. The amount of the residue would be more at very high flowrates. This shows that at high flowrates, the molecules of propane and butane was not able to over come the capture force. The common sign for the problem that is related to the discharging flowrate is the forming of ice formation layer on the cylinder wall (Leary, 1983). The ice formation layer becomes thicker when the flowrate is higher.

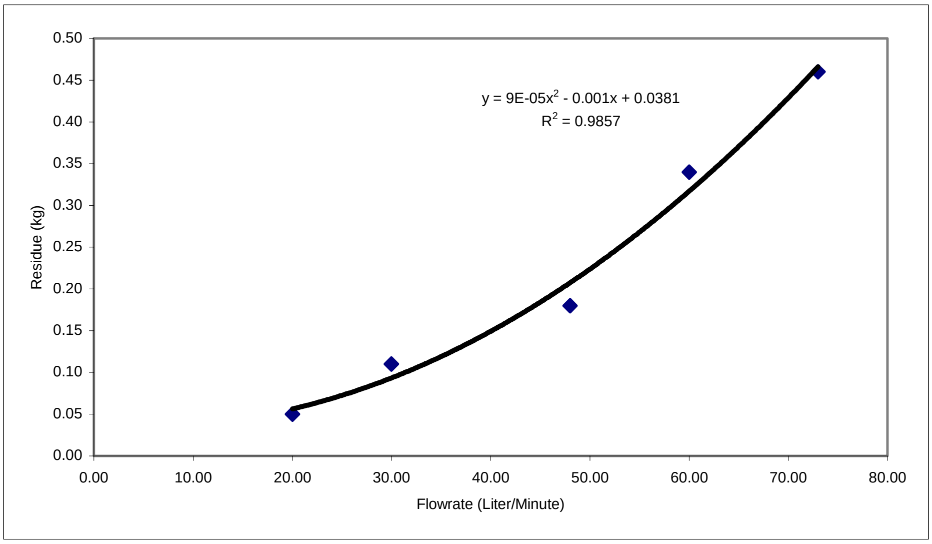


Figure 4.74. Residue of LPG of Various Flowrates at Composition 4060, Flowrate 48 Liter Per Minute, Surrounding Temperature 30^{o}C and Filling Weight 6 kg

The effect of the surrounding temperature to the amount of residue is shown in Figure 4.75. Based on the figure, the relation is an exponential pattern. That means there must be a level of surrounding temperature for the zero amount of residue.

The effect of the percentage of propane in the liquefied petroleum gas composition can be related with an exponential relationship to the residue amount. The relationship is illustrated in Figure 4.76. Based on the result recorded and the relation developed, there is no one propane percentage capable of emptying the cylinder except to minimize the residue amount. Although propane has higher vapor pressure and low boiling point, it still left residue behind in the cylinder. As explained previously, this might be due to the occurrence of the phenomena of molecule capture when the molecules are positioned at the middle section of the cylinder.

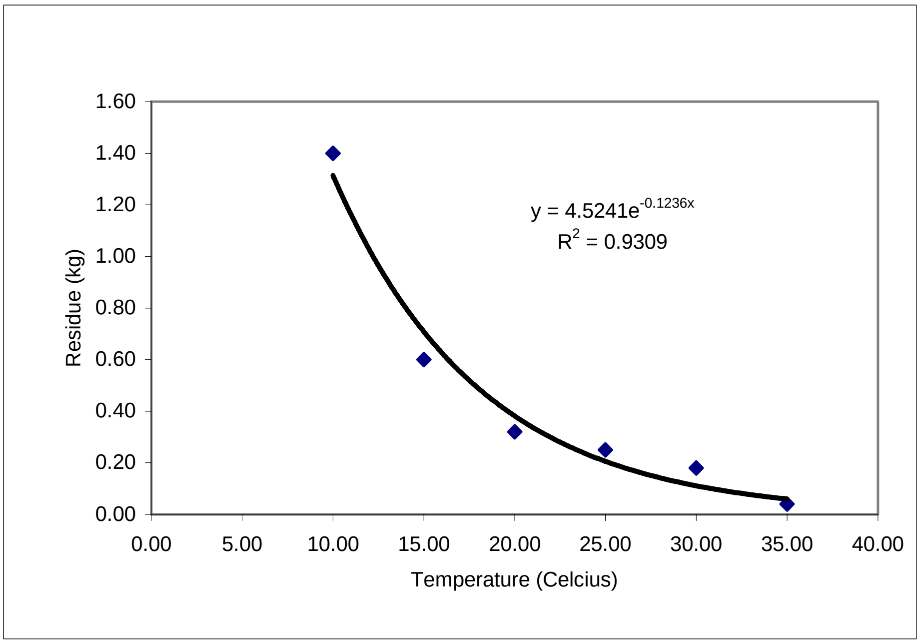


Figure 4.75. Residue of LPG of Various Surrounding Temperatures at Composition 4060, Flowrate 48 Liters Per Minute and Filling Weight 6 kg

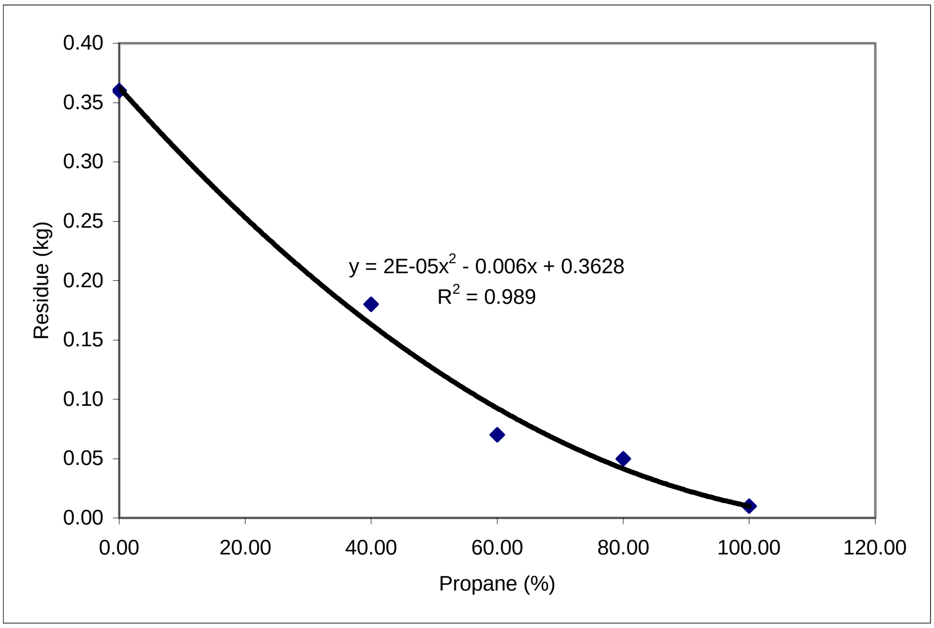


Figure 4.76. Residue of LPG of Various Compositions at Surrounding Temperature 30°C, Flowrate 48 Liters Per Minute and Filling Weight 6 kg

The phenomena of molecule capture is the result of an extreme fall in temperature causing the kinetic energy possessed by propane molecules not able to escape into the vapor phase and is also due to additional resistance from the butane molecules. This kinetic energy could also be connected to the theory of surface tension whereby surface tension will increase when the temperature is low (Malyshenko, 2002). Although the surface tension of propane is quite low, the high surface tension of butane became a resistance.

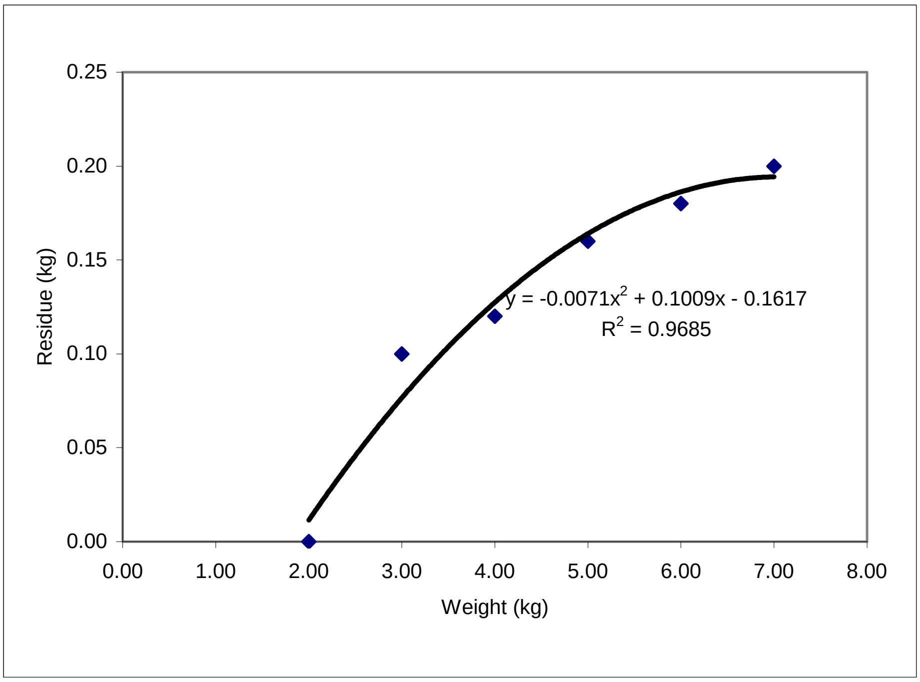


Figure 4.77. Residue of LPG of Various Filling Weights at Surrounding Temperature 30°C, Flowrate 48 Liters Per Minute and Composition 4060

This condition could be overcome if a number of propane molecules coexisted with butane molecules. From the previous discussion, the last factor that can be considered in planning is that the composition must be of a propane content of 60% or more.

Besides the percentage of propane, the quantity of filling into the cylinder also gave effect to the residue amount as shown in Figure 4.77. Based on Figure 4.77, the residue amount will achieve the maximum value so that there is no further increase in the residue amount even though the filling weight is further increased into the system under study. However, the possibility of emptying the cylinder can be achieved through the minimizing of the amount of filling weight. This is because propane molecules possess higher kinetic energy at higher temperatures since the liquid temperature is not too low due to evaporation process occurring within a short time period. Besides that, the initial weight of liquefied petroleum gas was setting by the maximum filling ratio method. Therefore, the maximum weight is based on the density of LPG, capacity of vessel, liquid temperature and the method of installation. The maximum filling ratio is developed due to the safety reason but not focused on the residue problem.

4.6 Summary

Based on the above discussions there are a few factors that can be highlighted. Firstly, compositions of propane of 60% or more must be considered in the planning of the design of liquefied petroleum gas composition for use in Malaysia. However, the use of commercial propane as the liquefied petroleum gas compositional design might probably be avoided due to the difference in cost or may cost more compared to compositional mixtures. This is because liquefied petroleum gas mixtures are cheaper compared to that of a pure component. Liquefied petroleum gas sold as mixtures is based on weight but as a pure component, it is based on the value of calories.

Secondly, the surrounding temperature can be used in the selection of the method of liquefied petroleum gas installation either through batch evaporation or flash evaporation. Based on the result recorded, the minimum level of the surrounding temperature for the batch evaporation method is 25^{o}C. Therefore, for the area that has the surrounding temperature below than 25^{o}C flash evaporation method must be considered.

Thirdly, initial weight of liquefied petroleum gas affects the residue amount, which increases when the initial weight increases. This is due to the longer time of evaporation process so that the possibility of liquid temperature achieving its boiling point becomes higher. Therefore, the higher the difference with the boiling point, it will be more advantageous for emptying LPG out of the cylinder.

Fourthly, the discharging flowrate plays an important role on the residue amount in the cylinder. The higher the discharging flowrate is, the higher the residue amount since the higher heat required from the surrounding. The design of discharging flowrate must be related to the vessel capacity since it is related to the amount of heat supplied.

The temperature drop holds the key role as it has a strong impact on cylinder performance. During discharging phase, the temperature drop is a function of several parameters, i.e., gas composition, flow rate, cylinder design and geometry, material of construction and surrounding temperature. One of the useful methods to analyze heat distribution in a cylinder is based on the dimensionless analysis, which is on the basis of axial and radial flow direction since it will provide a clear picture on the tank thermal behavior.

CHAPTER V

MATHEMATICAL MODELING

5.1 Introduction

A model of the liquefied petroleum gas in storage operation is developed based on the basic material and energy balance law. This model will later be used in the system described above to predict and validify the experimental data. Models are solved with MathCad Professional Software by employing the Fourth Order Range-Kutta method to solve for the system of differential equations.

The modeling of the system will be divided into two parts, which is the initial conditions and the discharge process. This means that prediction of the initial storage conditions will be done first before proceeding on with the discharge profiles of several system properties. Also, the initial conditions will be used as the property of the system when time is zero. We shall introduce properties of LPG, ambient air and other relevant constants before proceeding on with the models to describe the system.

5.2 Process Description

In the development of theoretical model the first step that we should clarify is the process of the system under study. The process is evaporation in closed system that containing binary component which is propane butane mixture. In practical, the liquefied petroleum gas evaporation process in cylinder can be highlighted in three main steps. Firstly, the designed amount of propane butane mixture evaporate is depend to the amount of gas required by the customer or discharge flow rate that we set at the outlet regulator. Secondly, to provide the required amount of gas to the customer than the evaporation of liquid propane butane mixture in the system must always be equal to or greater than the demand for LPG. Finally, some amount of heat from surrounding is required by the liquid LPG to vaporize it. The above mention process can be simply as shown in Figure 5.1.

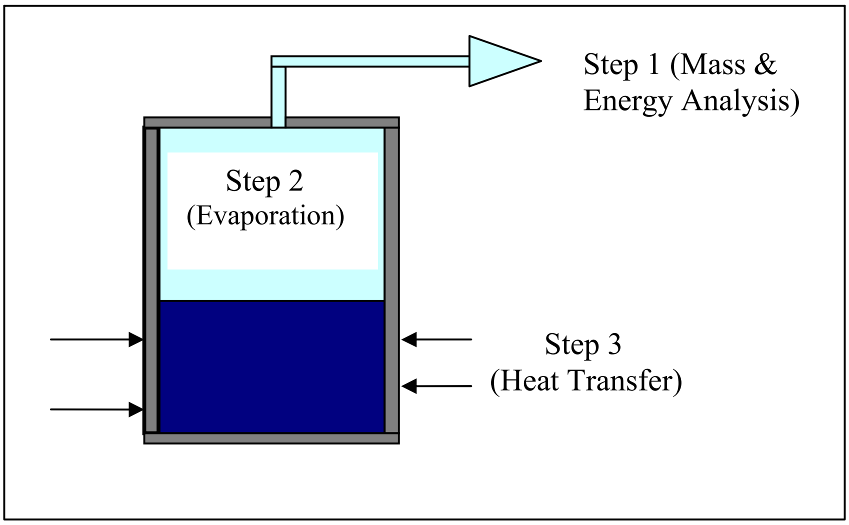


Figure 5.1. Arrangement of LPG Process

Based on Figure 5.1, we can summarize the theoretical approach that should take into consideration. Step 1 is under energy analysis, step 2 is under evaporation phenomena and vapor liquid equilibrium analysis and step 3 is under heat transfer analysis respectively.

5.3 Model Development

The development of mathematical model and discussion will start as ascending order, which is start with step 1 and end with step 3. The detail explanation will be highlighted in every step.

5.3.1 Mass and Energy Balance During Discharging Process

The law of conservation for mass states that mass can neither be created of destroyed (Felder, 1986). The first law of thermodynamics states that although energy assumes many forms, the total quantity of energy is constant, and when energy disappears in one form, it appears simultaneously in other forms (Smith *et al.*, 1996) and this called general balance equation.

In the application of the general balance equation, we will need to define system and surrounding. The system will be the area of which a process occurs or an area of interest. This area may have real or imaginary boundaries, rigid or flexible and of any size depending on particular conditions. The surrounding is everything else that interacts with the system. By convention, all inlet flows are positive and outlet flows are negative.

The general balance equation can be stated in terms of overall material, component, energy and momentum balance (Stephanopoulus, 1984). We will omit the momentum balance in this section assuming that there is no change in momentum balance since the system is static and does not move during the process. Equation (5.1), (5.2) and (5.3) are mathematical terms for each of the balance mentioned. Since unsteady-state approach is taken in this modeling, we will state all variables in terms of time. For steady-state assumptions, the accumulation term will be equal to zero since there will be no buildup within the system. This does not mean that system is zero. It only indicates that the system does not increase or decrease with respect to time. These equations will be the basis for the development of our model.

Overall Material Balance

$$\frac{d}{dt}\left[m_{Acc}(t)\right]=m_{In}(t)-m_{Out}(t)\pm m_{Gen/Cons}(t) \tag{5.1}$$

where,

m_{Acc}	= Accumulation of mass
m_{In}	= Mass in
m_{Out}	= Mass out
$m_{Gen/Cons}$	= Mass generated or consumed
t	= Time

Component Balance

$$\frac{d}{dt}\left[m_{Acc,i}(t)\right]=m_{In,i}(t)-m_{Out,i}(t)\pm m_{Gen/Cons,i}(t) \tag{5.2}$$

where,

$m_{Acc,i}$ = Accumulation of mass of component i

$m_{In,i}$ = Mass in of component i

$m_{Out,i}$ = Mass out of component i

$m_{Gen/Cons,i}$ = Mass generated or consumed of component i

t = Time

Energy Balance

$$\frac{d}{dt}\left[E(t)\right]=E_{In}(t)-E_{Out}(t)\pm Q(t)\pm W_S(t) \tag{5.3}$$

where,

E = Energy total

E_{in} = Energy in

E_{out} = Energy out

Q = Heat capacity

W_s = Work done on the system

t = Time

In the development of material balance equation for the under study system, Figure 5.2 designates each boundary describe for the system. Such boundaries are often described according to the information desired. Based on Figure 5.2, a material balance equation is done over boundary 1 to obtain mass, which is discharged with respect to time. Boundary 2 will indicate amount of mass remaining within the tank. However, boundary 2 is split into two, which is boundary 3 and boundary 4 to enable separate evaluation of liquid phase and vapor phase. This is done so that energy balance equation can be written for each phase thus giving solutions to temperature of each boundary. The general balance equations below are simplified with reasons accompanied. These differential equations will be solved simultaneously using mathematical software to obtain profiles of temperature, pressure, weight, compositions and liquid level during discharging process.

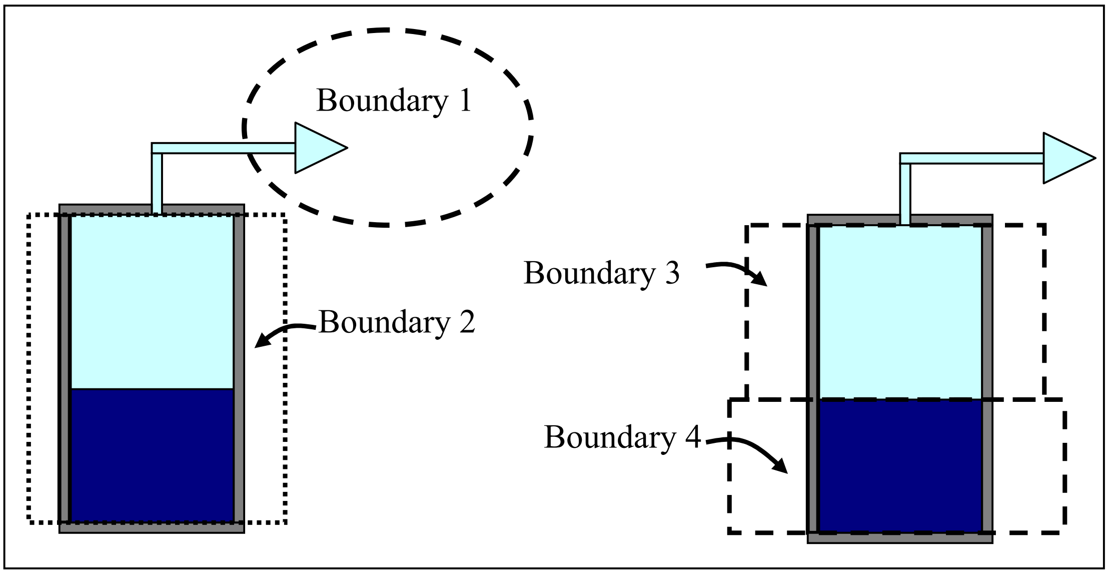


Figure 5.2: Boundaries for System

Boundary 1:

Taken as the external or surroundings where gas is Q discharged. Mass balance for this boundary can be written by Equation (5.4) and Equation (5.5).

$$\frac{d}{dt}\left[m_{exit}(t)\right] = m_{in}(t) - m_{out}(t) \pm Gen./Con. \tag{5.4}$$

where;

$m_{out}(t)$ = 0, assuming that once vapor is discharged to surroundings, it remains there without returning into tank and is therefore accumulated in the ambience

Gen/Con = 0, no occurring reactions

Therefore;

$$\frac{d}{dt}\left[m_{exit}(t)\right] = m_{in}(t) = \rho_v(t).Q(t) \tag{5.5}$$

Boundary 2:

Boundary 2 will represent the whole cylindrical tank. Mass balance for this boundary can be written by Equation (5.6) to Equation (5.8)

$$\frac{d}{dt}\left[m_{acc}(t)\right]=m_{in}(t)-m_{out}(t)\pm Gen./Con. \qquad (5.6)$$

where;

$m_{in}(t)$ = 0, no additional mass is added into systems during discharge

Gen/Con = 0, no occurring reactions

Therefore;

$$\frac{d}{dt}\left[m_{acc}(t)\right]=-m_{out}(t)=-\rho_v(t).Q(t) \qquad (5.7)$$

and then

$$\rho_v(t)=\frac{P(t).MW}{Z.R.T(t)} \qquad (5.8)$$

Boundary 3:

Only vapor phase within the cylinder. In this boundary mass balance and energy balance will be highlighted and can be written by Equation (5.9) to Equation (5.11).

Overall mass balance

$$\frac{d}{dt}\left[m_{accV}(t)\right]=m_{inV}(t)-m_{outV}(t) \qquad (5.9)$$

Component balance

$$\frac{d}{dt}\left[m_{accC3V}(t)\right]=m_{inC3V}(t)-m_{outC3V}(t) \qquad (5.10)$$

Energy balance

$$\frac{d}{dt}\left[E_V(t)\right]=E_{InV}(t)-E_{OutV}(t)\pm Q_{inV}(t) \qquad (5.11)$$

Boundary 4:
In this boundary only the liquid phase within the cylinder. Note that the overall material balance is not specified for the liquid phase. However, we can obtain necessary data by manipulating available data. The liquid phase total mass can be obtained simply by deducting overall material accumulated within cylinder with amount of vapor. Such manipulation holds true for other data.

Component balance

$$\frac{d}{dt}\left[m_{accC3L}(t)\right]=m_{inC3L}(t)-m_{outC3L}(t) \tag{5.12}$$

Energy balance

$$\frac{d}{dt}\left[E_L(t)\right]=-E_{outL}(t)\pm Gen./Con.\pm Q_{inL}(t) \tag{5.13}$$

In the liquid phase, there is a term for heat generation/consumption. This term will be described in sub-chapter 5.4.1 as the amount of heat needed for a change of phase from liquid to vapor or commonly known as the latent heat of vaporization.

5.3.1.1 Discharging Flowrate

The discharge flowrate is related to the storage pressure if a pressure difference is known in the vent (Emmons, 1987) or in the case of this system, the pressure difference in the valve. This relation is derived from the Bernoulli Equation (Emmons, 1995). We will establish this relationship.

The initial conditions are known with initial discharge rate occurring only when time is zero. The discharge rate immediately reduces rapidly but continues throughout the process until when the system pressure equals ambient pressure giving a pressure difference of zero. At this point, there is no driving force to push the vapor out of the storage and discharge is discontinued.

Assuming that the vapor is not compressed during discharge and there is no accumulation along the opening, the Bernoulli concept is valid for the consideration (Ditali *et al.*, 2000). Let's take the point inside the tank as point 1 while point at discharge as point 2. The flowrate at point 1 will be equal to zero since no flow is noted within the tank while the pressure at point 2 equals pressure at ambient. Since there is no change in elevation, the term ΔZ = 0. All units are in S.I. units and we can neglect the gravitational term g_c. Therefore, after substitution of initial values, the Bernoulli's equation to relate flowrate and pressure is calculated using Equation (5.14).

$$\begin{aligned}
\frac{(Q_1 - Q_2)^2}{2A_X} + \frac{(P_1 - P_2)}{\rho} &= 0 \\
\frac{(0_1 - Q_2)^2}{2A_X} + \frac{(P_1 - 1)}{\rho} &= 0 \\
Q_2^2 &= C_D(P_1 - 1) \\
Q_2 &= \sqrt{C_D(P_1 - 1)}
\end{aligned} \tag{5.14}$$

Initial conditions are known and we will substitute initial flowrate and initial pressure into the terms above to obtain the relationship between flowrate and pressure that can be calculated using Equation (5.15) and (5.16) for initial condition and during discharge condition respectively.

Initial Condition

$$Q_{Ini} = \sqrt{C_D(P_{Ini} - 1)} \tag{5.15}$$

Discharge Condition

$$Q(t) = \sqrt{C_D(P(t) - 1)} \tag{5.16}$$

The two equations above are divided and rearranged to obtain flowrate in terms of initial conditions and pressure. The relationship is shown in Equation (5.17) and is employed in the development of model.

$$Q(t) = Q_{Ini}\sqrt{\frac{[P(t)-1]}{(P_{Ini}-1)}} \tag{5.17}$$

5.3.2 Rate of Evaporation

The evaporation rate of liquid is not widely reported more so for an LPG cylindrical storage system. However, we will base our modeling on several facts of the system and process, which occurs throughout discharge, which is equal to or greater than the LPG demand as mention earlier.

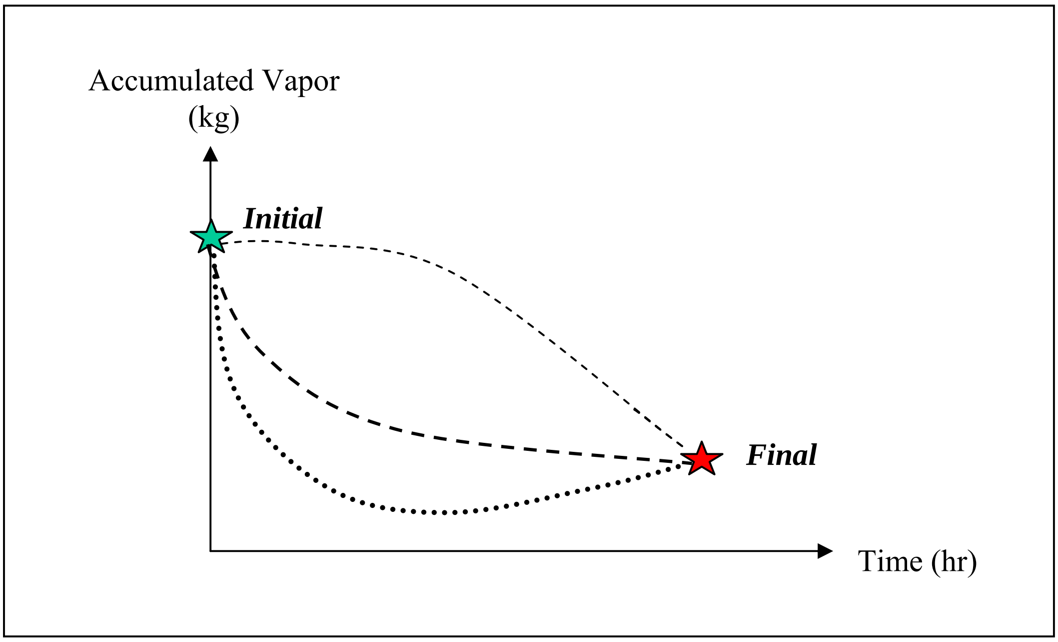


Figure 5.3: Accumulated Mass in Vapor Phase Versus Time

The initial mass of vapor phase can be calculated and will be shown in the sub-topic 5.3.2.1, which is in vapor liquid equilibrium section. We will assume that discharging completely stops when tank is at ambient or atmospheric pressure. This is possible when there is no more liquid to be vaporized and also when the tank is completely filled up with vapor. Therefore, initial and final amount of vapor within the cylindrical tank can be calculated. It is shown that the final amount of vapor is less than initial amount as depicted in graph as shown in Figure 5.3. However, we do not know the “route” of the drop in accumulated vapor mass. This will be established later by making a few assumptions and correlating results with available data to counter-check the assumptions.

We will now establish the relationship between accumulated mass in the vapor phase and the evaporation rate by Figure 5.4 with a few cases to consider.

Case 1: Evaporation Rate > Discharge Rate
Case 2: Evaporation Rate = Discharge Rate
Case 3: Evaporation Rate < Discharge Rate

With reference to the general material balance equation, and taking vapor phase as the system, inlet will be the evaporation rate while outlet will be the discharge rate. There is no reaction so no mass will be generated or consumed. Let’s take case 1 as an example. Since evaporation rate is higher than discharge rate, the inlet minus the outlet will give a positive value. This positive value means that there will be an increase in mass in the vapor phase.

Based on Figure 5.4, we conclude that evaporation rate and discharge rate are related by case 3. This means that evaporation rate will be lower than discharge rate at a certain point to allow amount of accumulated vapor to reduce. We will set the evaporation rate to a certain value for all discharge rates higher than evaporation rate.

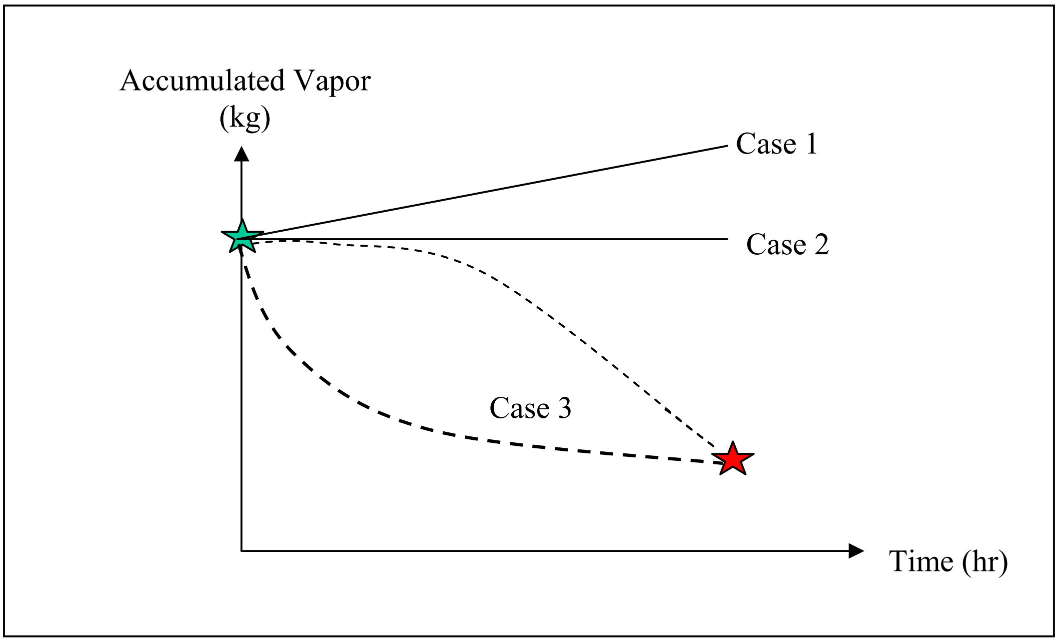


Figure 5.4: Accumulated Vapor Mass with Respect to Different Cases

When the valve is shut, we note a pressure build-up within the system. This indicates that the amount of vapor has risen. With reference to the general material balance equation, this indicates an inlet into the system. Therefore, we conclude that when discharge drops to a certain rate, a minimum evaporation rate will prevail.

$$m_{vap}(t) = \begin{bmatrix} m_{vapMax} \quad if \;\; \rho(t)\cdot Q(t) > m_{vapMax} \\ \rho(t)\cdot Q(t) \quad if \;\; m_{vapMin} < \rho(t)\cdot Q(t) \le m_{vapMax} \\ m_{vapMin} \quad if \;\; \rho(t)\cdot Q(t) \le m_{vapMin} \\ 0 \quad if \;\; m_L(t) \le 0 \end{bmatrix} \tag{5.18}$$

However, the last assumption here is no more than common sense. It will be sensible to conclude that evaporation rate will equals zero when there is no more liquid to be vaporized. The evaporation rates can then be summed up as shown in Equation (5.18).

The maximum evaporation rate, m_{vapMax} and minimum evaporation rate, m_{vapMin} are obtained by trial and error. The profile of each discharge is then compared with the experimental data for best fit. These values are known functions of surface area available for vaporization and also initial discharge flowrate. Therefore, we will assume a suitable downscale proportional to surface area for proposed system. However, values that giving better fit should be used if available. Some of the predicted values obtained by trial and error as shown in Table 5.1.

Table 5.1: Predicted Values of Evaporation Rates

Flowrate	m_{vapMax}	m_{vapMin}
10 m^3/hr	30 kg/hr	1 kg/hr
15 m^3/hr	36 kg/hr	1 kg/hr
20 m^3/hr	42 kg/hr	1 kg/hr

5.3.2.1 Vapor Liquid Equilibrium

Classical thermodynamics allows us to obtain a relationship between the equilibrium mole fraction in the liquid phase and the vapor phase. Therefore, to model the vapor liquid equilibrium, one must have a fundamental understanding of thermodynamics. Equilibrium between the liquid and vapor phases requires that the temperature, pressure and partial fugacities of each component be equal in the two coexisting phases.

The equilibrium relationship for any component in an equilibrium stage is defined in terms of the distribution coefficient or K value. The more volatile components will have lower K values. In distillation, the efficiency of separation of two components is often compared via a quantity called the relative volatility α. A relative volatility to unity means that the separation of the two components is likely to be difficult, whereas a relative volatility much greater or much less than unity means that few equilibrium stages are likely to be needed for separation. When a relative volatility has a value of one and separation is no longer feasible.

The relative volatility of a system that obeys Raoult's law is thus a ratio of two vapor pressures and is function only of the temperature. Only a small number of system containing chemically similar components obey Raoult's law and then only at low pressures which is less than 1 Mpa or 10 bar. There are the two major assumptions required for the Raoult's law approaches, which are the vapor phase, is an ideal gas and the liquid phase is an ideal solution. The majority of real systems are non-ideal. Non-ideal behavior can be described using two approaches, which are the activity coefficient and the equation of state approach.

Based on activity coefficient approach, vapor liquid equilibrium behavior in a mathematical equation can be written as in Equation (5.19) and known as Gamma/Phi Formulation.

$$f_i = \gamma_i x_i P_i^{sat} = \hat{\phi}_i \, y_i P \qquad (5.19)$$

Since the fugacity of each constituent species is the same in all phases than multiple phases at the same temperature and pressure are in equilibrium. Therefore, for specific case of multi-component vapor liquid equilibrium, Equation (5.19) becomes Equation (5.20).

$$f_i^v = f_i^l = f_i = \gamma_i x_i P_i^{sat} = \hat{\phi}_i \, y_i P \qquad (5.20)$$

Evaluation of each item, which is fugacity, fugacity coefficient and activity coefficient, will be done separately in this sub-topic. The evaluation will start with fugacity and end with activity coefficient.

Evaluation of the fugacity is usually done using the definition of the isothermal chemical potential and fugacity coefficient as shown in Equation (5.21).

$$f_i = f_i^{sat} \exp\left[\frac{V_i^L\left(P - P_i^{sat}\right)}{RT}\right] = \phi_i^{sat} P_i^{sat} \exp\left[\frac{V_i^L\left(P - P_i^{sat}\right)}{RT}\right] \qquad (5.21)$$

Fugacity coefficient of pure species of propane or butane is related to the generalized virial equation as shown in Equation (5.22).

$$\phi_i^{sat} = \exp\left\{\frac{P_r}{T_r}\left(B^o + \omega B^1\right)\right\} \tag{5.22}$$

or

$$\phi_i^{sat} = \exp\left\{\frac{P_r}{T_r}\left[\left(0.083 - \frac{0.422}{T_r^{1.6}}\right) + \omega\left(0.139 - \frac{0.172}{T_r^{4.2}}\right)\right]\right\} \tag{5.23}$$

since B^o and B^1 is defined as

$$B^o = 0.083 - \frac{0.422}{T_r^{1.6}}$$

$$B^1 = 0.139 - \frac{0.172}{T_r^{4.2}}$$

Substitution of Equation (5.21) into Equation (5.19) gives alternative form of Gamma/Phi Formulation, which is expressed as

$$y_i \Phi_i P = x_i \gamma_i P_i^{sat} \tag{5.24}$$

The new parameter of Φ_i in Equation (5.24) is term as

$$\Phi_i = \frac{\hat{\phi}_i}{\phi_i^{sat}} \exp\left[-\frac{V_i^L\left(P - P_i^{sat}\right)}{RT}\right] \tag{5.25}$$

and the exponential term in Equation (5.25) is known as Poynting correction factor which accounts for the expansion or compression of the liquid from saturated vapor pressure to system pressure (Tischmeyer, 2004). In this study, Poynting factor is negligible because it differs from unity by only a few parts per thousand at low to moderate pressure. Thus, Equation (5.25) is often simplified as

$$\Phi_i = \frac{\hat{\phi}_i}{\phi_i^{sat}} \tag{5.26}$$

Calculation of the fugacity coefficient requires knowledge of the P-V-T behavior of the system. This information is obtained from equation of state. However, in this discussion only volume explicit virial equation will be highlighted since this method is one of the equations of state method. The fugacity coefficient of any component in the vapor phase can be calculated if the second virial coefficients of the pure components and the cross second virial coefficients are available (Virendra *et al.*, 1995). The virial equation of state having a precise basis in statistical mechanics provides theoretical guidance for formulations of equation of state (Hall and Iglesias-Silva, 1993). The general equation to calculate the fugacity coefficient is using Equation (5.27).

$$\ln \hat{\phi}_i = B_{ii} + \frac{1}{2}\sum\sum y_k y_l \left(2\delta_{ki} - \delta_{kl}\right) \tag{5.27}$$

But Equation (5.27) is readily extended for application to multi components gas mixtures and can be calculated using Equation (5.28).

$$\ln \hat{\phi}_i = \frac{P}{RT}\left(B_{ii} + y_j^2\, \delta_{ij}\right) \tag{5.28}$$

Based on Equation (5.28), mixing rules are included when dealing with mixture. Mixture second virial coefficient is given by

$$B = \sum\sum y_i y_j B_{ij} \tag{5.29}$$

For binary mixture, Equation (5.29) is written as Equation (5.30).

$$B = y_1 B_{11} + y_2 B_{22} + y_1 y_2 \delta_{12} \tag{5.30}$$

where,

$$\delta_{12} = 2B_{12} - B_{11} - B_{22}$$

$$B_{ij} = \frac{RT_{cij}}{P_{cij}}\left(B^{o} + \omega_{ij} B^{1}\right)$$

$$T_{cij} = \left(T_{ci} T_{cj}\right)^{0.5}\left(1 - K_{ij}\right)$$

$$P_{cij} = \frac{Z_{cij} RT_{cij}}{V_{cij}}$$

$$V_{cij} = \left(\frac{V_{ci}^{1/3} + V_{cj}^{1/3}}{2}\right)^{3}$$

$$Z_{cij} = \frac{Z_{ci} + Z_{cj}}{2}$$

In Equation (5.30), k_{ij} is an empirical interaction parameter specific to i-j molecular pair. It represents the derivation from the geometric mean for T_{cij}. It is a true molecular constant independent temperature, composition and density. Generally, for chemically similar species, kij is equal to zero especially for the system under study (Prausnitz *et al.*, 1999).

Virial equation is applied for mixtures whose components are non-polar or weakly polar in order to yield a more accurate result (Prausnitz *et al.*, 1999). Virial equation has been widely used in industry and is recognized to be capable of reproducing experimental data with greater accuracy than cubic equation of state (Ortiz, 1996).

Activity coefficients are generally calculated by differentiation of the excess Gibbs energy. A number of expressions have been proposed for excess Gibbs energy as a function of pressure, temperature and composition. Some of the more popular are Margules method, Wilson method, NRTL method, UNIQUAC method and UNIFAC method. Even though there are a few popular method as mentioned above and suitable for propane butane binary system but values of interaction parameters are not available. Therefore, virial equation of state approach is chosen in this study.

In this study combination of the generalized virial equation and Gamma/Phi formulation facilitate the prediction of VLE for propane-butane mixture. Gamma/Phi formulation, when rearranged for both propane and butane, is expressed as

$$y_i = \frac{x_i \gamma_i P_i^{sat}}{\left(\frac{\hat{\phi}_i}{\phi_i^{sat}}\right) P} \tag{5.31}$$

Activity coefficients in Equations (5.31) can be expressed in another form of equation that established from the Lewis/Randall rule and excess function. By referring to that establishment, activity coefficient can be expressed as Equation (5.32).

$$\gamma_i = \frac{\hat{\phi}_i}{\phi_i} \tag{5.32}$$

Substituting Equation (5.32) into Equation (5.31), gives

$$y_i = \frac{x_i \left(\frac{\hat{\phi}_i}{\phi_i}\right) P_i^{sat}}{\left(\frac{\hat{\phi}_i}{\phi_i^{sat}}\right) P} = \frac{x_i P_i^{sat} \left(\frac{1}{\phi_i}\right)}{P \left(\frac{1}{\phi_i^{sat}}\right)} \tag{5.33}$$

Then, inserting Equation (5.33) into Equation (5.28) gives

$$\ln \hat{\phi}_i = \frac{P}{RT} \left[B_{ii} + \frac{\delta_{12} (x_i)^2 \left(\frac{1}{\phi_j}\right)^2 \left(P_j^{sat}\right)^2}{P^2 \left(\frac{1}{\phi_j^{sat}}\right)^2} \right] \tag{5.34}$$

Even though the derivation had been made for non-ideal behavior but due to the system under study which is pressure less than 10 bar or 1 MPa as well as continuously discharge from the cylinder which is not in equilibrium condition except for the early stage of experimental than the system can be assumed as ideal behavior which is ideal gas and ideal solution. Therefore the Equation (5.19) can be simplified as Equation (5.35) and this equation is called Raoult's law equation. If the system is considered in ideal behavior than fugacity coefficient and activity coefficient is equal to unity. Omission of this factor introduces negligible error. An ideal solution is one that is homogenous throughout the solution and where all molecules share the same chemical behavior or interaction between one another (Smith *et al.,* 1996). We shall assume that propane and butane differs only slightly.

$$x_i P_i^{sat}(T) = y_i P \tag{5.35}$$

Since the evaporation rate has already been established, we can now proceed with the component evaporation rate. The component evaporation will give the amount of propane and butane within the vapor phase. This indicates a vapor-liquid equilibrium within the system as a whole. We will use this vapor liquid equilibrium concept in developing the component evaporation rate.

We assume equilibrium exists on the surface of the liquid, which interacts with the vapor phase right above it. With this assumption, we can employ the Raoult's Law for a vapor-liquid equilibrium. The vapor pressure of each component is calculated with the Antoine equation at liquid temperature. Assuming that only the liquid interface and vapor phase directly above it is in equilibrium, we will conclude that this pressure be an "equilibrium" pressure and not that of the system pressure. The pressure is given by Equation (5.36) (Smith *et al.,* 1996).

$$P_{Eq} = x_{C3} P_{C3}^0(T) + x_{C4} P_{C4}^0(T) = x_{C3} P_{C3}^0(T) + (1 - x_{C3}) P_{C4}^0(T) \tag{5.36}$$

The term x_{C3} is the liquid mole fraction of propane component. This value can be obtained from solution of differential equations for component balance and overall liquid balance. However, the differential equation solutions are in terms of mass (kg) and appropriate conversion needs to be done first. The conversion of mass fraction of propane in liquid phase to mole fraction can be calculated using Equation (5.37).

$$x_{C3} = \frac{\frac{m_{C3L}}{MW_{C3}}}{\frac{m_{C3L}}{MW_{C3}} + \frac{m_{C4L}}{MW_{C4}}} \tag{5.37}$$

Now, all terms in Raoult's Law equation is already defined except for the vapor mole fraction, y. This term will be calculated to obtain composition of the vapor phase immediately above the liquid phase, which is said to be in equilibrium. The vapor mole fraction therefore can be calculated using Equation (5.38).

$$y_{C3} = \frac{x_{C3}\, P_{C3}^{0}(T)}{P_{Eq}} \tag{5.38}$$

We will now need to convert the vapor mole fraction back to mass fraction, which is used in the differential equations. Converting back from mole fraction to mass fraction can be calculated using Equation (5.39).

$$mass_{fracC3} = \frac{y_{C3}\, MW_{C3}}{y_{C3}\, MW_{C3} + (1 - y_{C3})MW_{C4}} \tag{5.39}$$

Note that the vapor pressures of components are evaluated at liquid temperature. This is further used later in energy balance section where vaporized liquid entering vapor phase is at liquid temperature.

Once the vapor mole fraction is established, we will relate this composition to the evaporation rate to get amount of propane and/or butane, which is vaporized at an instantaneous time. The amount of propane and vaporized can be calculated using Equation (5.40).

$$m_{vapC3} = mass_{fracC3}\, m_{vap}$$
$$m_{vapC4} = \left(1 - mass_{fracC3}\right) m_{vap} \qquad (5.40)$$

The amount of propane and butane discharged however is not equivalent to the amount vaporized. We will assume that vapor phase is even throughout and homogenous and composition of vapor, which discharges, is the same as accumulated composition. This composition is the result of differential equations for vapor phase and propane vapor component.

5.3.3 Energy Consumption

Energy is consumed for vaporization to take place. Liquid will change phase to be charged as vapor and delivered to consumers. However, this energy required transferring heat from surrounding into the liquefied petroleum gas cylinder. Therefore, in this sub-topic the heat transfer process will be discussed.

5.3.3.1 Heat Transfer Process

A difference in temperature between two regions provides the driving force for heat transfer. Heat transfer can be divided into two categories, which is steady-state heat transfer when this driving force does not change with time and unsteady-state heat when this driving force changes with time. The theory of unsteady-state heat transfer is especially important in industry, where it is used to predict the heating and cooling rates of various regions. Since temperature varies with temperature and position, a partial differential equation is needed to describe the heat transfer. When the partial differential equation is solved, the variation of temperature with time is known and the flux of energy at specific time can be determined (Welty *et al.* 1996).

For steady-state heat transfer, the accumulation within a control volume will be zero as in the case for material balance. The system studied is one, which is very much an unsteady-state process since almost all variables change with time except those, which we assume to be constant. This was done primarily to simplify solutions but should give reasonably accurate approximates.

Three types of heat transfer occurred in this study: conduction, this occurs through solid, liquid and gases by transfer of motion between adjacent molecules; convection, heat transfer by bulk transport and mixing of macroscopic elements of warmer portions with cooler portions. This occurs between solid surface and fluid (liquid or gas). Forced convection occurs when a liquid is forced to flow past the surface while natural convection results from circulation due to density difference. Natural convection is also known as free convection and is used in this system assuming ambient air flows naturally on the outer side of the storage tank; and radiation, this type of heat transfer can occur without any medium for propagation. Radiation occurs by means of electromagnetic waves. A black body is an object, which absorbs all energy while objects, which emits a portion of the energy, is termed a gray body. While there is not a single object that is completely "black body", we assume the cylindrical tank, which is housed in an enclosure to be almost a black body since the energy that is reflected will be reabsorbed, reflected and reabsorbed.

With reference to our system, heat transfer by conduction will occur through the radial and axial directions. From the axial directions, heat will flow through the tank that made from cast iron, which is a circular disc, but of the same cross sectional area. This surface will be taken as a slab while heat transfer from the radial area through the tank is liken to a hollow cylinder. Derivations of the heat transfer equation for circular disc and hollow cylinder are shown in Equation (5.41) and Equation (5.42) respectively.

$$Q = -kA\frac{dT}{dX} = \frac{Driving\ Force}{Resistance} \tag{5.41}$$

$$Q = -kA\frac{dT}{dr} = \frac{Driving\ Force}{Resistance} \tag{5.42}$$

For the convective heat transfer process through a fluid is given by the Equation (5.43).

$$Q = hA(T - T_{Wall}) = \frac{Driving\ Force}{Resistance} \tag{5.43}$$

The type of fluid flow whether laminar or turbulent of the individual fluid has an effect on the heat transfer coefficient, h. The heat transfer coefficient is a function of several factors. However, we will look directly into natural convective heat transfer since this mechanism is involved in our system. According to our system, the heat transfer coefficient of vertical position can be calculated using Equation (5.44) since height of the cylinder is less than one meter (Perry *et al*., 1984).

$$N_{Nu} = \frac{hL}{k} = a\left(\frac{L^3\rho^2 g\beta\Delta T}{\mu^2}\frac{c_p\mu}{k}\right)^m = a(N_{Gr}\ N_{Pr})^m \tag{5.44}$$

Constants of a and m are dependant on dimensionless numbers N_{Gr} and N_{Pr} (McAdams, 1952). Note that all air properties are evaluated at film temperature or also known as the average temperature. For natural convection coefficient of circular disc the same equation for natural convective heat transfer through vertical cylinders can be used except for the height, L of tank. For a circular disc, the height is taken as the effective diameter of the disc, which is 0.9 times the diameter (Geankoplis, 1993).

The radiative heat transfer equation for a black body is given by Equation (5.39). For system under study, the cylindrical tank system which is enclosed is considered to act as a black body since radiation to the wall is part absorbed and part reflected in all directions. The reflected radiation is then reabsorbed again and the process continues until essentially all the energy which enters the enclosure is absorbed by the tank. We conclude that the black body assumption for the tank will not contribute much error. This is further supported by the emissivity for water (assuming ice forms on outer tank wall) as reported to be 0.95, which is near unity as that for a black body.

$$Q = A\sigma\left(T_1^4 - T_2^4\right) \tag{5.45}$$

Heat transfer from the surrounding to the liquid phase inside the liquefied petroleum gas cylinder will pass through an outer air/convective layer before going through the cast iron wall and finally reaching onto the liquid. These different layers provide resistance to the heat flow. This resistance is analogous to voltage in electrical technology in which parallel or series layers will give a difference in total resistance.

In series layers, the total heat passing through each layer is equal. However, the resistance to flow will be the summation of all resistance. In parallel layers, total heat passing through is equals to summation of all heat flow in each individual layer. The illustration in Figure 5.5, Figure 5.6 and Figure 5.7 will show the difference in a parallel or series heat flow.

When radiation occurs, this heat transfer process is normally accompanied by a convective heat transfer process except in cases where the object is placed in a vacuum. Our system is placed in normal ambient conditions, it is true that radiation will occur together and simultaneously with convection. Since the radiation and convection reaches the wall of the tank together, the total heat transferred to the tank wall is the sum of both heat transfers and can be calculated using Equation (5.46) which is the combination of Equation (5.43) and Equation (5.45).

$$Q_T = Q_{Conv} + Q_{Rad} = \left(h_c + h_r\right)A\left(T_1 - T_2\right) \tag{5.46}$$

There are two direction of heat transfer flow from surrounding to the cylinder wall (boundary layer) which is radial and axial direction. Figure 5.8 illustrates that total heat to the boundary layer is the summation of both convective and radiative heat flow. This is true since both convective and radiative heat transfer normally occur together unless the ambient is in a vacuum as stated previously. This total heat will then flow through the cylinder wall before reaching the liquid LPG flowing in a series, meaning that the total amount of heat through the wall will be equal to the amount of heat into liquid LPG.

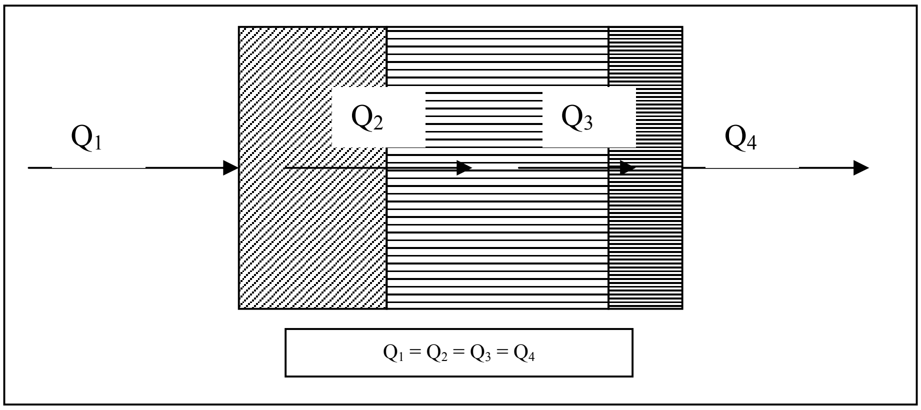


Figure 5.5: Series Heat Flow

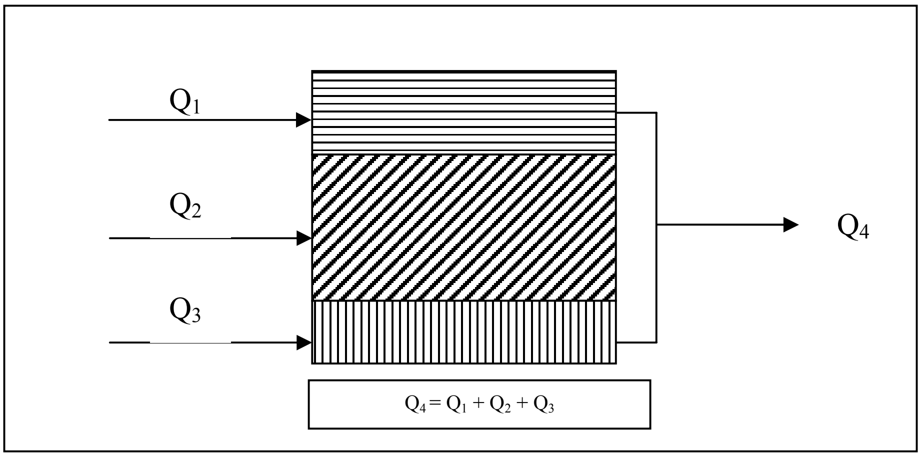


Figure 5.6: Parallel Heat Flow

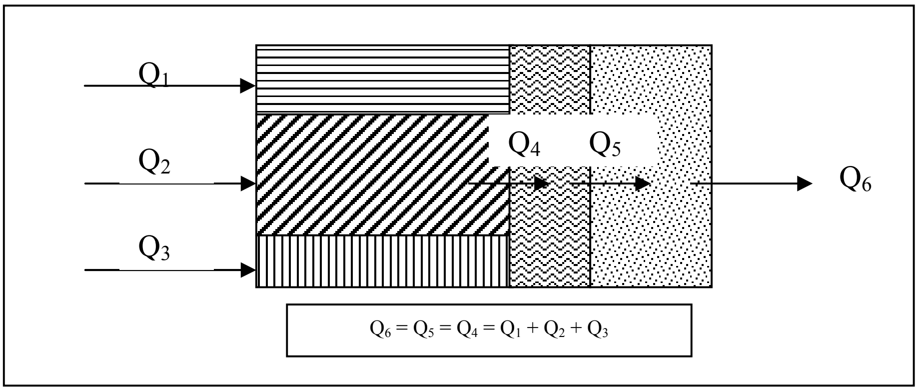


Figure 5.7: Combined Parallel and Series Heat Flow

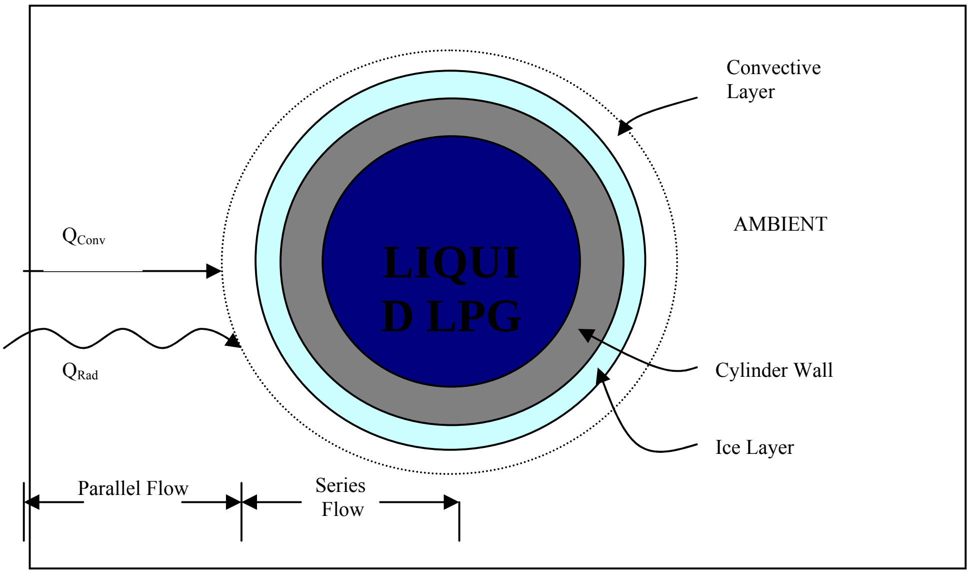


Figure 5.8: Radial Direction Heat Flow

When the total convective and radiative heat reaches the tank surface, heat transfer through the wall is by means of conduction. This occurs since material of tank is solid cast iron and conductive heat transfer through the hollow cylinder will be assumed. This will enable calculations to quantify the amount of heat transmitted through the tank wall into liquid phase. If the temperature on the wall drops below freezing point, we will assume that a layer of ice immediately forms thus adding to resistance. A similar approach is used for heat transfer into vapor phase.

The axial direction heat transfer is also similar to the radial direction heat transfer. The only difference will be the arrangements of resistance to flow. This is illustrated in Figure 5.9.

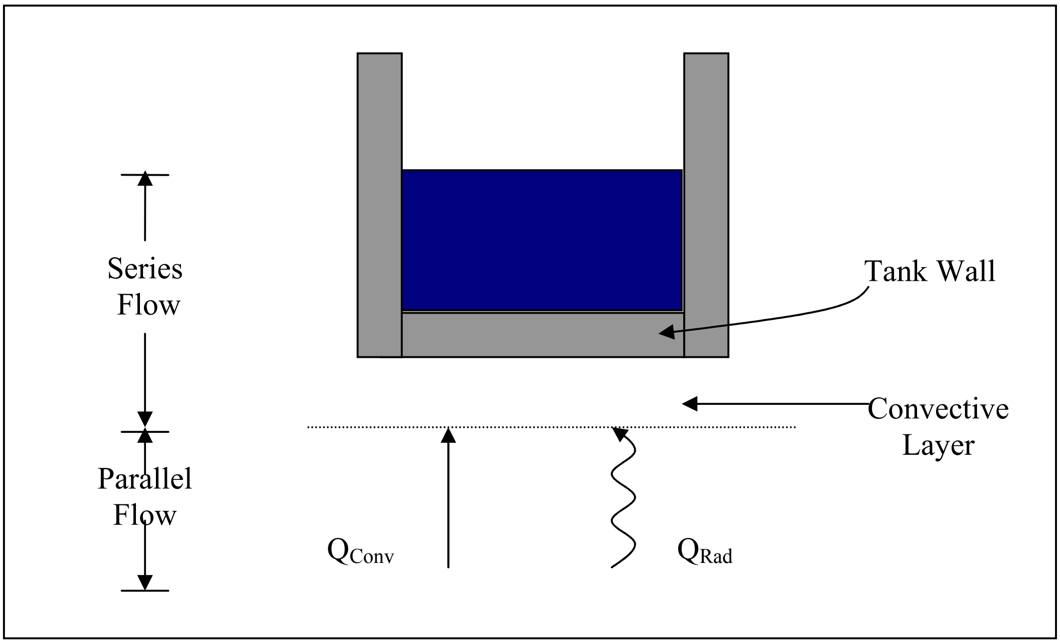


Figure 5.9: Axial Direction Heat Flow

Total amount of heat transfer can be termed simply as the temperature difference or driving force divided by the resistance as shown in Equation (5.41) to Equation (5.43). Each form of heat transfer and each layer of material provides different amount of resistance. In summary, the resistance for each flow of heat and each layer is as shown by Equation (5.47) until Equation (5.51).

i. Radial Direction

a) Boundary Layer Resistance:

$$R_B(t)=\frac{1}{\left[h_{conv}(t)+h_{rad}(t)\right]A_L(t)} \tag{5.47}$$

b) Wall Resistance:

$$R_{Wall}(t)=\frac{\ln\left(\frac{d_2}{d_1}\right)}{2\Pi k_{wall}H_L(t)} \tag{5.48}$$

c) Ice Resistance:

$$R_{ice}(t)=\frac{\ln\left(\frac{d_3}{d_2}\right)}{2\Pi k_{ice}H_L(t)} \tag{5.49}$$

ii. Axial Direction

a) Boundary Layer Resistance:

$$R_B(t)=\frac{1}{[h_{conv}(t)+h_{rad}(t)]A_X(t)} \tag{5.50}$$

b) Wall Resistance:

$$R_{Wall}(t)=\frac{\frac{d_2-d_1}{2}}{k_{wall}A_X} \tag{5.51}$$

c) Ice Resistance:

Assuming no ice forms on ends of cylinder

We will now establish the amount of resistance, which exists for flows in the radial and axial direction. The driving force will be taken as temperature difference of ambient and liquid temperature. Therefore, the total resistance will be layers in between these two.

For radial direction heat flow, the total resistance is slightly more complex since there will be ice formation on the outer wall. The ice formation is known to add resistance to heat transfer and has been quoted to be the source of LPG remainder within the tank. There are a few assumptions related to the formation of this ice layer.

Firstly, we shall assume that the ice forms immediately without going through a transitional phase (water). This means that condensation is neglected and the layer of ice forms immediately when temperature of wall drops below freezing point. Secondly, the ice layer is assumed to be of equal thickness (7 mm) from top to bottom and only appears on the liquid phase region. Therefore, ice height drops with reduction of liquid level and thus is an unsteady-state formation.

Therefore, resistance to heat flow in radial direction can be summarized as shown in Equation (5.52).

$$\sum R_{Radial}(t) = \left| \begin{array}{c} R_B(t) + R_{Wall}(t) + R_{Ice}(t) \; if \; T_{wo} \leq 273 \\ R_B(t) + R_{Wall}(t) \; if \; T_{wo} > 273 \end{array} \right. \qquad (5.52)$$

where,

R_B = resistance of both convective and radiative heat transfer.

For the axial heat transfer, the total resistance will be the summation of the boundary layer resistance and the tank end circular slab. This neglects any ice formation as we assume that water droplets will not appear on the end of tank due to gravitational force. Therefore, total resistance at end of tank is simpler and shown as Equation (5.53).

$$\sum R_{Axial}(t) = R_B(t) + R_{Wall}(t) \qquad (5.53)$$

With reference to the general heat balance equation, we will notice the terms heat input, heat output and heat consumption or generation. One such heat input will be by means of heat transfer as elaborated. We shall now look into the other terms for the heat balance equation and it will be discussed in sub-topic of input data.

5.4 Input Data

5.4.1 Heat Consumption or Generation

It is easy to imagine a heat generation in exothermic reactions and heat consumption in endothermic reactions. However, these consumption and generation also occur in our system of study although not directly related to any reactions.

For liquid phase LPG to be utilized, it must first vaporize before being discharged as gas to be used. This change in phase occurs within the cylindrical tank in the liquid phase, which becomes a matter of interest. The change of phase requires a considerable amount of heat (Waite, *et al.*, 1983 & Raj, 1981), which is commonly known as the latent heat of vaporization. Such heat supplied to enable a change of phase without raising temperature of liquid phase is the heat consumed by the system.

This consumption of heat will be added into the general heat equation balance for the liquid phase boundary. However, we will realize that there is no heat consumed in the vapor phase boundary. This is obvious since vapor phase does not change phase any further before being discharged to the atmosphere.

We now relate the amount of heat consumed or the latent heat of vaporization as a function of temperature. This is done since system is in unsteady-state operation with liquid phase temperature changing throughout the experiment (Raj, 1981). Latent heat data are readily available at normal boiling points but easily related as a function of temperature by the Watson's equation as shown in Equation (5.54) (Watson, 1943). This is done assuming that latent heat is solely a function of temperature with pressure not exerting much effect.

$$\Delta H_{vap}(T) = \Delta H_{vap}(T_b)\left[\frac{T_c - T}{T_c - T_b}\right]^{0.38} \tag{5.54}$$

Therefore, energy consumed for the vaporization to take place can be calculated using Equation (5.55).

$$E_{conc}(t)=\rho_v(t)Q(t)\Delta H_{vap}(T_b)\left[\frac{T_c-T(t)}{T_c-T_b}\right]^{0.38} \tag{5.55}$$

5.4.2 Heat Input or Output

Heat transfer into tank represents one heat input to the system. However, there is another heat input, which is the flow of LPG. This occurs when different boundaries are described for the system as shown in Figure 5.2. Since general heat balance equations are only written for boundaries 3 and 4, we will immediately look into heat input and output for these two boundaries. These heat flows are in terms of enthalpy. The enthalpy of material is a strong function of temperature and tabulated data are also readily available for liquid enthalpy of LPG (Perry, 1984) while the vapor enthalpy is calculated using the ideal gas heat capacity by Equation (5.56) (Aly and Lee, 1981).

$$H_{vapor}^{ig}=\int c_p^{ig}dT=\int_{T_{ref}}^{T}\left(A+BT+CT^2dT\right) \tag{5.56}$$

where,

H	= enthalpy of vapor
C_p	= heat capacity
A, B, C	= heat capacity coefficients
T_{ref}	= reference temperature

The exact enthalpy of a substance is not known. However, the change in enthalpy is of importance and as such, any reference temperature will not influence the change in enthalpy as shown by the relation in Equation (5.57).

$$\Delta H_{vapor}^{ig}=\int_{T_{ref}}^{T_1}c_p^{ig}dT-\int_{T_{ref}}^{T_2}c_p^{ig}dT=\int_{T_2}^{T_1}c_p^{ig}dT \tag{5.57}$$

Thus the energy out from the system can be calculated using Equation (5.58).

$$E_{out}(t) = m(t).H(t) \tag{5.58}$$

If the reference temperature in Equation (5.57) is taken as zero Kelvin and substitute in Equation (5.58) becomes Equation (5.59).

$$E_{out}(t) = \frac{P(t).Q(t).MW.C_p}{Z(t).R} \tag{5.59}$$

5.4.3 Material Properties

5.4.3.1 Physical & Chemical Properties of LPG

Properties of propane, n-butane and i-butane is used in the modeling are obtained from published tabulated data as shown in Table 5.2 (Perry, 1984; Sinnott, 1983 and Winnick, 1977). However the units of the properties have to be standardized as shown in Table 5.3.

Since commercial butane is assumed to be 50% n-butane and 50% i-butane (percentage by mass), all properties of butane in this modeling is taken as 50-50 of each respectively. We will also assume that other components available in LPG are of minute amounts and negligible. Therefore, the LPG is made up entirely of propane and butane at specific compositions.

Table 5.2: Physical and Chemical Properties of LPG

Properties	Propane	n-Butane	i-Butane
Physical Properties			
T_c (K)	369.8	425.2	408.1
T_b (K)	231.05	272.65	261.25
P_c (atm)	41.9245	37.5031	36.0227
V_c (cm^3/mol)	200.0	255.0	262.7
Z_c	0.276	0.274	0.282
ω_c	0.152	0.200	0.181
M.W. (g/mol)	44.097	58.124	58.124
ΔH_{vap} (J/mol)	18786	21311	22408
Antoine Coefficients			
A	15.7260	15.6782	15.5381
B	1872.46	2154.90	2032.73
C	-25.16	-34.42	-33.15
Ideal Gas Heat Capacities			
A	1.213	1.935	1.667
B	28.785 x 10-3	36.915 x 10-3	37.853 x 10-3
C	-8.824 x 10-6	-11.402 x 10-6	-11.945 x 10-6
D	-	-	-

Table 5.3: Standardized Units

Item	Units
Mass	Kilogram (kg)
Volume	Cubic meters (m^3)
Time	Hour (hr)
Pressure	Atmosphere (atm)
Energy	Kilojoules (kJ)
Length	Meters (m)

5.4.3.2 Air Properties

Air properties are used in calculation for heat transfer. These air properties are evaluated at film temperature, T_f. It is a standard practice of evaluating all thermo physical properties at average temperature and can be calculated using Equation (5.60) (Conrado and Vesovic, 2000).

$$T_f = \frac{T_B + T_W}{2} \tag{5.60}$$

where,

T_f = Film temperature

T_B = Bulk temperature

T_W = Wall temperature

To simplify evaluation, we shall assume that wall temperature has an average temperature of the ice layer, which forms over it, which is equivalent to freezing point of water. We note that air properties differ relatively less compared to the change in liquid height. Therefore, influence of air properties on heat transfer is reasonably negligible. Properties of air are shown in Table 5.4.

Table 5.4: Properties of Air (Wagman, 1952)

Properties	Value
Density, ρ (kg/m³)	1.219
Viscosity, μ (kg/m.s)	1.797 x 10-5
Volumetric Expansion Coefficient, β (1/K)	3.4911 x 10-3
Conductivity, k (W/m.K)	0.02535
Prandtl Number, N_{Pr}	0.711

5.4.3.3 Miscellaneous Properties

Miscellaneous properties used in the modeling are shown in Table 5.5.

Table 5.5: Miscellaneous Properties (McAdam, 1952)

Properties	Value
Conductivity of Cast Iron, $k_{c.s.}$ (W/m.K)	52.0
Conductivity of Ice, k_{ice} (W/m.K)	2.25
Universal Gas Constant, R (L.atm/mol.K)	0.08206
Gravitational Force, g (m/s^2)	9.80665

5.4.3.4 System Properties

The system properties are the operating conditions of the process. Readily experimental data are available for several operation conditions as shown in Table 5.6.

Table 5.6: Operation Conditions

Items	Conditions
LPG Composition	C3, 80/20, 60/40, 40/60, C4
Flowrate	15 liter/minute to 73 liter/minute
Ambient Temperature	10^oC to 35^oC
Type of Discharge	Continuous
Weight	2 kg to 7 kg

5.4.3.5 Tank Physical Properties

Earlier experiment was carried out using a prototype cylinder with 18-liter water capacity and that the tank is a cylindrical with flat ends. The prototype cylinder specifications are as shown in Table 5.7. Height of the cylinder was slightly adjusted from hemispherical shape to flat shape at disk end and can be calculated using Equation (5.61).

$$H = \frac{V_T}{\Pi \left(\frac{d_I}{2} \right)^2} \tag{5.61}$$

where,

H = Height

V_T = Volume

d_I = Internal diameter

Table 5.7: Prototype Cylinder Physical Properties

Properties	Value
Total Volume	18 liters
Inside Diameter	216.6 mm
Outside Diameter	228.6 mm
Material of Construction	Cast Iron
Height of Tank	0.4572 m

5.4.4 Vapor Pressure

For a single component system, the vapor pressure can be related to the system temperature from a phase diagram. For multi-component systems, the pressure-temperature relationship is thus more complex. There are several methods to estimate vapor pressure of a process stream.

The Clapeyron Equation relates the vapor pressure of a pure substance and temperature (Smith *et al.,* 1996). However, the latent heat of vaporization is needed to solve for the vapor pressure. Except at high pressures, the specific volume of liquid can be neglected since it is relatively very small compared to the vapor volume. Also, if the latent heat of vaporization is independent of temperature, the Clapeyron Equation can be integrated to yield the Clausius – Clapeyron Equation as shown in Equation (5.62) with B being a constant, which is different for each substance.

$$In\left[P^{o}(T)\right]=-\frac{\Delta H_{Vap}}{RT}+B \tag{5.62}$$

where,

$P^o(T)$ = Vapor pressure

T = Temperature

ΔH = Latent heat of evaporation

R = Gas constant

B = Constant

We notice from the Clausius – Clapeyron equation above that a plot of ln[P^o(T)] versus 1/T will give a linear line. This leads to a simpler method of obtaining vapor pressures of specific components. Such chart is available for wide range of substances and is commonly known as the Cox Chart.

However, the simplest method is to employ the Antoine Equation as shown in Equation (5.63). The Antoine Equation is a relatively simple empirical equation, which correlates vapor pressure and temperature extremely well (Winnick, 1997 & Riddick *et al*., 1970).

$$In\left[P^{o}(T)\right]=A-\frac{B}{T+C} \tag{5.63}$$

where,

$P^o(T)$ = Vapor pressure

T = Temperature

A = Constant

B = Constant

C = Constant

The Antoine coefficients or constants A, B and C are obtained from chemical engineering tabulated table (Sinnott, 1983) and shall be used in this modeling. The coefficients for propane, n-butane and i-butane are as shown in Table 5.2.

5.4.5 Molar Volume

While liquid molar volumes can be estimated with cubic equation of states for gases, they may not be very accurate. Generalized equations available for estimation of molar volumes of saturated liquid given by Rackett provide one of the simplest calculations known as the Rackett Equation as shown in Equation (5.64) (Rackett, 1970 & Spencer and Adler, 1978).

$$V^{Sat} = V_c Z_c^{(1-T_r)^{0.2857}} \qquad (5.64)$$

where,

V_{sat} = Saturated molar volume

V_c = Critical molar volume

Z_c = Critical compressibility factor

T_r = Pseudo reduced temperature

We can also obtain the density of liquid as a function of temperature by inversing the molar volumes as shown in Equation (5.65).

$$\rho_L = \frac{1}{V^{Sat}} = \frac{1}{V_c Z_c^{(1-T_r)^{0.2857}}} \qquad (5.65)$$

where,

ρ_L = Liquid density

V_{sat} = Saturated molar volume

V_c = Critical molar volume

Z_c = Critical compressibility factor

T_r = Pseudo reduced temperature

5.4.6 Storage Pressure

Storage pressure is calculated based on the amount of vapor existing within the vapor phase. This pressure will also be influenced by the volume available and temperature of gas. We shall include the compressibility factor in this section since calculation is relatively simple. The non-ideal gas equation is shown as in Equation (5.66).

$$PV = ZnRT \tag{5.66}$$

where,

P	= Pressure
V	= Volume
Z	= Compressibility factor
n	= Number of mole
R	= Gas constant
T	= Temperature

The concept of partial pressure described by Dalton's Law states that the total pressure of a system is the summation of partial pressure of each component present in the system. Therefore, we will assume that the total pressure is the pressure exerted by propane and butane respectively in the vapor phase and can be calculated using Equation (5.67).

$$P = P_{C3} + P_{C4} = \frac{(Z_{C3}\,n_{C3} + Z_{C4}\,n_{C4})RT}{V} \tag{5.67}$$

where,

P	= Total pressure
P_{C3}	= Partial pressure of propane component
P_{C4}	= Partial pressure of butane component
Z_{C3}	= Compressibility factor of propane component
Z_{C4}	= Compressibility factor of butane component
n_{C3}	= Number of mole of propane component
n_{C4}	= Number of mole of butane component

R = Gas constant

T = Temperature

V = Volume

5.4.7 Compressibility Factor

There are many ways to take into account the compressibility factor of gases. These include the virial and cubic equation of states. However, each equation is limited by some rules and is only suitable in certain conditions. The simplest form of the generalized virial-coefficient equation (Praunsnitz *et al.*, 1999) where reduced pressure is from low to moderate (Smith, 1996) provides reasonable prediction of compressibility factor, Z. The equation is shown in Equation (5.68a), (5.68b), (5.68c) and (5.68d).

$$Z = 1 + \left(\frac{BP_c}{RT_c}\right)\left(\frac{P_r}{T_r}\right) \tag{5.68a}$$

$$\left(\frac{BP_c}{RT_c}\right) = B^0 + \omega B^1 \tag{5.68b}$$

$$B^0 = 0.083 - \frac{0.422}{T_r^{1.6}} \tag{5.68c}$$

$$B^1 = 0.139 - \frac{0.172}{T_r^{4.2}} \tag{5.68d}$$

where,

Z = Compressibility factor

B = Constant

P_c = Critical pseudo reduced pressure

R = Gas constant

T_c = Critical temperature

P_r = Pseudo reduced pressure

T_r = Pseudo reduced temperature

ω = Acentric factor

B^0 = Constant

B^1 = Constant

Combining all terms above and solving for compressibility factor using Equation (5.69).

$$Z = 1 + \left[\left(0.139 - \frac{0.172}{T_r^{4.2}} \right) + \omega \left(0.139 - \frac{0.172}{T_r^{4.2}} \right) \right] \frac{P_r}{T_r} \tag{5.69}$$

This compressibility factor term is used in the program development for the solution of the model. We will calculate compressibility factors separately for each propane and butane component before adding partial pressures of each component for the total system pressure.

5.4.8 Liquids and Vapor Height

Referring to the liquid density calculation based on the inverse of specific liquid volume calculations by Rackett Equation, we can obtain the liquid height. This liquid height refers to the height of liquid inside the tank as shown in Figure 5.10.

The liquid height can be calculated easily if we have the mass of liquid for each component propane and butane. This data can be obtained by solving the differential equations of material balance. With the data available, the liquid height can be calculated using Equation (5.70).

$$H_L(t) = H_{C3L}(t) + H_{C4L}(t) = \frac{m_{C3}(t)}{A_X \rho_{C3}} + \frac{m_{C4}(t)}{A_X \rho_{C4}} \tag{5.70}$$

where,

H_L = Total height of liquid

H_{CL3} = Height of liquid of propane component

H_{CL4} = Height of liquid of butane component

m_{C3} = Mass of propane

m_{C4} = Mass of butane

A_X = W Cross sectional wetted area

ρ_{C3} = Density of propane

ρ_{C4} = Density of butane

t = Time

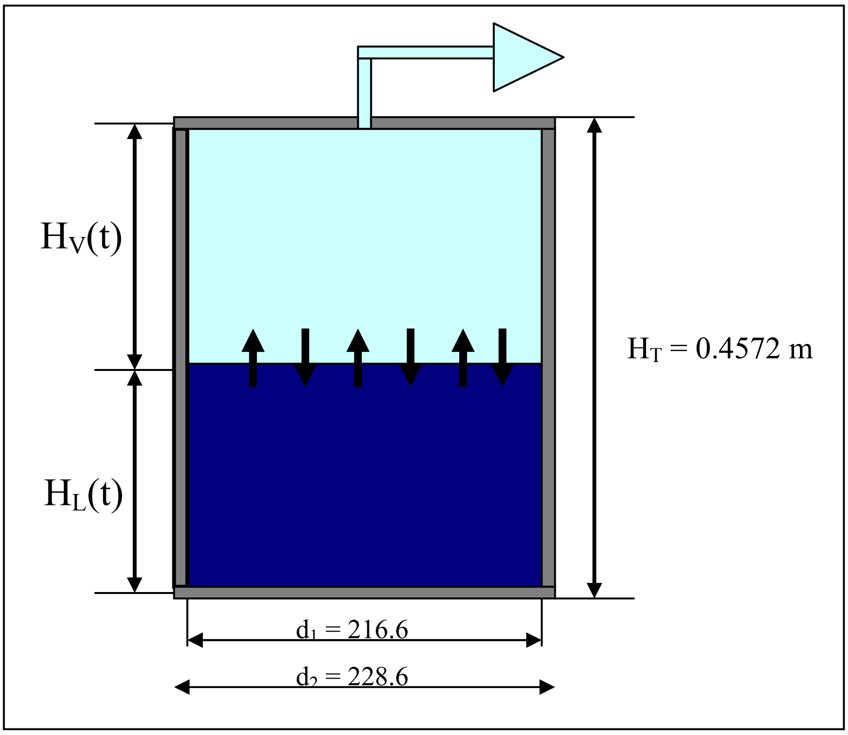


Figure 5.10: Tank Dimensions with Liquid and Vapor Levels

We recall that density of liquid can be related to the Rackett Equation. Therefore, the liquid height can be expressed as Equation (5.71)

$$H_L(t) = \frac{m_{C3}(t)}{A_X \dfrac{1}{V_{cC3} Z_{cC3}^{(1-T_r)^{0.2857}}}} + \frac{m_{C4}(t)}{A_X \dfrac{1}{V_{cC4} Z_{cC4}^{(1-T_r)^{0.2857}}}} \tag{5.71}$$

where,

H_L	= Total height of liquid
m_{C3}	= Mass of propane
m_{C4}	= Mass of butane
A_X	= Cross sectional wetted area
T_r	= Pseudo reduced temperature
V_{cC3}	= Critical molar volume of propane
V_{cC4}	= Critical molar volume of butane
Z_{cC3}	= Critical compressibility factor of propane
Z_{cC4}	= Critical compressibility factor of butane

With the liquid height already known, we can immediately obtain vapor height and vapor phase volume within the tank since total height does not change. Therefore, the vapor height is expressed as Equation (5.72).

$$H_V(t) = H_T(t) - H_L(t) \tag{5.72}$$

where,

H_V	= Height of vapor
H_T	= Total height of cylinder
H_L	= Height of liquid
t	= Time

5.5 Model Verifications

The verification was based on the LPG at composition of 6040, flowrate of 48 liter per minute and surrounding temperature of 30^{o}C. The profiles temperature distribution, pressure, liquid level, composition of vapor and liquid and weight will be discussed separately. The measured results from the experiments for all parameters under study were shown to be of lower value compared with the model.

5.5.1 Temperature Distribution Profile

Even though there are several temperature sensors used to record the liquid LPG temperature in the test cylinder, the lowest and the upper sensors were selected to compare with the reading given by the model. This concept is to make sure that the temperature recorded is always by the sensor in liquid phase and vapor phase. This is because the reading recorded by the model is the temperature of bulk liquid and bulk vapor. Furthermore, the result of temperature profile only highlighted the test parameters at constant flowrate and surrounding temperature but varies with LPG compositions.

Figure 5.11 and Figure 5.12 show the temperature profiles of liquid and vapor temperature. A rather good agreement between the theoretical and experimental data was obtained. This is due to the pattern of temperature changing, which is reduced at the initial stage but will be increased latter. However, the result based on the model is slightly lower than the experimental for both phases. The difference may be due to the fact that ice layer that exist on the cylinder is assumed to be of constant thickness whereas in the actual condition, the thickness of ice layer is thicker at the bottom part. This theory is almost valid if we look at the vapor temperature profile which is the difference is too small. The difference also might be due to the both phases being measured based on bulk temperature for the model whereas the actual fact is the temperature at the most bottom and upper was respectively lower and higher temperature. The range of the difference was 0.24% to 5.03 % for liquid temperature and 2.44% to 3.69% for vapor temperature between the experiment and model data respectively. This was because during evaporation process; the heat required was from the surroundings and from the liquid itself (Conrado & Vesovic, 2000). The latent heat of evaporation was from two sources for a short period, but with time the source was from the liquid only. Although the heat was still supplied by the surroundings, it was in a small quantity due to the resistance to the formation of ice on the outer wall of the cylinder.

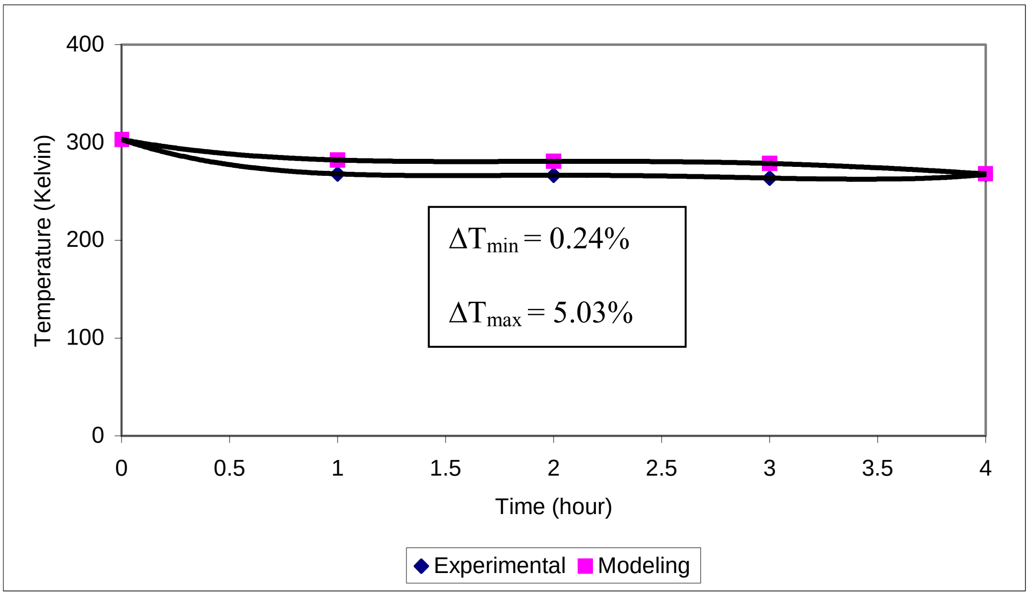


Figure 5.11 Liquid Temperature of Mixture 6040 at Surrounding Temperature of 30°C and Discharge Flowrate of 48 Liter Per Minute

Based on the Figures, cooling was seen terrible for the first one hour. Further evaporation will further decrease in temperature. Although there was also a decrease in temperature at thermocouple in vapor phase for the first one-hour, the reduction was due to the discharge of cool vapor. At the end of the experiment, all temperature readings were tending to reach a control temperature, which is the surrounding temperature of cylinder. The thermocouple will turn the position in other phase when the increase of temperature is sudden. This condition was due to heat needed for evaporation only from the liquid content and not the vapor content.

The role of temperature on vaporization process was determined by the comparison of temperature readings recorded in liquid phase. This was because the thermocouple in liquid phase continuously recorded the liquid temperature and the lowest temperature until the cylinder was almost empty. If the temperature readings in liquid phase were close to boiling point or dew point temperatures, vaporization would be very slow and might stop if temperatures were below those point temperatures (Leary, 1980). At this point, there is no more LPG that will vaporize and it will be left with the residue in the cylinder. Therefore, to minimize the left over problem the liquid temperature must be avoided from reaching the boiling or dew point.

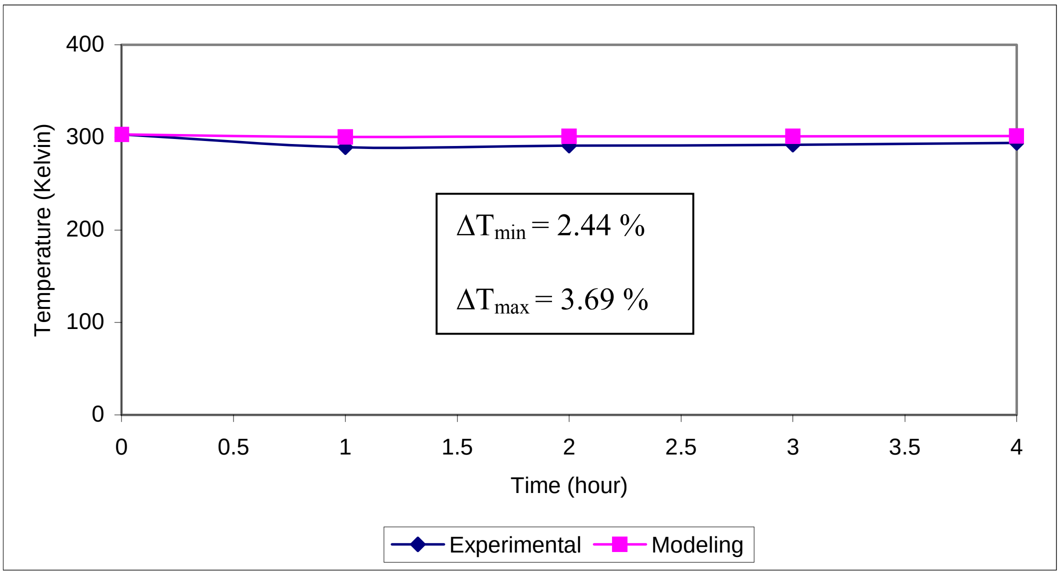
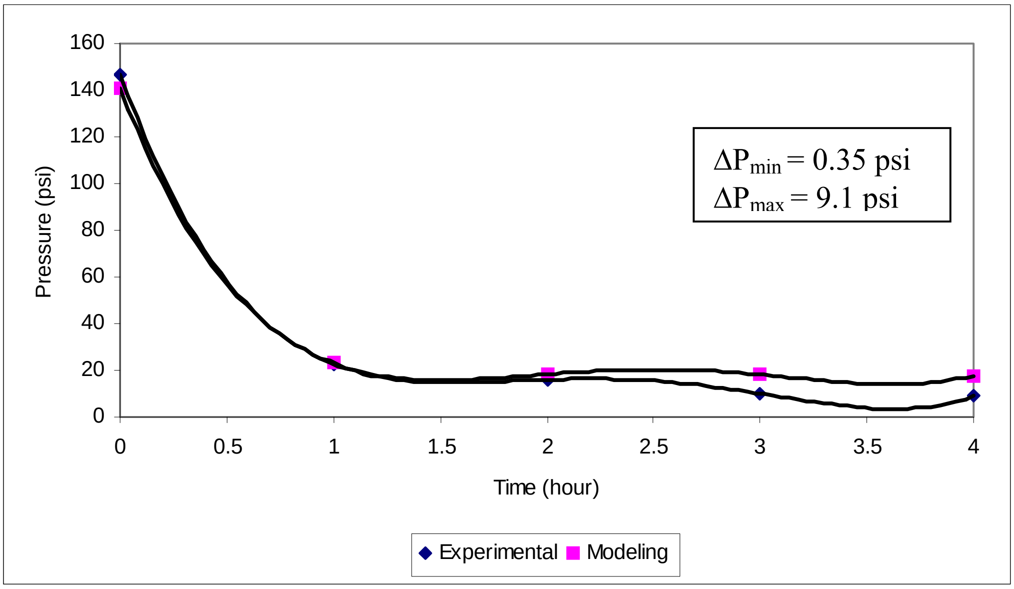


Figure 5.12: Vapor Temperature of Mixture 6040 at Surrounding Temperature of 30°C and Discharge Flowrate of 48 Liter Per Minute

5.5.2 Pressure Profile

Figure 5.13 were shows a pressure distribution profile obtained from the experiment and model respectively. Again, there is a rather good agreement between the two methods. Based on the figure, both methods showed similar trend of pressure reduction. However, the deviation started after 1.5 hour of discharging operation and became higher toward the end which is the pressure detected by the experiment which is always at the lower site. The range of the difference between both methods of measurement was 0.35 psi to 9.1 psi. However, the difference is almost constant when the discharging operation reached to hour 3 at the end.

The possible reason that contributed to the differences between both methods is as mentioned in sub-section 5.5.1, which is due to the assumption of the thickness of the ice formation layer form onto the cylinder wall so that it will contribute to the value of the sensible heat used in the model considerations. Since similar trend is achieved and the deviation is under acceptable range, therefore, the developed model can be considered as a suitable tool in the prediction of the pressure during the discharging operation of LPG from the cylinder or vessel.



Figures 5.13: Pressure Distribution Profile of Mixture 6040 at Surrounding Temperature of 30°C and Discharge Flow rate of 48 Liter Per Minute

5.5.3 Composition Distribution Profile

Similar to the temperature and pressure profile, the deviation was gathered on the composition of vapor and liquid profile as shown in Figure 5.14 and Figure 5.15 respectively. Even though the distribution trend was quite similar between both methods but the difference was slightly higher and the difference increases towards the end of the discharging operation except for the liquid composition.

This factor might be due to the similar temperature value as mentioned in sub-section 5.5.1 since the propane component is very volatile or sensitive to the temperature.

Another possible reason is due to the location of the measurement since the model was detected in the cylinder where the experiment was measured outside of the cylinder.

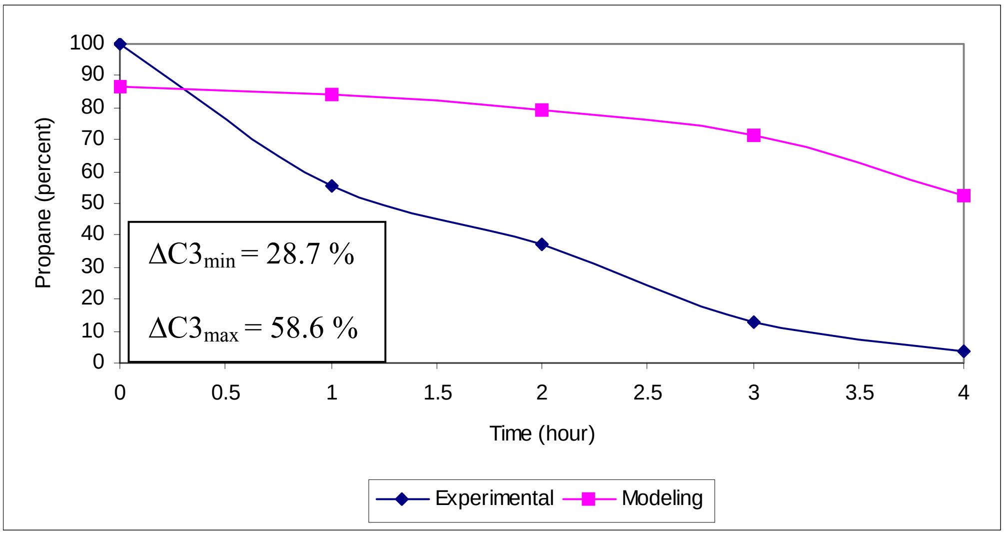


Figure 5.14: Vapor composition of Mixture 6040 at Surrounding Temperature of 30°C and Discharge Flow rate of 48 Liter Per Minute

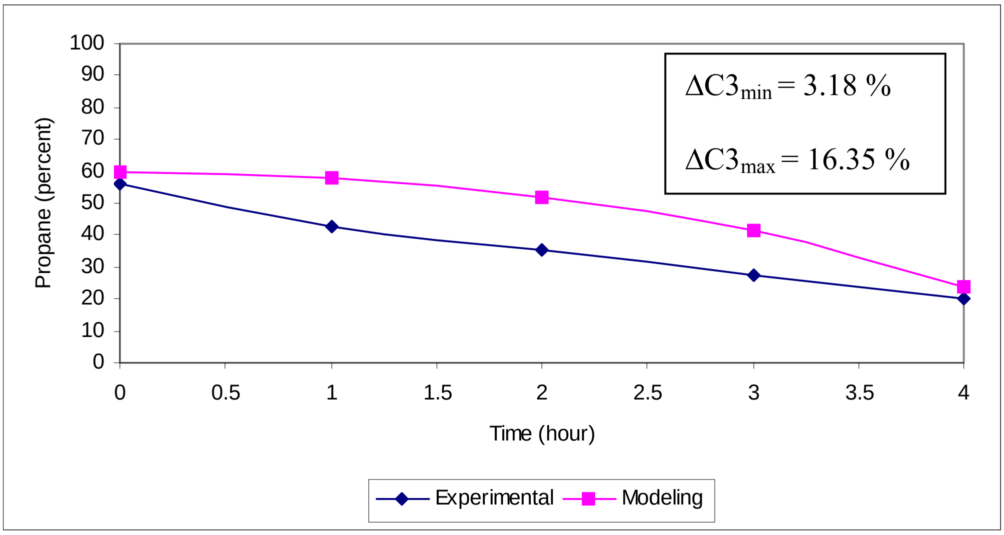


Figure 5.15: Liquid composition of Mixture 6040 at Surrounding Temperature of 30°C and Discharge Flow rate of 48 Liter Per Minute

Therefore, it believed that the difference between the both methods would be minimized if the above-mentioned factor is avoided. Again, this argument is considered valid since the difference in the liquid composition was small since both cases the measurement was in the cylinder except the detection point. The range of difference for vapor and liquid was 28.7% to 58.6% and 3.18% to 16.35% respectively. In conjunction to that, the developed model again can be recommended as a suitable tool in the prediction of the LPG composition through out the discharging operation.

5.5.4 Liquid Level Distribution Profile

Figure 5.16 shows a good agreement of both methods. However, the experiment result gave a lower level through out the discharging operation. Furthermore, the difference between both methods was quite constant at all times except for the period before it reached the first one hour. Again, it might be due to the unequal temperature as mentioned in sub-section 5.5.1. The liquid level measured in the experiment method was taken as an average level since it is not in stagnant condition because of the involvement of the liquid circulation process due to the difference of density of LPG between at the bottom and upper portion of the cylinder especially at the higher discharging flowrate.

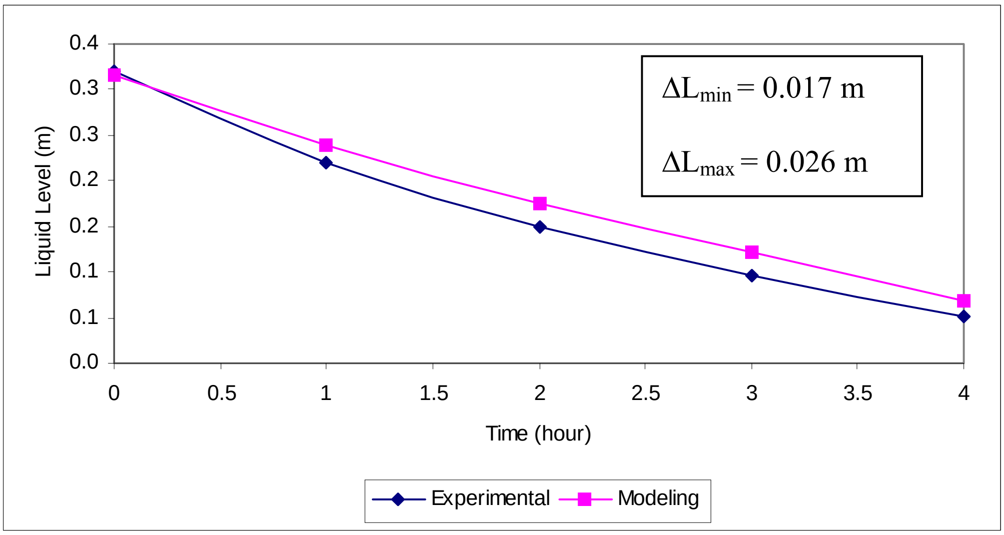


Figure 5.16: Liquid level of Mixture 6040 at Surrounding Temperature of 30°C and Discharge Flow rate of 48 Liter Per Minute

The liquid level would contribute to the cylinder-wetted area, which is one of the main factors that influence the rate of evaporation that contributed to the residue amount. By getting the actual liquid level through out the discharging operation then the amount of sensible heat supplied into the cylinder could be predicted. Therefore, the maximum allowable discharging flowrate would be advisable to be related to the minimum residue amount (Leary, 1980) since there is probably no single method to completely empty the cylinder.

However, the developed model successful and consideration as a prediction tool will become beneficial since the difference was considered small which varies from 0.017 m to 0.026 m.

5.5.5 Weight Distribution Profile

The most important parameter in evaluating the residue amount is the weight distribution profile since it will provide real time result. The developed model was successful in the real time determination. Even though there were deviations in the both methods along the way of discharging process but it keep decreasing towards the end as shown in Figure 5.17.

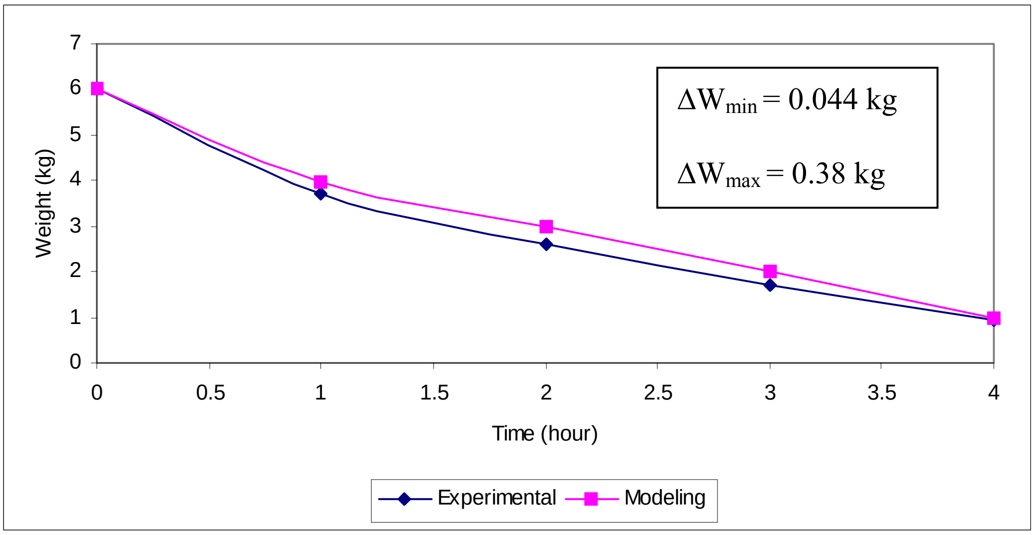


Figure 5.17: Weight distribution profile of Mixture 6040 at Surrounding Temperature of 30^{o}C and Discharge Flow rate of 48 Liter Per Minute

Based on the figure, the difference of the residue amount of the mixture of 6040 at the surrounding temperature of 30°C and discharge flowrate of 48 liter per minute was 0.044kg. As mentioned in sub-section 5.5.1, the deviation between both methods is again, might be due to the effect of unequal temperature that has been considered especially in the prediction through model since it is a major contributing factor to the evaporation process.

5.6 Summary

There are many models for the description of behavior of the LPG vessel but not even one discussed about LPG vaporization behavior related to the residue. Therefore, in this study, a simple theoretical model is proposed, which gives the main features of an influence of the profiles of the distribution of temperature, pressure, flowrate, discharge composition as well as liquid level to the left over problem. A model of the process is first developed based on the readily available experimental data. A rather good agreement between the theoretical and experimental data was obtained; therefore it would be recommended as a suitable tool in the prediction of the LPG behaviors through out the discharging operation.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This research will identify the problem that associated with the problems of 30% LPG residue in LPG cylinder through continuous exhaustion. This research is a national interest as 90% of LPG liquid in LPG cylinder is expected can be consumed. However, there is no single method capable to empty the LPG cylinder.

Based on the experimental study, several conclusions can be addressed as follows:

1. There is a relationship between factors affect the evaporation process to the residue amount. The relationship developed is based on the curve fix method and below are the relationships:
    a. Effect of flowrate

    $$\mathrm{Re}\,sidue(kg) = 9\,x10^{-5}\;x(Q)^2 - 0.001\,x(Q) + 0.0381$$

    b. Effect of surrounding temperature

    $$\mathrm{Re}\,sidue\,(kg) = 4.5241\,x\,e^{-0.1236(T)}$$

    c. Effect of mixture of composition

    $$\mathrm{Re}\,sidue\,(kg) = 2\,x10^{-5}\;x(C_3H_8)^2 - 0.006(C_3H_8) + 0.3628$$

    d. Effect of initial weight of filling

    $$\mathrm{Re}\,sidue(kg) = -\,0.0071(wt)^2 + 0.1009(wt) - 0.1617$$

2. The compositions of propane of 60% or more must be considered in the planning of the design of liquefied petroleum gas composition for use in Malaysia to get better performance of flame characteristic as well as to achieve minimum leftover problem.

3. The surrounding temperature can be used in the selection of the method of liquefied petroleum gas installation either through batch evaporation or flash evaporation. The minimum level of the surrounding temperature for the batch evaporation method is 25^{o}C. Therefore, for the area that has the surrounding temperature below than 25^{o}C flash evaporation method must be considered.
4. The initial weight of liquefied petroleum gas affects the residue amount, which increases when the initial weight increases. This is due to the longer time of evaporation process so that the possibility of liquid temperature achieving its boiling point becomes higher. Therefore, the higher the difference with the boiling point, it will be more advantageous for emptying LPG out of the cylinder.
5. The discharging flowrate plays an important role on the residue amount in the cylinder. Therefore, the design of discharging flowrate must be related to the vessel capacity since it is related to the amount of heat supplied since the higher the discharging flowrate will contribute the higher the residue amount.
6. The temperature drop holds the key role as it has a strong impact on cylinder performance. During discharging phase, the temperature drop is a function of several parameters, i.e., gas composition, flow rate, cylinder design and geometry, material of construction and surrounding temperature. One of the useful methods to analyze heat distribution in a cylinder is based on the dimensionless analysis, which is on the basis of axial and radial flow direction since it will provide a clear picture on the cylinder thermal behavior. The distribution of heat profile in the cylinder can be highlighted as follows:
    a. The distribution of heat from the surroundings to the internal cylinder is not equal with the heat used for the evaporation process. The sensible heat used for evaporation process is taken mainly at the internal wall so that the heat cannot be distributed into the centre of the cylinder. It means that, the distribution of heat from the surrounding to the internal cylinder is not equal with the heat used for the evaporation process. However, at the early stage of the evaporation process the sensible heat used is taken from both sources, which are from the surrounding and liquid molecules.

b. The heat derive as a sensible heat for the evaporation process is not enough from surrounding since the reduction of temperature from external wall to the internal wall was very high compared to temperature drop from the internal wall to centre of the cylinder.
c. The reduction of temperature from the external wall to the internal wall is less compare to temperature drop from the internal wall to the centre of the cylinder. This is show that, the heat derive as a sensible heat for the evaporation process is not enough supplied from surrounding. Therefore, the heat is consumed from the liquid molecules and the higher the flow rate the bigger the heat required for the evaporation process.
d. The gradient of the temperature drop is different in both phases, which is the gas phase and liquid phase. The higher gradient of temperature drops shows that the vapor temperature kept increasing since the heat is not used as a sensible heat for the evaporation process.

6.2 Recommendations

Considering in the present study, a recommendation can be proposed for further work is an analyzing the temperature distribution profile through developing of a mathematical model, which is including rollover phenomena in the liquefied petroleum gas cylinder.

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APPENDIX A

TEMPERATURE DATA &
TEMPERATURE DISTRIBUTION PROFILE

APPENDIX B

OTHERS EXPERIMENTAL DATA & PRESSURE DISTRIBUTION PROFILE

APPENDIX C

VAPOUR AND LIQUID DISTRIBUTION PROFILE

APPENDIX D

WEIGHT DISTRIBUTION PROFILE

APPENDIX E

FLOWRATE DISTRIBUTION PROFILE

APPENDIX F

LIQUID LEVEL DISTRIBUTION PROFILE

APPENDIX G

EXPERIMENTAL PROCEDURES

APPENDIX H

CALIBRATION RESULT

APPENDIX I

LIQUEFIED PETROLEUM GAS MIXING PROCEDURE

APPENDIX J

DIMENSION OF TESTING CYLINDER

APPENDIX K

MATHEMATICAL MODELING

Table A1: Temperatures Data of Commercial Propane for Surrounding Temperature of 30°C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	27.5	24.1	23.4	21.1	25.4	25.5	27.4	25.2	24.5	23.0	26.8	27.4	28.5	27.4	26.9	27.1	26.8	28.0
10	24.2	19.0	17.0	14.9	17.4	19.5	23.6	20.5	18.1	17.0	20.0	21.5	27.3	25.1	24.5	23.1	25.0	26.6
15	20.4	15.1	11.1	9.7	12.2	14.2	22.2	18.7	14.2	11.7	16.8	17.3	26.2	25.1	23.6	22.8	23.5	24.6
20	17.0	12.9	7.6	5.5	8.2	8.9	19.8	15.6	9.9	9.6	9.8	10.2	25.9	24.3	22.4	20.7	21.1	22.5
25	15.9	11.7	4.6	2.3	4.5	5.1	15.8	13.0	7.3	5.4	5.6	6.3	24.7	23.4	21.6	18.5	18.4	18.4
30	14.6	10.7	2.6	2.5	3.4	2.0	15.6	12.6	5.5	4.4	4.8	5.1	23.7	22.8	20.8	17.1	17.3	17.3
35	13.9	10.1	1.1	0.3	1.0	0.5	14.9	11.8	4.5	2.8	2.7	2.5	23.6	22.5	20.5	15.8	16.4	16.8
40	13.4	9.6	0.2	-1.4	-1.3	-1.8	14.5	11.3	3.7	1.9	1.8	1.8	23.1	22.0	20.5	14.8	15.1	15.9
45	12.4	8.6	-1.1	-2.4	-3.2	-3.7	13.4	10.3	2.5	0.9	0.8	0.2	22.7	21.7	19.6	13.7	12.4	12.2
50	12.4	7.6	-1.8	-3.1	-4.9	-5.6	13.5	9.0	1.3	-0.2	-0.7	-0.9	22.2	20.7	19.0	13.3	10.8	10.6
55	12.6	9.2	-0.6	-5.0	-5.7	-6.6	13.6	11.0	6.3	-1.5	-1.4	-2.5	23.5	22.9	20.2	13.3	10.5	9.9
60	13.8	10.7	0.9	-4.5	-5.5	-6.8	14.5	11.4	1.9	-2.1	-4.6	-5.8	23.5	20.6	19.2	13.7	11.9	10.2
90	14.4	11.2	3.1	-4.8	-6.0	-7.4	15.1	12.9	3.6	-3.8	-5.5	-6.8	24.2	21.6	18.7	12.5	10.7	8.6
120	15.3	12.2	5.7	-4.2	-6.9	-7.8	16.8	13.6	6.4	-3.1	-6.1	-7.1	25.5	22.6	19.5	13.6	9.4	7.7
150	16.3	13.6	7.4	-3.2	-8.6	-11.9	17.7	14.2	8.3	-2.9	-7.5	-11.3	26.1	23.6	20.5	14.4	8.9	6.7
180	22.7	18.3	11.9	1.4	-9.6	-14.9	23.3	19.8	12.5	2.1	-8.8	-14.1	26.3	23.9	21.3	15.4	10.5	4.7
210	23.9	20.1	15.5	5.6	-2.1	-12.2	24.4	20.8	16.9	6.4	-1.4	-11.6	28.2	26.7	25.7	20.7	11.4	6.5

Table A2: Temperatures Data of Commercial Butane for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.0
5	28.6	23.4	23.3	20.9	24.2	25.6	26.1	24.7	24.2	22.5	25.9	26.3	29.5	27.2	27.9	26.8	28.8	29.7
10	27.4	23.4	22.2	19.7	24.7	26.2	25.6	23.9	20.7	19.2	22.0	24.3	28.8	26.9	25.9	24.7	27.1	29.6
15	19.7	16.6	13.3	12.5	12.9	13.0	21.9	17.4	14.9	14.3	16.8	17.1	26.1	25.2	24.4	22.7	23.8	25.0
20	18.3	14.2	10.8	9.3	9.9	9.1	20.9	15.0	13.7	13.2	13.5	13.8	25.6	24.3	23.5	21.4	22.8	24.2
25	17.9	12.5	8.0	7.6	7.7	6.8	20.1	13.5	11.4	10.7	10.6	11.0	24.9	23.8	22.7	19.2	20.7	21.7
30	17.2	11.5	6.5	5.6	6.2	5.7	19.6	12.8	9.4	9.3	8.7	8.6	24.6	23.6	22.3	18.7	19.6	21.0
35	17.4	12.0	5.7	4.3	4.2	3.4	19.8	12.7	8.8	8.2	6.4	5.4	24.4	23.3	21.9	18.4	19.0	19.1
40	17.5	12.5	4.9	3.3	3.9	2.8	19.7	12.6	8.4	7.1	5.2	4.5	24.1	23.0	21.5	17.7	18.1	18.1
45	17.6	13.6	4.3	2.4	2.7	1.9	19.6	12.4	8.0	6.1	4.7	3.6	23.8	22.9	21.4	17.5	17.5	17.5
50	17.7	14.0	5.9	1.7	2.4	1.5	19.6	12.5	7.9	4.5	3.8	2.9	23.6	22.7	21.0	17.2	17.4	16.6
55	18.1	14.5	6.2	1.4	2.2	0.9	19.7	12.8	8.2	4.2	3.6	2.6	23.4	23.0	21.4	17.1	16.9	16.5
60	18.6	15.2	6.8	2.2	1.8	0.2	19.1	16.3	7.9	3.7	2.7	1.1	26.1	23.7	22.5	18.7	16.5	16.3
90	19.4	16.5	9.4	3.6	0.8	-0.6	20.4	17.3	9.6	2.1	1.1	0.6	26.4	24.6	21.5	15.9	14.6	15.6
120	20.5	17.8	10.7	3.7	0.4	-0.7	21.4	18.2	11.6	2.5	0.9	0.0	26.7	24.2	23.4	17.7	15.5	15.0
150	20.8	18.3	12.8	4.1	0.2	-0.7	21.5	19.3	13.5	4.7	0.1	0.0	27.1	25.9	24.7	18.3	14.5	13.9
180	21.3	18.7	14.2	5.7	0.0	-0.9	21.8	19.8	15.7	6.7	0.6	-0.5	27.3	26.1	25.2	19.9	15.6	13.0
210	21.3	20.8	15.6	6.3	1.6	-0.5	21.8	21.6	16.3	7.4	2.4	0.6	27.4	26.4	25.6	20.6	16.2	13.6
240	22.4	21.2	16.7	9.6	2.8	0.0	23.6	21.8	17.9	10.9	3.4	0.9	27.5	26.8	25.6	22.4	18.5	14.5
270	23.2	21.5	16.1	10.7	5.8	0.8	24.3	21.8	18.9	12.3	6.8	1.7	27.9	26.9	25.7	23.2	19.5	15.2
300	23.8	22.6	18.7	12.9	6.9	1.2	25.2	23.4	19.6	14.4	7.7	2.2	28.1	27.4	26.4	23.9	20.3	16.2
330	24.5	22.8	19.6	13.2	8.0	1.2	25.7	23.9	20.3	14.8	8.7	2.8	28.3	27.8	26.7	24.2	21.7	18.3
360	25.8	23.4	19.8	13.8	8.9	2.7	25.9	24.7	21.4	15.9	9.3	3.0	28.5	27.9	27.5	25.6	21.9	19.2
390	26.7	24.0	20.2	14.8	12.3	4.8	26.4	25.9	22.5	16.7	12.8	4.5	28.5	28.1	27.6	25.5	22.6	20.7

Table A3: Temperatures Data of 8020 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celcius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	17.0	15.8	15.3	17.1	21.4	24.0	27.8	26.4	24.7	23.9	25.2	25.6	28.4	27.4	26.5	24.9	27.8	28.9
10	25.6	20.2	18.7	16.1	19.4	21.3	24.1	21.3	18.5	17.2	20.2	21.8	27.5	25.6	24.9	23.3	26.4	28.3
15	14.8	11.0	5.8	9.4	11.1	8.7	20.2	13.1	9.7	9.8	10.0	10.8	26.7	24.9	23.4	21.2	25.5	27.3
20	15.2	10.3	4.5	6.3	7.8	5.3	19.7	12.3	7.4	7.1	6.8	7.3	26.5	24.6	22.6	20.2	24.4	25.9
25	14.5	9.2	3.6	3.2	2.8	2.1	18.9	11.3	6.0	4.6	3.7	3.9	25.9	23.9	22.1	18.7	22.7	25.3
30	14.5	8.9	2.2	0.7	1.7	-0.6	18.7	11.0	4.4	2.9	2.4	1.1	25.5	23.6	21.5	17.7	22.4	24.7
35	14.0	8.2	1.2	-0.1	-0.1	-1.2	18.4	10.4	4.5	1.8	1.0	0.2	25.0	22.9	21.5	17.2	21.7	22.4
40	13.8	8.0	0.1	-0.7	-1.1	-2.1	18.0	10.2	4.4	-0.3	-0.8	-1.2	24.9	22.8	21.2	16.3	19.8	19.2
45	13.2	9.7	-0.4	-1.0	-2.8	-3.0	17.8	10.0	4.0	-1.3	-1.6	-2.1	24.6	23.1	20.7	15.1	17.7	16.6
50	13.0	10.3	-0.7	-1.4	-3.2	-4.4	17.1	9.8	3.9	-2.2	-2.1	-3.5	24.4	22.6	20.8	14.9	15.9	14.2
55	13.1	10.5	-1.1	-2.0	-4.3	-5.8	16.7	10.0	3.1	-2.6	-3.2	-4.7	24.2	22.6	20.6	14.3	13.2	12.6
60	14.7	11.7	1.7	-2.3	-4.7	-6.1	15.7	12.1	2.5	-1.8	-3.8	-5.5	24.2	21.6	20.8	13.8	12.5	11.1
90	15.1	12.3	4.6	-3.2	-5.2	-6.8	16.5	13.9	5.1	-2.5	-4.4	-5.9	24.4	22.2	19.8	13.1	11.6	9.4
120	16.5	13.2	6.6	-3.0	-6.6	-7.6	17.4	14.4	7.3	-2.9	-5.8	-6.9	25.7	22.8	20.8	14.5	10.1	8.9
150	17.2	15.1	8.9	-2.3	-7.7	-10.4	18.9	16.4	9.2	-1.7	-6.2	-9.8	26.3	24.5	21.6	15.1	9.9	7.7
180	17.7	16.4	10.1	2.4	-8.7	-12.1	19.3	17.4	11.6	3.2	-7.9	-11.8	26.7	25.2	23.3	17.5	12.8	7.5
210	18.9	17.2	11.7	3.2	-6.5	-12.7	20.8	17.9	12.2	4.1	-5.7	-10.8	26.8	25.5	24.2	19.7	14.3	9.5
240	20.4	18.7	12.9	5.1	-3.4	-8.7	21.2	19.2	13.8	6.8	-2.8	-8.1	26.8	25.7	25.2	20.7	15.2	10.5
270	21.6	19.5	14.7	7.6	2.3	-4.2	22.4	20.4	15.2	8.3	3.2	-3.2	27.1	26.0	25.8	21.9	16.6	11.7
300	21.9	23.2	19.4	14.5	10.3	3.9	26.4	24.5	20.5	15.9	11.5	5.3	27.4	26.8	26.1	22.6	18.1	13.1

Table A4: Temperatures Data of 6040 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.2	26.0	24.9	25.1	25.5	26.1	29.3	28.4	27.4	26.4	25.6	25.9	29.5	28.7	26.1	27.6	29.1	29.3
10	26.6	21.7	20.5	17.1	22.3	23.4	24.9	22.9	19.3	18.1	22.7	22.4	28.1	26.2	25.3	24.8	26.7	29.1
15	18.8	17.1	14.8	15.9	16.6	16.8	24.2	18.6	16.5	16.8	17.8	17.3	25.1	24.8	25.7	24.4	26.3	27.0
20	17.4	14.2	9.3	12.1	13.5	10.6	22.1	16.4	11.5	13.0	14.1	14.0	24.8	24.3	24.4	23.5	25.5	26.4
25	16.2	12.6	7.4	9.4	7.1	6.1	21.5	15.1	10.6	11.0	10.4	8.9	25.0	24.3	23.2	22.8	24.7	24.9
30	14.5	12.0	6.3	7.3	0.8	2.6	20.9	13.4	9.5	8.4	6.1	4.5	25.1	23.8	22.4	22.3	24.2	24.4
35	14.4	11.2	4.6	5.6	1.8	-0.4	20.6	13.2	8.5	6.7	0.3	1.5	24.8	23.8	22.4	21.9	21.3	20.8
40	13.9	10.5	3.5	4.1	0.2	-1.6	20.4	12.7	7.6	5.2	1.5	0.9	24.9	23.6	22.0	21.7	19.9	19.3
45	14.3	10.3	2.9	2.9	-0.8	-2.2	20.2	12.7	6.9	4.9	2.5	-1.4	24.7	22.9	22.0	20.2	17.8	16.7
50	14.2	10.1	2.6	1.8	-1.5	-3.9	20.2	12.7	6.3	1.9	3.4	-2.1	24.5	21.6	21.4	18.4	16.9	15.6
55	13.9	9.8	2.1	0.7	-2.4	-4.3	20.0	12.7	6.0	0.7	-1.9	-3.9	24.5	22.1	20.9	17.5	15.5	14.9
60	16.2	12.5	2.7	-1.3	-3.5	-5.3	17.2	13.7	3.8	-0.1	-2.6	-4.9	25.1	22.5	19.4	16.7	14.2	13.9
90	17.1	13.6	6.6	-1.6	-4.3	-6.2	18.1	14.5	6.8	-1.1	-3.1	-5.3	25.3	22.9	20.3	14.0	12.8	11.3
120	17.9	14.4	7.5	-1.9	-5.2	-6.7	18.5	15.7	8.4	-0.9	-4.7	-6.3	25.9	23.4	21.7	15.1	11.9	10.6
150	18.7	16.3	9.3	-1.5	-6.6	-8.9	19.1	17.1	10.1	1.8	-5.2	-7.7	26.5	23.9	22.5	16.5	11.4	9.2
180	18.9	17.2	11.5	3.8	-6.7	-9.5	20.1	18.3	12.4	4.6	-6.2	-8.7	26.9	25.1	23.9	17.6	12.2	8.6
210	19.4	18.3	12.9	4.8	-5.6	-7.2	20.9	18.9	13.6	5.3	-4.7	-6.8	26.9	25.8	24.6	18.8	13.9	10.9
240	20.8	19.5	13.5	6.9	-1.6	-5.9	21.8	20.6	14.4	7.7	-1.7	-4.6	27.1	25.9	24.9	19.1	15.7	11.8
270	22.2	20.5	14.8	8.7	2.8	-3.2	22.9	20.6	15.9	9.5	3.9	-2.6	27.3	26.1	25.3	21.6	16.5	13.1
300	22.8	20.8	16.5	9.3	4.2	-1.3	23.5	21.2	17.1	10.5	4.7	-1.2	27.6	26.7	26.5	22.8	18.7	14.9
330	23.8	22.4	20.6	14.5	9.8	-0.1	26.3	24.1	21.4	15.3	10.5	0.7	27.9	27.1	26.9	23.5	19.2	15.3

Table A5: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.2	25.7	24.5	26.9	29.4	28.7	27.7	25.8	25.2	27.8	29.6	29.5	29.2	27.4	26.4	30.6	30.9
10	27.1	22.1	21.7	18.9	23.5	24.3	25.4	23.6	20.2	20.7	24.3	24.9	24.4	26.7	25.3	24.4	26.8	29.6
15	25.2	23.6	19.8	18.1	20.4	21.1	24.9	23.2	19.3	19.5	21.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	20.9	18.8	14.9	13.0	15.1	16.3	23.9	22.7	18.1	16.1	18.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	18.7	16.3	11.4	11.9	8.9	7.3	22.8	21.4	17.9	14.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	16.4	14.8	6.1	9.6	5.3	4.6	21.8	20.3	14.1	12.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	15.3	13.8	4.3	8.7	3.1	1.8	20.3	18.2	10.2	9.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	14.3	11.1	3.6	5.9	1.0	0.4	20.8	16.1	8.4	7.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	10.8	2.3	3.0	0.3	-1.8	19.3	14.1	6.7	4.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	14.7	12.0	3.0	2.1	-0.3	-1.9	18.6	13.3	4.9	2.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	15.4	13.3	3.2	0.5	-1.0	-2.0	17.5	14.3	4.2	1.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	17.8	14.8	4.5	1.2	-1.3	-3.1	18.8	15.2	5.1	2.1	-0.3	-2.7	26.4	24.6	23.2	16.3	15.8	15.3
90	18.6	15.7	8.5	2.9	-2.4	-3.4	19.8	16.6	8.8	0.6	-1.9	-2.9	25.6	23.8	20.7	14.7	13.6	13.3
120	19.5	16.4	9.8	3.9	-2.6	-3.8	20.7	17.1	10.8	1.8	-1.1	-3.2	26.2	24.3	22.8	16.7	14.6	13.6
150	19.9	17.6	13.1	4.5	-2.1	-4.4	20.9	18.7	12.6	3.8	-1.4	-3.6	26.5	24.5	23.9	18.0	16.3	12.4
180	20.4	19.9	14.8	5.7	-1.0	-2.8	21.9	17.9	14.1	5.2	-1.6	-3.9	27.3	25.8	24.2	18.7	17.2	13.0
210	21.1	20.2	15.4	8.7	1.1	-1.8	22.2	18.2	15.5	6.2	0.1	-2.2	27.6	26.1	24.5	20.4	17.6	12.9
240	22.8	21.2	16.4	10.1	4.8	-0.9	23.5	19.4	16.8	9.4	2.2	-1.1	27.8	25.4	24.7	22.0	18.6	13.4
270	23.4	21.9	17.8	11.8	5.2	0.0	24.2	20.9	18.4	11.5	5.9	0.4	27.9	25.7	24.9	22.7	19.5	14.9
300	24.1	22.2	18.2	12.4	6.8	1.1	24.6	21.5	19.8	13.7	8.4	1.4	28.0	26.2	25.2	23.3	20.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	23.5	20.6	15.0	10.6	3.1	28.2	26.4	25.4	23.9	21.9	17.4
360	25.5	23.4	20.8	14.8	8.9	3.7	26.0	24.9	21.2	17.8	12.4	6.9	28.6	26.7	25.8	24.9	23.0	18.8

Table A6: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 70 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30	30.7	29.9	30.3	30.6	30.1	30	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	30.1	28.9	28	21.5	29.2	29.4	29.5	28.3	29	26.8	29.7	30.5	29.8	29.5	29.5	27.7	30.4	30
10	19.1	15.4	12.7	8.9	26.5	27.3	22.1	17	15.7	14	26.5	29.2	27.3	26.1	25.6	24.8	27.7	29.3
15	17.9	12.7	7.1	6.3	15.5	26.8	21.3	15.3	9.4	8.5	18.1	28.4	25.9	24.2	22.9	21.8	26.4	29.3
20	16.9	11.8	6.8	5.9	10.5	15.2	20.5	13.9	9.1	7.7	15.1	21.1	24.5	22.8	22.2	21.4	24.1	26.7
25	15.6	11.3	5.8	4.7	9.5	10.3	20.3	13.5	7.8	7.5	13	18.1	24.2	22.9	22	20.6	22.5	24.4
30	15.4	7.8	5.1	2.6	7.3	9.6	20	12.2	7	5.8	8.4	13.1	23.7	22.5	21.7	18.7	20.8	22.1
35	15.4	10.5	4	1.7	6.4	6.1	19.4	12.7	5.2	3.4	8.2	11	23.5	21.3	20.1	18.1	18.6	20.1
40	14.1	10.3	3.3	-0.1	3.6	3.2	19.3	12.3	4.5	1.6	5.4	8.4	23.2	20.3	19.7	17.3	17.6	18.4
45	13.8	9.6	2.1	-2.4	-0.8	-1.1	18.9	11.8	4	-0.6	2.5	3.9	22.8	20	19.4	15.8	16.6	15.8
50	13.5	9.5	1.6	-3.7	-1.5	-1.5	18.7	11.4	3.5	-1.8	-0.1	2.2	22.7	19.8	19.1	15	16.2	13
55	13.4	9.4	1.3	-5.6	-3.5	-3.6	18.4	11.1	3.1	-2.7	-1.9	0	22.5	19.6	18.6	12.4	13.3	11.6
60	13.4	7.8	0.5	-5	-5.3	-5.9	18	11.6	2.4	-3.8	-3.9	-2.9	22.3	20.3	18	10.3	9.9	8.3
90	14.6	10	1.1	-4.8	-5.8	-6.3	17.4	12.5	2.9	-4.3	-4.1	-3.7	22	20.6	18.4	9.6	8.3	7.3
120	16.5	11.6	4.3	-4.4	-6.1	-6.5	18.1	13.5	5.8	-3.9	-5.6	-4.5	22.6	21.3	19.5	8.7	8.1	6
150	17.9	12.6	6.2	-3.5	-5.1	-6.7	19.3	14.7	7.5	-2	-4.3	-5.4	23.6	21.6	19.9	8.5	6.5	4.5
180	20.4	15.3	8.6	-1.6	-4.2	-6.8	21.5	16.3	9.5	0.4	-3.6	-5.5	24.4	21.7	20.4	10.1	6.8	3.9
210	21.4	16.1	9.6	2.2	-2.4	-6	22.8	19.8	11.2	3.9	-2	-4.3	25.6	22.7	20.6	11.5	8.4	5.1
240	22	18	12.7	2.8	-0.4	-4	24.3	20.1	14.9	5.4	0.3	-2.5	26.3	23.3	21.1	13	10.4	6.5
270	22.6	18.8	14.3	4.7	1.8	-1.9	24.6	21	16.6	6.4	3.1	0.5	26.9	24.2	21.5	15.1	12	8.9
300	22.8	19.3	15.2	5.7	2.7	-1.5	25.4	22.8	20.8	7.1	4.8	1.6	27.3	25.3	22.9	17.6	14.3	11.4
330	23.1	20.3	16.7	7.5	4.5	-0.7	25.9	23.5	21.4	9.8	5.3	2.5	27.8	26.5	23.4	19.1	16.3	13.9
360	25	22.6	19.2	12.4	6.8	2.7	26.6	24.5	22.7	13.7	7.3	4.2	28.3	27	25.2	23.2	18.8	15.4
380	25.6	23.3	20.4	14	11.2	4.6	27.1	25.2	23.7	15.1	12.6	6.1	28.6	27.7	26.4	24.9	21.3	17.4

Table A7: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 60 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	28.4	27.5	24.0	25.5	27.3	29.9	29.4	28.2	26.2	28.2	29.6	30.4	30.3	28.9	27.7	28.7	30.3	30.5
10	19.9	16.5	13.3	9.6	27.1	29.7	22.3	18.6	16.8	14.9	27.9	28.9	28.1	26.9	25.3	24.9	28.1	29.4
15	16.9	12.3	7.4	7.0	20.1	26.2	19.9	15.3	12.4	13.9	22.4	28.4	25.8	24.0	23.5	22.2	26.9	29.0
20	15.2	10.1	6.5	5.4	15.2	21.4	19.5	11.9	9.6	10.9	17.0	22.7	24.8	23.3	22.4	20.8	25.3	26.3
25	13.7	9.5	5.8	4.3	10.3	16.1	19.4	11.6	9.0	9.3	14.6	17.8	24.4	23.1	22.1	20.5	23.4	24.0
30	14.9	8.7	5.6	3.8	8.6	10.3	19.1	12.9	7.9	7.7	9.4	14.3	24.3	23.1	21.9	20.1	21.7	23.2
35	15.9	9.8	5.0	3.2	5.5	6.2	18.8	13.2	7.5	6.5	7.4	10.0	24.2	22.9	21.6	19.9	21.4	21.5
40	16.0	10.7	4.9	3.0	4.6	5.2	19.0	13.6	7.3	4.8	5.4	7.1	24.0	22.7	21.5	18.8	20.2	19.7
45	16.4	11.8	4.8	1.2	2.8	2.4	19.2	13.9	6.9	4.0	3.8	5.4	23.8	22.4	21.1	18.5	17.4	17.9
50	16.6	12.0	4.7	-0.1	1.4	1.0	19.5	14.2	6.7	2.6	2.1	3.2	23.6	22.3	21.0	17.4	15.0	15.3
55	16.7	12.1	4.4	-1.6	0.3	-0.2	19.7	14.5	6.5	0.4	1.0	2.2	23.3	22.5	20.4	14.8	12.9	12.3
60	16.9	12.4	4.6	-2.3	-2.4	-2.8	19.9	13.6	5.7	-2.1	-1.4	-1.6	23.1	21.8	20.0	12.5	11.5	9.9
90	17.1	12.8	4.9	-3.4	-3.6	-4.7	20.2	14.1	5.6	-2.2	-3.0	-2.9	24.1	22.0	20.6	11.4	10.4	9.4
120	17.7	13.0	5.3	-4.3	-4.1	-5.8	20.4	15.5	6.3	-2.7	-3.6	-3.7	24.3	22.5	21.2	9.9	9.7	8.4
150	19.7	13.9	6.8	-2.4	-4.2	-6.3	21.1	16.6	7.5	-1.6	-2.9	-3.0	24.6	22.7	21.6	9.3	8.7	6.9
180	20.9	15.9	9.1	-0.5	-3.3	-6.4	22.3	17.3	10.1	1.9	-3.2	-3.8	24.9	23.3	21.9	12.5	9.8	5.5
210	21.6	16.5	10.2	2.5	-2.0	-5.7	23.4	18.7	12.1	3.7	-0.9	-2.9	26.1	23.6	22.5	13.2	8.4	5.1
240	22.5	18.7	13.1	3.8	0.5	-3.4	24.0	20.0	15.7	5.2	1.1	-1.2	26.5	24.4	22.7	15.0	12.2	8.6
270	23.3	19.2	14.6	5.2	2.6	-1.4	25.2	21.0	17.9	7.6	3.8	1.5	27.1	24.6	23.4	16.3	13.8	9.9
300	24.1	20.9	15.9	6.6	3.5	-0.9	25.5	22.6	19.1	8.9	5.3	2.4	27.5	25.6	24.2	18.3	15.2	12.6
330	24.9	22.0	17.4	7.3	4.7	0.4	26.5	23.2	20.8	9.5	6.6	3.7	28.1	26.8	25.1	21.6	17.4	15.1
360	25.6	23.1	19.8	13.1	7.9	3.3	27.2	24.6	21.3	15.2	9.1	5.1	28.8	28.4	26.7	23.0	20.6	18.4
390	26.7	24.5	21.6	16.3	10.1	5.3	27.6	25.3	22.7	18.5	13.1	8.4	29.1	28.7	28.3	24.4	21.8	20.1

Table A8: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.5	17.2	17.7	22.5	28.9	25.4	25.7	24.7	26.1	24.2	29.8	30.6	29.5	29.2	27.4	26.4	30.6	30.9
10	15.1	9.1	7.0	8.9	26.5	24.3	24.1	17.6	12.0	14.3	27.3	30.3	29.4	28.7	26.3	25.4	29.8	30.8
15	14.2	4.6	2.8	4.1	10.4	17.1	23.9	17.2	10.3	13.5	17.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	13.9	3.8	1.9	3.0	5.1	10.3	23.9	16.7	11.1	12.1	10.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	13.7	4.3	1.4	1.9	2.9	5.3	23.8	16.4	11.9	11.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	13.4	4.8	0.1	0.6	1.3	2.6	23.8	16.3	12.1	11.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	13.3	5.8	-0.3	-0.7	1.1	1.8	23.3	16.2	12.2	10.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	13.3	6.1	-0.6	-0.9	0.0	0.4	22.8	16.1	12.4	8.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	6.8	-0.3	-1.0	0.3	-1.8	22.3	16.1	12.7	7.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	12.7	7.0	0.0	-1.1	-1.3	-1.9	21.6	15.3	12.9	5.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	12.4	7.3	0.2	-1.5	-1.7	-2.0	21.5	15.3	13.2	4.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	13.4	7.8	1.5	-2.0	-2.3	-3.1	21.8	15.2	13.9	5.7	-0.3	-0.7	26.4	24.6	23.2	16.3	15.8	15.3
90	14.6	10.0	2.5	-3.0	-3.3	-4.4	19.8	14.6	14.1	6.6	-1.9	-3.2	25.0	23.8	23.7	14.7	13.6	13.3
120	15.5	11.4	4.8	-2.0	-2.6	-4.2	19.7	15.1	14.8	8.8	-1.7	-3.0	25.2	24.3	23.8	15.7	14.6	13.6
150	16.9	13.1	7.2	0.0	-1.4	-3.2	19.9	16.7	15.6	11.8	-0.7	-2.0	26.1	24.5	23.9	18.0	16.3	13.4
180	17.9	14.6	9.1	1.5	-1.0	-2.4	21.9	17.9	16.1	13.2	1.3	-1.3	26.3	24.8	24.2	18.7	17.2	13.5
210	19.4	15.9	10.8	4.7	-0.5	-1.8	23.2	18.2	17.1	14.2	2.1	-0.2	26.6	25.1	24.5	20.4	17.6	13.9
240	20.1	17.2	12.4	7.0	-0.1	-1.4	23.5	19.4	18.8	15.4	4.2	0.1	26.8	25.4	24.7	22.0	18.6	14.4
270	20.8	18.3	13.8	8.1	1.8	-1.3	24.2	19.9	19.4	16.5	6.9	0.4	26.9	25.7	24.9	22.7	19.5	14.9
300	21.4	19.0	14.8	8.8	2.0	-1.5	24.6	20.5	19.8	17.7	8.4	1.4	27.3	26.2	25.2	23.3	20.6	15.8
330	22.1	19.9	16.2	11.4	4.8	-0.7	25.2	21.5	20.6	18.0	10.6	3.1	27.5	26.4	25.4	23.9	21.9	17.4
360	23.5	21.8	19.2	15.0	6.8	2.7	26.0	23.9	22.2	20.8	14.4	6.9	27.6	26.7	25.8	24.9	23.0	18.8

Table A9: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 30 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.3	26.3	25.9	28.0	28.7	28.9	28.1	27.8	26.5	28.3	29.7	29.3	28.5	28.6	27.3	29.7	30.9
10	25.1	19.6	17.1	14.2	26.0	27.6	26.4	24.9	23.4	18.5	27.8	29.0	28.8	28.1	25.5	26.7	28.5	29.7
15	23.9	16.4	10.4	9.5	23.4	24.6	24.2	22.8	14.8	14.0	25.7	27.3	27.5	25.3	24.8	23.7	26.8	28.6
20	21.3	15.3	9.6	8.6	19.4	20.8	22.0	20.8	13.5	12.7	20.9	25.5	26.7	24.0	23.7	22.7	25.1	27.1
25	19.5	14.4	8.8	7.9	16.8	17.6	21.9	18.4	12.1	10.8	18.1	23.1	26.4	23.4	23.3	22.2	23.2	26.7
30	17.8	13.7	8.1	7.5	12.8	15.2	22.8	17.0	11.3	9.7	15.9	18.9	25.7	23.3	23.2	22.3	23.7	25.6
35	17.7	12.4	8.3	6.9	11.6	12.5	19.6	14.6	9.6	8.8	12.5	16.1	25.4	23.0	22.8	21.2	21.0	21.9
40	17.9	13.1	8.2	6.5	9.0	10.9	18.4	14.5	9.4	7.1	11.9	13.4	25.5	22.6	22.5	20.5	20.4	21.4
45	18.1	13.6	7.8	6.3	7.7	8.4	18.6	14.8	9.0	8.2	9.7	10.3	25.1	22.4	22.3	20.4	20.2	20.0
50	18.2	13.9	7.3	6.0	5.6	6.2	19.1	15.0	8.5	7.8	7.6	8.1	25.3	22.3	22.1	19.6	18.8	19.0
55	18.4	14.3	7.1	5.5	4.7	5.2	19.8	15.8	8.4	6.9	6.0	7.3	25.4	23.0	22.8	19.1	18.5	17.1
60	18.6	14.1	7.1	5.1	4.9	4.8	20.3	15.3	8.2	6.3	5.5	6.5	25.1	23.8	22.5	18.9	17.2	15.8
90	19.6	15.0	7.9	4.9	3.7	2.7	21.2	17.2	9.8	4.6	4.1	5.0	24.7	23.4	22.3	17.2	16.3	13.9
120	20.9	15.7	9.9	4.1	2.6	1.9	21.5	17.5	10.7	4.9	3.7	3.8	24.5	23.3	22.5	15.1	14.6	12.7
150	21.4	16.0	10.5	3.3	1.5	1.3	22.1	17.7	11.7	5.7	3.5	3.7	24.7	24.2	23.2	14.5	13.5	11.5
180	22.6	17.1	11.1	2.9	0.8	0.1	22.9	18.5	14.4	6.1	3.7	3.9	25.5	23.2	22.8	15.1	12.3	9.1
210	23.6	19.2	14.6	5.1	2.1	0.9	23.9	19.6	15.2	7.8	4.3	4.1	26.6	24.5	23.7	15.3	14.4	10.7
240	23.9	19.9	15.3	6.9	3.8	1.9	24.5	20.4	16.7	8.8	5.4	4.7	27.3	25.8	24.2	17.2	15.6	11.8
270	24.1	20.2	16.5	8.7	4.8	1.7	24.9	20.9	17.3	9.8	6.2	5.6	27.5	26.1	25.1	20.2	17.6	14.2
300	24.9	21.4	18.6	9.7	6.3	2.7	25.5	22.0	19.7	11.3	8.1	6.3	27.5	24.4	22.6	18.2	13.8	11.6
330	25.2	21.9	19.1	10.4	7.8	3.3	26.8	23.0	20.5	13.5	10.7	6.5	28.2	25.3	25.6	22.2	18.8	16.6
360	26.4	22.6	21.5	12.7	9.6	6.3	27.9	26.8	22.2	16.7	13.2	7.6	28.6	27.9	26.9	24.3	21.6	19.7
375	27.4	23.6	22.5	15.9	11.5	8.1	28.2	27.2	23.8	18.7	14.8	11.3	29.2	28.6	27.7	25.1	22.6	20.3

Table A10: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^oC, Flowrate of 20 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	27.3	24.1	22.3	20.7	27.2	28.8	28.3	26.8	25.8	24.4	28.4	29.2	29.6	29.1	28.4	27.6	28.9	29.7
10	25.7	20.1	17.8	14.8	26.3	27.9	26.0	25.2	25.1	22.2	27.3	28.2	28.9	28.3	27.9	27.2	28.7	29.7
15	23.4	17.7	14.7	12.7	23.3	25.7	25.6	22.5	21.6	20.5	23.3	27.1	28.1	27.0	26.0	25.0	27.3	27.4
20	21.2	16.2	12.0	10.4	19.2	23.4	24.5	20.5	17.1	14.7	20.1	24.7	27.7	26.3	25.0	23.9	26.1	26.8
25	19.6	14.8	10.5	8.3	16.8	18.4	24.0	18.3	14.8	13.5	18.9	20.9	27.0	25.8	23.7	23.3	25.7	26.3
30	18.7	14.0	8.6	7.8	13.2	16.9	23.4	17.4	11.8	10.7	16.4	19.2	26.2	25.6	23.5	22.8	24.3	25.0
35	18.2	12.8	8.2	6.7	8.8	13.5	20.2	17.2	11.1	9.6	11.7	17.0	23.7	25.4	22.3	22.1	22.7	23.6
40	17.8	10.2	7.9	6.5	8.5	10.1	20.4	17.1	10.3	9.4	10.3	14.5	24.2	24.9	22.1	21.7	22.1	23.1
45	17.3	11.7	7.5	6.3	7.8	9.9	20.9	16.8	10.2	8.8	9.6	12.1	24.4	24.5	21.4	21.3	21.5	21.5
50	17.0	12.5	7.4	6.1	7.1	7.9	21.1	16.6	10.3	8.9	9.3	9.9	24.5	24.3	21.3	20.8	20.8	21.2
55	18.1	13.4	7.2	5.9	6.2	6.1	21.3	16.5	9.5	8.0	8.8	8.6	24.7	24.2	21.0	20.6	19.7	20.7
60	18.9	14.7	6.8	5.7	5.8	5.5	21.5	16.4	10.1	7.4	7.7	8.0	25.2	24.1	21.6	20.1	19.1	18.9
90	20.1	15.4	8.0	5.5	5.2	4.8	22.2	17.6	10.4	7.9	7.1	7.0	25.3	23.9	21.8	18.7	17.8	14.7
120	21.5	16.8	11.7	5.3	4.7	3.5	22.4	18.5	11.1	6.7	6.6	6.5	25.5	24.4	22.0	17.5	16.5	15.6
150	21.9	16.4	10.8	4.9	2.1	1.7	22.6	18.9	12.0	6.4	5.6	5.1	25.9	24.2	22.4	15.8	14.2	13.7
180	22.5	17.7	13.1	3.6	1.1	0.6	22.9	19.3	15.3	6.9	5.6	5.9	26.2	24.5	22.7	17.0	15.5	12.5
210	23.1	19.8	15.1	6.5	3.8	3.3	23.8	20.8	16.4	8.2	6.6	6.4	26.3	24.7	23.1	16.5	15.2	12.1
240	24.1	20.4	16.2	7.5	4.7	3.9	24.5	21.2	17.2	9.0	7.5	6.8	26.6	25.2	24.5	17.9	16.5	13.2
270	24.4	20.6	16.7	9.3	5.2	3.0	25.2	22.5	19.1	11.4	7.9	6.9	27.2	25.7	24.8	18.7	17.6	14.4
300	25.2	21.5	19.4	10.3	6.5	3.6	26.3	23.4	20.3	13.7	8.3	7.2	27.7	26.3	25.2	23.1	19.5	15.1
330	25.6	22.3	19.8	11.7	8.1	4.6	26.0	24.7	21.9	15.3	11.7	7.8	27.9	26.7	25.5	25.4	22.2	16.7
360	26.0	23.6	20.3	14.6	10.2	6.9	26.3	25.8	23.2	17.6	13.1	8.5	27.8	26.9	26.0	29.1	26.3	17.6
390	26.3	24.0	21.2	15.8	12.4	7.2	26.9	26.5	23.9	18.5	14.1	10.2	28.1	27.4	26.2	22.1	16.5	18.1
420	26.8	25.5	21.9	16.9	14.5	9.2	27.4	26.9	24.5	18.9	16.7	12.0	29.3	27.7	26.5	23.1	18.8	19.1
450	27.4	26.4	23.2	17.5	16.8	11.7	28.2	27.6	25.3	20.0	18.9	14.1	29.6	28.7	26.7	23.7	21.3	19.7
480	27.7	26.6	24.2	18.6	18.7	14.2	28.8	27.7	26.8	21.4	19.6	16.3	29.9	29.4	27.6	24.3	22.9	20.4

Table A11: Temperatures Data of 4060 Composition for Surrounding Temperature of 35^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	35.9	35.0	35.5	34.9	35.0	35.9	35.1	35.5	36.0	35.2	35.0	35.1	35.1	35.5	35.2	35.2	35.0	35.1
5	33.0	28.2	25.3	23.0	30.7	32.9	33.7	30.6	28.9	24.6	32.8	33.8	33.8	31.5	30.3	26.5	33.3	34.5
10	17.8	12.5	7.7	9.3	23.2	27.5	24.8	18.6	14.5	18.9	31.4	30.3	31.7	31.5	31.2	31.1	31.5	31.7
15	18.3	12.1	7.2	9.6	11.2	25.3	24.5	18.3	11.6	11.7	12.5	19.1	31.3	30.6	29.6	27.6	27.8	31.4
20	17.4	11.6	7.1	8.4	10.3	12.7	24.3	18.1	10.9	10.9	11.1	14.6	31.2	30.0	29.4	27.1	28.5	29.6
25	18.3	14.1	6.1	7.3	9.3	9.8	24.2	17.9	11.3	10.5	10.6	12.5	31.0	29.8	29.4	26.7	27.2	27.7
30	18.1	14.1	6.1	6.7	8.3	8.5	24.0	17.7	11.7	10.2	9.3	9.2	30.8	29.6	29.3	26.1	25.0	24.9
35	18.2	15.1	6.7	5.8	6.2	6.7	23.8	17.6	11.8	9.8	8.5	8.6	30.5	29.2	29.2	25.9	24.1	23.2
40	18.5	15.4	6.9	4.4	4.9	4.2	23.6	17.5	13.5	8.5	7.9	5.8	30.1	29.0	28.9	25.8	23.0	22.4
45	19.1	16.1	7.5	3.5	3.2	2.6	23.5	17.4	13.0	7.9	7.1	3.6	30.2	28.9	28.5	24.7	22.3	20.9
50	19.3	16.6	7.5	1.8	2.3	1.1	23.3	17.1	13.8	7.2	5.0	3.0	29.9	28.0	28.4	23.1	20.8	19.4
55	19.3	17.2	8.1	0.3	1.6	0.3	23.2	16.7	14.2	8.3	3.1	2.3	30.3	29.2	28.1	21.9	18.5	17.9
60	19.3	17.5	8.8	-0.1	0.5	-0.5	23.1	16.5	14.3	9.0	2.7	1.5	30.5	29.2	28.5	19.7	16.1	14.3
90	20.3	18.6	9.2	1.5	0.9	-1.2	24.4	16.8	15.6	10.0	1.7	0.4	30.8	29.2	27.8	18.2	15.1	13.7
120	20.7	19.3	9.6	3.6	1.1	-1.6	25.0	17.3	16.1	10.2	0.6	-1.1	30.8	29.4	26.8	20.1	17.7	15.1
150	21.1	19.6	11.0	7.1	1.6	-1.1	26.4	21.3	17.6	11.5	3.8	0.4	31.1	29.8	26.5	20.8	18.7	16.2
180	22.5	20.3	12.8	9.2	2.2	-0.9	27.3	22.5	19.1	13.5	5.1	0.5	31.3	30.0	27.8	21.9	19.2	17.0
210	23.8	21.1	14.7	11.3	4.9	-0.4	28.0	23.5	20.5	15.5	7.7	1.7	31.5	30.4	29.8	24.7	20.8	17.7
240	25.7	22.1	16.6	14.4	6.1	0.1	29.4	25.2	22.6	18.2	10.5	2.6	31.7	30.7	30.3	24.9	22.5	18.3
270	26.1	23.0	18.8	16.0	7.6	0.6	29.6	25.5	23.4	19.5	12.3	1.8	31.9	31.4	30.5	25.9	23.0	18.9
300	26.3	23.4	19.4	17.0	8.7	1.6	29.7	25.8	23.7	20.0	13.9	5.1	32.5	31.7	30.9	27.8	26.3	21.1
310	26.8	24.1	20.7	18.8	9.8	2.5	29.9	26.3	24.8	21.7	16.2	9.9	32.9	32.5	31.3	29.0	26.9	21.8

Table A12: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.2	25.7	24.5	26.9	29.4	28.7	27.7	25.8	25.2	27.8	29.6	29.5	29.2	27.4	26.4	30.6	30.9
10	27.1	22.1	21.7	18.9	23.5	24.3	25.4	23.6	20.2	20.7	24.3	24.9	24.4	26.7	25.3	24.4	26.8	29.6
15	25.2	23.6	19.8	18.1	20.4	21.1	24.9	23.2	19.3	19.5	21.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	20.9	18.8	14.9	13.0	15.1	16.3	23.9	22.7	18.1	16.1	18.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	18.7	16.3	11.4	11.9	8.9	7.3	22.8	21.4	17.9	14.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	16.4	14.8	6.1	9.6	5.3	4.6	21.8	20.3	14.1	12.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	15.3	13.8	4.3	8.7	3.1	1.8	20.3	18.2	10.2	9.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	14.3	11.1	3.6	5.9	1.0	0.4	20.8	16.1	8.4	7.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	10.8	2.3	3.0	0.3	-1.8	19.3	14.1	6.7	4.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	14.7	12.0	3.0	2.1	-0.3	-1.9	18.6	13.3	4.9	2.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	15.4	13.3	3.2	0.5	-1.0	-2.0	17.5	14.3	4.2	1.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	17.8	14.8	4.5	1.2	-1.3	-3.1	18.8	15.2	5.1	2.1	-0.3	-2.7	26.4	24.6	23.2	16.3	15.8	15.3
90	18.6	15.7	8.5	2.9	-2.4	-3.4	19.8	16.6	8.8	0.6	-1.9	-2.9	25.6	23.8	20.7	14.7	13.6	13.3
120	19.5	16.4	9.8	3.9	-2.6	-3.8	20.7	17.1	10.8	1.8	-1.1	-3.2	26.2	24.3	22.8	16.7	14.6	13.6
150	19.9	17.6	13.1	4.5	-2.1	-4.4	20.9	18.7	12.6	3.8	-1.4	-3.6	26.5	24.5	23.9	18.0	16.3	12.4
180	20.4	19.9	14.8	5.7	-1.0	-2.8	21.9	17.9	14.1	5.2	-1.6	-3.9	27.3	25.8	24.2	18.7	17.2	13.0
210	21.1	20.2	15.4	8.7	1.1	-1.8	22.2	18.2	15.5	6.2	0.1	-2.2	27.6	26.1	24.5	20.4	17.6	12.9
240	22.8	21.2	16.4	10.1	4.8	-0.9	23.5	19.4	16.8	9.4	2.2	-1.1	27.8	25.4	24.7	22.0	18.6	13.4
270	23.4	21.9	17.8	11.8	5.2	0.0	24.2	20.9	18.4	11.5	5.9	0.4	27.9	25.7	24.9	22.7	19.5	14.9
300	24.1	22.2	18.2	12.4	6.8	1.1	24.6	21.5	19.8	13.7	8.4	1.4	28.0	26.2	25.2	23.3	20.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	23.5	20.6	15.0	10.6	3.1	28.2	26.4	25.4	23.9	21.9	17.4
360	25.5	23.4	20.8	14.8	8.9	3.7	26.0	24.9	21.2	17.8	12.4	6.9	28.6	26.7	25.8	24.9	23.0	18.8

Table A13: Temperatures Data of 4060 Composition for Surrounding Temperature of 25°C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	25.2	24.9	24.9	24.7	25.0	25.6	24.6	25.1	25.3	24.9	25.0	25.6	25.6	25.5	25.6	25.7	25.6	25.7
5	15.7	12.2	12.0	13.4	22.6	23.0	23.0	15.3	13.2	16.7	24.5	24.7	25.0	23.3	23.7	23.4	25.3	25.2
10	11.4	6.6	4.8	7.5	18.1	22.1	20.4	13.6	12.6	14.4	22.5	24.3	23.8	21.2	20.6	21.2	24.6	24.5
15	8.7	4.7	1.5	6.0	19.8	20.8	19.8	13.3	12.2	13.5	20.1	21.8	22.5	20.2	19.6	19.5	22.8	23.6
20	8.3	4.8	1.3	5.4	15.9	17.0	19.7	12.9	12.0	13.1	16.4	17.4	22.4	20.0	19.3	19.2	20.9	22.1
25	9.0	5.1	1.0	4.3	5.1	5.3	19.8	12.7	11.5	10.4	9.8	7.3	22.3	19.8	19.1	19.0	20.0	20.9
30	9.3	5.3	0.8	2.6	3.0	3.5	19.6	12.7	11.4	9.5	8.3	5.5	22.2	19.7	19.0	18.6	19.3	19.7
35	9.5	5.6	0.1	0.9	1.9	1.8	19.3	12.5	10.8	8.9	6.5	3.1	22.1	19.6	19.0	18.3	18.1	18.2
40	9.7	5.8	-0.6	-0.5	0.4	0.3	19.2	12.5	10.7	7.5	3.2	1.5	22.0	19.5	18.8	17.9	17.6	16.8
45	10.1	6.1	-0.7	-0.7	-0.4	-1.0	19.2	12.1	10.5	6.3	2.1	1.0	21.9	19.4	18.7	17.6	17.3	15.5
50	10.3	6.4	-1.2	-2.0	-1.6	-2.1	19.1	12.0	10.1	5.8	1.2	0.1	21.7	19.4	18.6	17.5	16.9	14.1
55	10.6	6.5	-1.7	-3.1	-2.6	-3.4	18.9	11.9	9.7	5.1	0.6	-2.2	21.6	19.2	18.6	16.3	14.3	12.6
60	10.7	6.6	-2.4	-4.6	-4.0	-4.6	18.0	10.7	8.6	4.6	-0.1	-3.0	21.4	19.0	18.5	14.7	11.5	9.8
90	11.1	7.2	-1.7	-6.0	-5.3	-7.2	17.4	9.8	7.2	1.9	-2.3	-4.1	20.3	18.8	17.4	13.0	9.3	6.3
120	11.4	8.1	0.4	-4.0	-5.1	-7.4	17.7	11.1	6.5	-0.9	-4.0	-5.2	21.2	19.0	18.9	12.7	8.5	6.1
150	13.2	9.4	3.4	-1.7	-5.3	-6.9	18.9	13.1	9.2	4.1	-2.9	-4.7	21.3	19.1	19.2	11.9	9.9	6.9
180	14.8	10.7	5.6	2.2	-3.7	-6.0	19.1	15.5	10.9	6.2	-1.5	-3.9	21.8	20.5	19.5	13.2	10.4	7.2
210	14.7	10.8	6.9	3.9	-2.5	-5.2	19.5	17.7	12.0	8.1	0.0	-2.8	22.0	20.6	20.1	14.2	11.4	8.5
240	15.9	11.8	8.3	5.7	0.4	-4.2	20.7	18.5	13.7	9.4	2.2	-1.8	22.2	20.9	20.4	15.4	12.7	9.0
270	16.4	13.3	10.3	6.7	2.0	-3.4	21.3	19.1	13.9	9.8	3.8	-0.5	22.4	21.1	20.5	16.0	13.8	10.6
300	16.7	14.0	12.9	8.0	2.2	-3.1	21.5	19.5	14.2	11.0	5.2	0.0	22.7	21.3	20.8	17.5	14.7	11.8
330	19.7	16.5	14.3	10.6	5.0	-2.8	21.7	16.7	15.3	12.5	6.9	1.0	22.9	21.5	21.2	18.5	15.0	12.1
360	21.8	18.5	16.1	12.6	6.3	-1.2	22.3	19.3	16.8	13.2	8.1	2.3	23.2	21.8	21.4	18.7	16.0	13.0
390	22.7	20.3	17.3	14.0	7.0	-0.2	23.1	20.8	17.7	14.6	9.4	3.1	23.6	22.1	22.1	19.3	16.7	14.6
420	24.3	21.3	19.5	15.8	9.8	1.0	24.5	21.9	19.9	16.8	11.9	4.7	24.8	22.7	22.4	20.1	17.6	16.3

Table A14: Temperatures Data of 4060 Composition for Surrounding Temperature of 20^oC, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	19.8	19.8	19.6	19.5	20.0	20.4	19.4	19.9	20.0	19.8	20.0	20.6	20.7	20.3	20.6	20.7	20.5	20.4
5	10.4	7.2	5.2	7.9	16.7	18.1	15.1	9.3	4.5	8.8	19.9	19.6	19.2	17.5	16.8	16.4	19.8	19.1
10	7.5	3.1	1.1	3.3	15.6	17.4	13.7	7.3	2.6	6.2	18.4	19.5	18.1	16.1	15.2	13.4	19.0	19.0
15	6.0	1.9	0.4	2.7	9.9	15.0	12.5	6.3	2.0	4.2	2.6	16.2	17.4	15.0	14.1	12.6	17.7	18.8
20	5.3	1.5	-0.6	1.4	8.1	11.8	13.0	5.9	1.8	2.9	2.8	13.1	17.2	14.9	13.3	12.4	16.3	18.1
25	6.7	2.3	-1.2	0.6	1.8	1.8	12.8	5.4	1.6	1.5	3.5	3.4	17.0	14.7	13.1	12.1	15.4	16.4
30	7.0	2.7	-1.9	-1.4	0.6	-0.7	12.7	5.1	1.4	0.4	1.4	1.3	16.9	14.7	12.6	11.6	14.7	15.7
35	7.0	3.1	-2.7	-2.4	-1.1	-2.4	12.3	5.0	1.3	-0.9	-0.5	-0.4	16.6	14.5	12.5	10.8	14.0	15.0
40	7.0	3.2	-3.4	-3.0	-2.9	-4.0	12.2	4.8	1.0	-1.2	-1.5	-2.0	16.5	14.4	12.2	9.8	11.9	12.6
45	7.3	3.4	-3.9	-4.0	-3.1	-5.2	12.2	5.1	0.9	-1.8	-2.2	-3.4	16.5	14.3	11.9	9.6	10.7	10.3
50	7.2	3.5	-4.2	-5.1	-5.4	-6.4	12.3	5.4	1.1	-2.2	-3.1	-4.4	16.3	14.2	12.4	9.3	9.5	8.8
55	7.4	3.9	-4.3	-6.4	-6.4	-7.2	12.4	5.9	1.3	-2.4	-3.6	-5.2	16.2	14.0	12.8	9.1	8.3	7.1
60	7.3	4.3	-4.3	-7.0	-6.8	-8.0	12.5	6.3	1.4	-2.9	-3.8	-6.1	16.1	14.1	13.1	9.0	7.3	5.6
90	7.8	4.5	-2.9	-8.0	-7.9	-10.3	12.7	6.9	2.8	-3.6	-4.2	-7.9	16.0	14.3	13.3	8.9	6.3	4.2
120	8.1	5.3	-1.6	-6.2	-7.6	-10.2	13.9	7.6	3.9	-3.9	-6.4	-9.3	15.9	14.4	13.4	8.8	4.9	3.9
150	10.0	6.0	1.2	-2.7	-6.9	-10.4	14.1	9.4	6.1	1.1	-5.7	-8.1	16.2	14.6	13.6	8.3	4.5	3.0
180	10.5	7.7	3.1	-0.8	-5.6	-9.4	14.4	10.8	7.4	3.5	-4.9	-6.8	16.6	15.0	13.8	9.8	7.4	5.4
210	11.5	8.2	4.4	0.1	-4.1	-8.1	15.5	11.3	9.1	5.2	-3.1	-5.7	16.7	15.1	14.5	10.7	7.8	6.2
240	12.0	9.2	5.3	2.4	-2.9	-7.4	15.7	11.8	9.7	6.3	-1.6	-4.9	16.8	15.3	15.1	11.1	8.1	6.6
270	13.2	10.2	6.5	3.4	-1.5	-6.3	15.8	12.4	10.2	7.2	-0.2	-3.4	17.0	15.5	15.3	12.9	9.1	7.2
300	14.9	11.3	9.2	6.0	0.1	-5.4	16.5	12.8	11.2	8.5	1.1	-2.5	17.1	15.7	15.5	13.3	10.3	7.5
330	15.3	12.9	10.8	7.9	1.8	-4.9	16.6	13.0	11.7	9.4	2.1	-2.1	17.3	15.9	15.6	13.8	10.8	7.7
360	15.8	13.2	12.9	8.1	2.7	-3.4	16.9	13.3	12.4	10.2	3.5	-0.8	17.4	16.2	15.9	14.0	11.5	9.1
390	16.3	14.5	13.3	8.2	1.0	-3.3	16.4	13.6	12.2	10.3	4.6	0.1	17.5	16.3	16.1	15.2	12.0	10.1
420	16.8	15.7	13.8	8.9	2.1	-2.7	16.9	13.8	12.7	11.0	6.6	1.9	17.8	16.4	16.4	15.5	13.1	11.5
450	17.6	16.2	14.6	9.7	4.3	-1.4	17.1	14.4	13.3	11.8	7.7	2.1	17.8	16.5	16.5	13.8	13.6	12.3

Table A15: Temperatures Data of 4060 Composition for Surrounding Temperature of 15^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	14.4	14.7	14.3	14.4	15.0	15.2	14.2	14.7	14.7	14.6	15.0	15.6	15.7	15.1	15.6	15.7	15.4	15.0
5	3.8	1.4	-0.2	2.9	13.7	13.9	9.4	3.7	2.3	3.5	14.9	15.5	14.3	12.5	13.2	12.4	15.0	13.9
10	1.0	-2.6	-8.5	-5.9	10.7	13.4	7.2	-0.8	-6.0	-3.2	12.4	14.7	13.2	10.8	10.1	9.7	14.4	13.8
15	-0.6	-4.6	-9.7	-7.2	6.7	9.9	5.8	-2.4	-7.6	-5.8	10.6	11.4	12.2	10.7	9.3	9.2	13.3	13.4
20	-2.4	-5.4	-9.6	-7.7	4.1	6.1	5.3	-3.0	-8.4	-6.1	6.5	7.4	11.7	10.5	9.0	8.7	12.0	12.5
25	-2.2	-6.4	-8.9	-8.1	1.9	3.3	5.4	-2.3	-6.7	-6.7	-5.8	-4.9	11.6	10.2	8.9	8.4	9.3	9.8
30	-1.4	-5.6	-8.2	-7.9	-4.5	-5.6	5.9	-0.8	-6.3	-7.1	-6.0	-5.7	11.5	10.0	8.6	8.0	7.8	8.6
35	-0.6	-4.4	-7.5	-7.9	-6.9	-6.4	5.8	-0.6	-5.9	-7.5	-6.5	-6.5	11.2	9.9	8.6	7.8	6.9	6.5
40	-0.1	-3.5	-7.2	-9.2	-7.7	-9.1	5.8	-0.5	-5.5	-7.7	-7.1	-7.3	11.1	9.8	8.7	7.7	6.8	5.0
45	0.4	-3.4	-6.9	-9.9	-9.7	-10.3	5.6	-0.7	-5.0	-8.9	-8.2	-8.5	11.0	9.7	8.8	7.6	6.5	4.7
50	0.7	-3.3	-6.6	-10.7	-10.9	-11.7	5.8	-0.4	-4.7	-9.7	-8.9	-9.4	10.9	9.6	9.0	7.5	6.4	4.5
55	0.9	-3.1	-6.4	-11.3	-10.3	-12.1	5.8	-0.5	-4.5	-10.3	-9.2	-10.1	10.7	9.5	9.1	7.2	6.0	4.1
60	1.3	-3.1	-5.7	-11.5	-11.1	-12.6	5.9	-0.3	-4.3	-10.9	-10.0	-11.3	10.5	9.7	9.1	7.0	5.8	3.9
90	2.1	-2.5	-5.1	-9.5	-12.3	-13.3	6.8	1.1	-2.6	-9.3	-10.6	-11.6	10.1	9.7	8.3	6.4	5.2	3.4
120	2.6	-1.3	-5.9	-9.1	-9.9	-13.0	7.2	2.1	-1.8	-6.3	-8.2	-11.8	11.1	9.9	8.4	6.2	4.3	2.2
150	3.1	0.4	-4.3	-6.5	-8.4	-12.5	7.4	4.6	-0.8	-5.4	-7.8	-10.7	11.3	10.3	9.1	7.3	4.4	2.4
180	5.1	1.7	-3.1	-5.9	-7.6	-11.0	8.2	6.8	2.8	-3.7	-6.7	-9.6	11.5	10.0	9.8	8.4	6.5	4.5
210	6.9	3.4	-1.3	-3.5	-6.7	-9.9	8.9	7.9	4.4	-2.6	-5.7	-8.6	11.8	10.3	9.9	8.7	6.6	4.6
240	7.9	3.9	2.4	-1.6	-4.1	-8.4	9.6	8.9	5.7	-0.5	-3.9	-7.3	11.9	10.5	10.2	9.1	6.7	4.7
270	8.2	5.5	4.1	-0.5	-3.3	-7.8	10.7	9.1	6.3	1.4	-2.3	-5.8	12.1	10.7	10.5	9.5	6.8	4.9
300	10.8	8.4	6.1	0.8	-1.0	-6.5	11.5	9.3	7.1	2.4	-0.3	-4.7	12.4	10.9	10.7	9.8	6.9	5.2
330	11.2	9.1	7.9	3.8	0.3	-6.3	11.7	9.7	8.7	4.5	-0.9	-3.2	12.6	11.1	11.0	8.7	7.0	5.5
360	11.4	9.5	9.4	5.9	1.4	-4.6	11.9	10.1	9.7	6.3	2.3	-1.3	12.7	11.6	11.2	9.1	7.2	5.8
390	12.7	10.8	10.3	6.7	3.0	-2.1	13.1	11.8	10.7	7.4	5.4	0.0	13.9	12.6	11.7	9.6	7.7	6.2
420	12.8	11.2	10.8	8.0	4.7	-0.8	13.5	12.2	11.3	8.7	6.4	3.1	14.1	13.2	12.5	9.9	8.3	6.9
450	13.1	12.5	11.6	10.2	6.5	2.6	13.8	13.1	12.1	11.8	8.8	5.7	14.3	13.9	12.9	10.2	9.3	7.3

Table A16: Temperatures Data of 4060 Composition for Surrounding Temperature of 10^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	10.0	10.6	10.0	10.3	10.0	10.1	10.0	10.5	10.4	10.5	10.0	10.6	10.7	10.0	10.5	10.6	10.3	10.6
5	4.8	2.4	1.8	3.8	8.0	9.5	8.7	4.4	2.7	4.7	9.0	10.4	9.6	8.7	9.1	9.5	9.6	9.8
10	0.3	-2.2	-4.1	4.6	6.9	8.1	7.1	1.5	-1.8	-1.7	7.3	8.9	9.3	8.3	7.1	8.1	9.0	9.6
15	-2.3	-2.6	-4.5	1.9	4.0	4.1	6.8	-0.9	-2.3	-2.2	5.2	6.8	8.9	8.0	7.2	8.2	8.1	7.6
20	-3.0	-2.7	-4.9	-0.4	0.7	2.8	5.1	-2.4	-2.7	1.1	3.0	5.0	8.7	7.8	6.0	7.7	8.2	7.6
25	-2.2	-2.9	-5.1	-1.6	0.0	0.2	4.5	-2.7	-3.2	-2.3	1.5	2.7	8.6	7.8	5.6	7.6	6.1	5.7
30	-1.7	-3.1	-4.6	-4.9	-3.2	-2.9	4.1	-3.0	-3.3	-3.1	-2.0	-0.8	8.5	7.6	5.3	7.4	5.8	4.6
35	-0.4	-3.3	-6.4	-5.2	-4.9	-4.8	3.9	-2.0	-3.7	-3.5	-3.7	-1.3	8.3	7.4	5.1	7.1	5.7	3.7
40	0.0	-3.5	-6.6	-5.4	-5.5	-6.0	3.5	-1.4	-3.4	-4.5	-4.7	-3.9	8.0	7.2	5.6	6.9	5.6	3.5
45	0.4	-3.6	-6.8	-8.5	-8.7	-8.0	3.3	0.5	-3.6	-5.7	-5.5	-5.5	8.1	6.7	5.7	6.6	5.5	3.2
50	0.7	-3.8	-7.0	-9.9	-9.9	-10.5	3.0	1.1	-3.5	-5.8	-6.9	-7.5	8.2	7.0	6.5	6.4	5.3	3.0
55	1.0	-3.9	-7.2	-11.0	-11.7	-12.8	2.8	1.4	-3.9	-6.3	-7.8	-9.5	8.3	7.2	6.4	6.3	5.2	2.9
60	1.3	-4.1	-7.5	-12.7	-12.5	-14.1	2.7	1.4	-4.1	-7.0	-8.9	-10.1	8.5	7.5	6.4	6.2	5.0	2.6
90	1.5	-4.5	-7.0	-10.2	-13.9	-14.7	2.6	1.5	-3.4	-7.7	-9.6	-12.8	8.7	7.7	6.2	5.1	4.7	2.2
120	1.9	-4.8	-6.8	-10.9	-12.4	-14.4	3.6	1.7	-4.7	-8.5	-11.1	-13.2	8.8	7.9	6.4	4.7	3.1	1.4
150	2.3	-3.1	-6.1	-8.6	-10.3	-13.8	4.7	2.2	-2.9	-7.8	-9.8	-12.1	8.9	8.1	7.8	5.9	2.9	1.2
180	2.5	-1.5	-5.4	-7.8	-9.3	-12.4	5.2	3.6	-1.2	-5.5	-8.5	-11.2	9.1	8.3	7.9	6.8	4.7	2.3
210	3.6	0.5	-4.2	-5.6	-8.5	-11.8	7.5	6.6	1.4	-3.3	-7.6	-9.9	9.3	8.6	8.1	7.3	5.6	2.5
240	4.7	1.1	-0.1	-3.2	-6.2	-10.9	7.4	6.8	2.3	-1.9	-6.9	-8.2	9.5	8.7	8.0	7.7	5.9	2.9
270	6.1	3.7	1.5	-2.4	-5.9	-8.9	7.5	7.0	3.4	0.4	-4.3	-6.6	9.5	8.8	8.1	7.9	6.1	3.5
300	7.6	6.4	3.2	-1.1	-3.4	-7.5	7.8	7.4	4.8	1.6	-3.6	-5.5	9.6	8.9	8.3	8.1	6.6	4.1
330	8.1	7.2	4.1	-0.1	-2.9	-6.2	8.2	7.8	5.0	2.4	-1.8	-4.1	9.7	9.1	8.5	8.3	6.9	4.5
360	8.5	7.8	5.7	3.2	0.9	-3.2	8.9	8.1	6.5	3.9	-0.6	-2.5	9.8	9.2	8.9	8.6	7.2	5.0
390	8.6	8.2	6.0	4.6	3.1	1.4	9.1	8.5	7.6	6.4	4.6	2.3	9.8	9.4	9.1	8.9	7.8	6.4

Table A17: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 7 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	26.7	24.0	18.4	20.1	27.2	29.5	27.2	25.5	20.9	23.0	28.1	29.9	26.4	23.3	20.4	22.9	28.8	29.1
10	18.5	13.7	8.1	10.3	23.4	29.3	22.9	18.9	12.5	14.8	27.9	29.5	23.3	20.3	14.2	15.8	28.4	29.2
15	17.4	12.3	7.8	12.3	16.4	20.4	20.2	15.6	12.6	13.3	14.6	23.8	24.5	19.7	13.5	15.2	26.4	29.0
20	16.9	11.7	7.6	10.3	12.7	13.7	18.0	14.1	12.1	12.2	12.8	14.6	24.3	19.5	12.7	15.0	24.9	26.8
25	16.4	11.2	6.9	7.1	8.4	10.3	17.5	13.6	10.9	10.1	10.6	11.9	24.0	19.3	11.9	14.8	23.7	25.7
30	16.1	11.1	6.3	6.1	7.3	8.1	17.3	12.2	8.6	7.8	7.7	8.2	23.9	18.7	12.5	14.6	22.8	25.0
35	15.9	10.3	6.0	5.0	6.6	7.3	17.1	11.8	7.9	6.1	6.3	6.4	23.6	18.4	12.9	14.5	21.7	22.2
40	15.5	9.7	5.9	5.5	5.0	5.6	15.7	10.6	7.5	5.5	4.3	3.7	23.5	18.0	13.2	14.2	21.3	21.5
45	15.3	9.4	5.5	5.0	3.7	3.3	15.5	8.1	6.8	4.7	2.1	2.4	23.1	18.2	13.8	14.0	17.7	18.6
50	14.8	9.3	5.3	4.6	2.8	2.5	15.3	7.9	6.3	3.4	1.2	1.0	22.7	18.3	14.2	13.9	17.2	18.0
55	14.6	9.0	5.2	4.0	1.8	1.4	15.2	7.7	5.9	2.7	0.7	0.3	21.6	18.5	14.5	13.7	16.9	17.4
60	14.4	8.3	4.9	3.4	0.6	-0.7	15.0	7.5	5.4	3.5	1.2	0.8	20.8	18.7	14.8	13.8	16.2	16.2
90	13.6	6.9	4.8	2.6	-1.5	-2.6	14.2	7.3	5.2	2.9	-1.0	-2.1	21.4	19.9	15.9	13.4	15.8	15.3
120	14.5	6.1	3.4	0.9	-2.5	-3.1	15.1	6.7	3.9	1.6	-2.0	-2.6	22.1	21.2	16.7	13.1	12.9	12.3
150	16.2	5.2	2.7	-0.6	-3.6	-4.2	16.7	5.8	3.3	-0.1	-3.0	-3.8	22.5	21.5	17.1	14.1	12.1	11.4
180	17.7	4.7	2.2	-2.5	-4.1	-4.8	18.1	5.2	2.7	-2.1	-3.7	-4.3	23.7	22.1	18.3	15.3	11.4	10.2
210	18.7	5.5	1.3	-3.8	-4.7	-5.3	19.2	5.9	1.9	-2.7	-4.2	-4.8	23.9	23.2	19.9	15.8	10.6	9.6
240	19.6	6.7	1.8	-4.5	-5.2	-5.9	20.1	7.2	2.3	-3.9	-4.8	-5.3	25.8	25.5	23.1	18.2	9.7	8.6
270	20.4	8.2	2.6	-3.6	-6.1	-6.4	20.8	8.8	3.1	-3.2	-5.7	-6.1	27.3	26.1	24.8	20.8	9.2	8.1
300	23.4	10.8	4.1	-1.3	-4.1	-5.8	23.9	11.3	4.7	-0.8	-3.6	-5.3	27.8	26.8	25.1	21.2	8.4	7.6
330	24.6	12.4	5.8	2.4	-2.4	-4.6	25.1	12.8	6.2	2.9	-2.0	-4.1	28.1	26.1	25.7	22.2	11.4	9.7
360	25.4	22.3	16.1	9.7	5.9	0.3	25.9	23.9	17.6	10.4	6.6	1.5	28.5	27.4	26.5	23.5	19.4	14.1
385	26.9	24.7	19.7	17.5	14.9	7.9	27.1	25.9	24.1	19.9	15.3	9.7	29.3	28.2	27.0	25.2	21.7	18.4

Table A18: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 6 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	28.5	27.2	20.7	24.5	26.9	29.4	28.7	27.7	21.8	25.2	27.8	29.6	29.5	28.2	23.4	26.4	28.6	29.8
10	19.5	15.1	12.7	14.9	24.5	26.3	23.1	18.6	13.2	15.8	25.3	28.9	23.9	19.7	14.3	16.4	26.8	29.2
15	18.2	14.6	11.2	12.5	18.4	21.1	22.9	23.2	12.3	13.5	19.6	22.2	23.7	24.2	13.1	14.6	20.5	26.8
20	17.9	14.0	9.9	10.4	15.1	16.3	22.3	22.7	10.5	11.1	16.7	17.2	23.5	28.1	11.3	13.4	18.3	23.2
25	17.7	13.8	9.4	9.1	8.9	9.3	21.5	21.4	10.0	10.6	9.8	11.0	23.3	22.2	11.0	12.9	15.8	21.9
30	17.4	13.3	9.1	9.0	6.3	7.6	21.0	20.3	9.7	10.2	7.4	8.1	23.1	21.1	10.7	11.6	13.2	18.9
35	17.3	13.0	8.8	8.7	5.1	5.8	20.8	18.2	9.2	9.0	6.3	6.5	23.0	19.3	10.3	11.2	12.8	16.0
40	17.0	12.8	8.3	6.9	3.0	3.4	20.3	17.1	8.9	7.7	4.1	4.1	22.9	18.2	9.8	10.6	11.4	13.5
45	16.8	12.6	8.0	5.0	2.3	1.8	19.3	16.1	8.7	5.6	2.8	2.2	22.7	17.1	9.6	10.2	10.0	11.0
50	16.7	12.4	7.8	4.1	1.3	0.9	18.6	15.3	8.3	5.3	1.9	1.1	22.5	16.4	9.2	10.0	9.6	10.3
55	16.4	12.0	7.7	3.5	0.6	-0.7	18.5	14.3	8.0	3.9	0.7	-0.4	22.2	15.1	9.0	9.6	9.2	9.5
60	16.3	11.8	7.5	2.0	-0.3	-1.1	18.0	13.2	7.9	2.7	0.5	-0.9	22.0	14.4	8.8	9.3	8.8	8.3
90	15.5	12.6	8.9	1.3	-2.3	-3.4	16.8	13.7	9.4	1.6	-1.9	-2.9	25.6	14.9	10.1	8.7	8.5	8.2
120	16.5	13.4	9.8	0.3	-2.8	-3.8	17.5	14.5	10.6	0.8	-2.1	-3.2	26.2	15.3	10.9	9.7	8.1	7.6
150	17.9	14.1	10.7	-1.4	-3.8	-4.8	20.9	14.7	11.6	-1.1	-3.3	-4.1	26.5	15.9	12.2	11.0	9.3	7.4
180	18.9	15.6	11.1	0.1	-4.9	-5.4	21.9	16.9	12.1	0.6	-4.1	-4.9	27.3	17.7	12.9	11.7	10.2	8.0
210	21.1	16.2	12.4	3.2	-4.2	-5.8	22.2	17.8	13.5	3.9	-3.8	-5.2	27.6	18.5	14.3	13.4	11.6	8.9
240	22.8	18.2	15.4	7.1	-3.7	-6.4	23.5	18.7	16.8	7.7	-3.1	-6.0	27.8	19.4	17.7	16.1	12.6	10.4
270	23.4	19.9	17.8	9.8	-2.1	-5.5	24.2	20.5	18.4	10.5	-1.7	-4.9	27.9	21.2	19.9	18.7	14.5	11.9
300	24.1	20.2	18.2	11.4	-0.2	-2.7	24.6	20.8	19.8	11.7	0.4	-2.1	28.0	21.8	20.8	20.3	17.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	22.9	20.6	14.0	8.6	3.1	28.2	23.4	21.5	20.9	19.9	17.4
360	25.5	23.4	20.8	14.8	8.9	5.7	26.0	23.9	21.2	15.8	12.4	9.5	28.6	24.7	23.1	21.9	20.0	18.8

Table A19: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 5 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.2	19.1	13.6	15.2	25.3	28.1	25.0	23.1	22.0	23.9	26.1	30.0	28.6	28.2	28.0	27.1	29.2	31.0
10	21.1	16.5	10.1	11.8	18.3	24.1	23.6	19.7	17.1	15.2	22.1	27.0	25.5	21.9	18.6	16.8	26.1	28.1
15	20.1	17.7	12.3	12.1	14.3	16.2	23.8	19.5	16.3	15.0	16.5	17.2	25.0	21.6	17.2	16.2	20.9	23.3
20	19.9	17.5	12.1	10.5	10.1	11.9	23.3	19.1	13.9	13.4	12.1	13.4	24.8	21.3	17.0	15.7	18.3	21.1
25	19.7	17.4	11.1	7.7	8.3	9.2	23.0	18.7	13.1	10.7	9.4	10.8	24.7	20.9	16.7	14.5	17.4	19.4
30	19.5	16.7	10.7	4.8	5.1	5.8	22.7	18.5	11.6	7.2	6.7	8.4	24.6	20.3	16.5	13.9	15.9	16.3
35	19.3	16.3	9.9	4.1	4.2	4.9	22.3	18.0	10.7	5.4	5.3	6.5	24.2	19.9	16.6	13.3	14.0	15.4
40	19.1	16.0	9.4	2.9	3.2	2.2	22.1	17.8	10.4	4.7	4.8	4.8	24.1	19.5	16.8	13.0	13.3	14.9
45	19.0	15.8	9.0	2.1	2.1	1.7	21.8	17.5	10.3	3.4	3.4	3.4	23.8	19.2	17.1	14.2	13.0	14.5
50	20.3	15.6	8.8	1.3	1.0	0.7	21.6	17.3	9.8	3.2	2.4	2.3	23.7	20.0	17.7	14.8	12.9	14.1
55	20.1	15.2	8.7	1.0	0.4	-0.2	21.5	16.9	9.7	2.1	1.3	1.4	23.0	20.3	17.9	15.0	12.7	13.8
60	18.8	13.5	8.7	0.2	-1.2	-2.5	21.4	15.6	9.5	0.5	-0.8	-1.9	23.4	20.6	18.2	15.5	12.5	13.5
90	17.5	11.5	7.8	0.8	-2.9	-3.7	20.9	16.8	8.2	1.3	-2.2	-3.2	23.9	21.8	18.7	15.9	13.7	12.4
120	18.9	10.2	6.4	-0.6	-3.4	-4.2	21.7	17.0	7.5	-1.3	-3.7	-4.1	24.0	22.9	21.9	15.8	13.5	10.7
150	20.8	12.7	7.9	-2.0	-4.2	-5.3	22.3	17.9	8.8	-1.7	-3.6	-4.8	24.2	23.3	21.9	16.4	13.0	10.9
180	21.2	15.1	9.6	-3.9	-5.4	-6.3	23.1	19.0	10.7	-2.7	-4.7	-5.7	24.5	23.5	22.3	17.2	13.2	10.2
210	22.8	19.2	13.0	-1.1	-3.8	-6.2	23.3	20.2	13.5	-0.8	-3.1	-5.5	24.8	24.1	23.1	17.8	16.1	10.8
240	23.6	20.6	16.9	3.0	-1.8	-4.4	23.8	21.3	17.6	3.8	-0.9	-3.8	25.4	24.7	23.4	20.2	17.5	13.9
270	25.0	21.1	17.9	8.5	2.7	-1.1	24.8	22.6	18.9	9.9	3.5	-0.7	26.4	25.5	24.0	21.0	19.2	15.3
285	25.2	22.3	19.3	13.2	7.3	3.1	25.0	23.7	20.3	14.6	8.0	3.8	27.4	26.0	24.7	22.4	21.1	19.1

Table A20: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 4 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.7	20.7	18.4	15.5	26.8	27.4	28.8	21.5	21.2	16.3	27.1	29.8	27.2	26.9	26.8	24.4	27.0	28.7
10	22.5	18.8	15.2	12.4	15.7	20.3	24.3	20.9	15.6	12.8	16.9	21.5	25.8	22.9	20.4	19.5	22.5	26.7
15	21.3	16.1	10.4	9.8	10.8	18.7	22.1	17.3	14.9	10.3	11.2	21.0	24.5	21.6	19.9	19.1	20.0	27.7
20	20.8	15.5	10.0	8.1	8.9	10.8	21.7	16.2	12.7	8.8	10.0	12.7	24.1	21.1	18.6	17.8	19.2	24.7
25	20.6	15.3	9.1	6.8	6.2	8.0	21.6	15.8	11.0	7.2	7.9	9.9	23.9	20.5	17.7	17.4	18.1	22.8
30	20.3	15.1	8.9	5.5	5.8	6.7	21.3	15.6	9.7	5.9	6.7	7.8	23.5	20.1	17.2	16.8	17.3	20.9
35	19.8	14.9	8.6	4.9	4.0	5.7	21.6	15.7	9.4	5.0	5.3	6.2	23.2	19.8	16.9	16.5	16.5	18.7
40	19.5	14.7	8.0	3.0	2.3	2.8	21.8	16.3	9.0	4.5	3.7	3.3	23.1	19.4	16.6	16.4	14.6	16.3
45	19.2	14.9	7.4	2.5	1.9	-0.6	22.1	17.7	8.5	4.2	2.3	0.2	22.9	19.0	17.1	16.0	12.9	14.2
50	19.5	15.5	7.0	2.0	0.9	-1.2	22.3	17.5	8.1	3.7	1.9	-0.8	23.2	19.7	17.5	15.7	11.1	13.0
55	20.0	16.2	7.6	1.9	-1.1	-2.7	22.5	17.8	8.3	2.5	-0.6	-2.1	23.5	20.8	18.0	15.7	10.4	11.7
60	20.3	16.8	9.1	-0.3	-2.1	-3.5	22.6	18.4	11.8	0.7	-1.1	-2.8	23.8	21.6	18.5	15.9	9.2	9.1
90	21.6	17.2	9.8	-0.9	-3.5	-4.2	23.0	18.7	10.8	-0.1	-2.8	-3.7	24.4	22.3	19.2	16.8	8.6	8.1
120	21.9	18.6	10.8	-0.6	-3.4	-5.5	23.4	19.2	12.3	0.3	-2.7	-4.9	25.1	23.7	20.0	17.6	8.8	7.8
150	22.2	19.6	12.4	1.8	-4.8	-6.2	24.1	20.1	14.5	2.7	-3.7	-5.3	25.7	23.9	21.6	18.0	9.7	7.4
180	22.8	20.6	14.9	4.5	-4.2	-6.6	24.5	21.0	16.7	5.6	-3.1	-5.5	26.5	24.1	22.7	19.0	10.5	6.8
210	24.0	21.0	16.8	7.8	-2.8	-5.8	25.0	22.5	18.3	8.6	-2.0	-4.9	27.1	24.5	23.2	20.5	13.3	8.4
240	25.1	22.1	19.6	9.7	-1.8	-3.7	26.7	23.3	21.3	11.5	-0.9	-3.1	27.8	25.6	24.4	21.9	15.8	9.4

Table A21: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 3 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	24.3	20.7	19.4	16.5	17.4	28.7	25.3	21.1	20.1	18.2	18.1	29.1	28.2	27.2	26.1	25.2	23.5	22.0
10	23.9	19.9	17.8	14.1	13.9	18.5	24.3	20.5	18.2	15.6	14.3	19.4	27.8	24.5	21.9	19.7	18.6	21.3
15	23.7	18.6	16.2	13.0	12.2	15.5	24.1	19.2	16.8	13.3	12.8	15.9	26.5	23.0	20.5	18.7	16.9	18.0
20	23.1	17.5	15.9	11.5	8.2	10.2	23.7	18.3	16.3	11.8	8.7	10.9	26.0	22.4	19.6	17.0	14.4	16.8
25	22.9	17.3	14.3	10.5	4.3	4.9	23.5	18.1	15.1	10.9	4.8	5.3	25.7	21.1	19.0	17.8	13.2	14.1
30	22.2	17.0	13.0	8.1	1.8	1.2	23.1	17.8	13.5	8.6	2.3	1.6	25.3	21.7	19.2	18.1	12.4	13.7
35	21.9	16.8	12.3	7.2	0.4	-0.1	22.3	17.5	12.8	7.5	0.9	0.3	24.9	21.4	19.3	18.3	11.6	12.1
40	21.8	16.7	12.9	6.7	-0.7	-1.3	22.1	17.3	13.3	7.1	-0.1	-0.8	24.8	21.8	19.5	18.4	10.3	10.1
45	21.5	16.6	13.1	5.2	-1.7	-2.4	21.9	17.1	13.7	5.7	-1.1	-1.9	24.6	22.0	19.7	18.5	9.9	9.3
50	21.1	16.2	13.4	4.0	-2.6	-3.5	21.5	17.0	13.9	4.5	-2.1	-3.1	24.3	22.1	20.0	18.6	9.7	8.8
55	21.3	16.3	13.5	3.4	-2.6	-4.0	21.8	17.2	14.0	3.7	-2.3	-3.7	24.1	22.3	20.2	18.8	9.3	8.4
60	21.7	17.4	14.7	3.0	-2.9	-4.4	22.2	17.8	15.2	3.5	-2.4	-3.9	24.5	22.5	20.4	18.9	9.1	8.2
90	22.9	18.2	15.1	4.8	-4.3	-5.4	23.5	19.4	15.6	5.3	-3.9	-4.9	25.6	23.7	21.5	19.8	8.8	7.5
120	23.4	19.3	16.5	6.7	-4.7	-5.9	23.9	20.1	16.9	7.2	-4.1	-5.2	26.3	24.1	22.1	20.2	9.1	6.7
150	24.6	20.4	18.8	9.7	-5.9	-7.1	25.1	21.4	19.3	10.4	-5.3	-6.8	27.1	24.9	23.6	21.4	12.4	6.1
165	25.3	22.3	20.8	11.8	2.6	-1.1	25.8	23.1	21.4	12.2	3.5	-0.9	27.8	26.0	23.8	22.0	14.2	8.5

Table A22: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight of 2 kg

Time	Center Probe (Celsius)						Internal Wall Probe (Celsius)						External Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	26.6	23.0	20.0	16.5	15.9	18.7	27.1	23.4	20.5	17.1	16.4	19.1	29.5	27.6	27.6	26.8	25.6	27.7
10	25.1	22.2	18.6	15.8	12.7	8.2	25.4	22.6	19.1	16.3	13.3	8.6	28.1	25.1	22.2	20.2	18.1	17.1
15	24.2	21.8	17.6	11.7	9.7	5.3	24.6	22.1	18.0	12.3	10.2	5.8	27.0	24.8	20.2	18.4	17.8	23.8
20	23.5	19.8	16.4	9.7	6.6	1.5	23.9	20.1	16.9	10.2	7.1	1.9	26.6	23.3	19.7	16.5	16.3	22.6
25	23.0	19.3	15.5	6.6	4.1	-2.9	23.6	19.7	15.9	7.1	4.8	-2.5	25.3	23.7	19.5	15.7	15.3	20.3
30	22.9	19.0	14.5	5.7	3.4	-4.9	23.3	19.4	15.1	6.1	3.9	-4.3	25.1	23.5	19.3	15.1	14.7	18.6
35	22.7	18.8	14.2	5.1	2.9	-5.5	23.1	19.1	14.8	5.8	3.3	-5.1	25.0	23.3	19.1	15.0	14.5	14.0
40	23.1	18.6	13.3	3.7	2.7	-6.5	23.6	19.0	14.1	4.3	3.1	-6.1	25.2	23.9	19.7	15.4	14.1	13.5
45	23.7	18.0	13.2	3.2	2.6	-7.8	24.1	18.5	13.9	3.9	3.0	-6.6	25.4	24.1	20.1	16.2	13.8	12.4
50	24.9	17.7	13.0	4.1	2.9	-8.0	25.3	18.1	13.7	4.3	3.3	-7.7	26.5	24.3	20.5	17.9	13.7	10.4
55	25.8	18.4	13.8	6.2	3.6	-7.9	26.4	18.9	14.2	6.9	4.1	-7.2	27.6	24.5	21.1	18.7	13.2	9.2
60	27.0	19.6	15.0	6.5	4.1	-7.6	27.2	20.1	15.7	7.6	4.7	-6.9	28.7	24.8	21.9	19.1	13.7	7.7
90	28.1	20.6	16.7	10.2	8.9	-5.5	28.3	21.1	17.2	11.4	9.5	-5.1	29.2	25.4	24.4	19.1	16.3	12.7
115	29.1	23.4	20.6	13.8	10.8	5.1	29.3	23.9	21.1	14.6	11.1	5.4	29.6	26.4	25.8	21.4	18.8	16.7

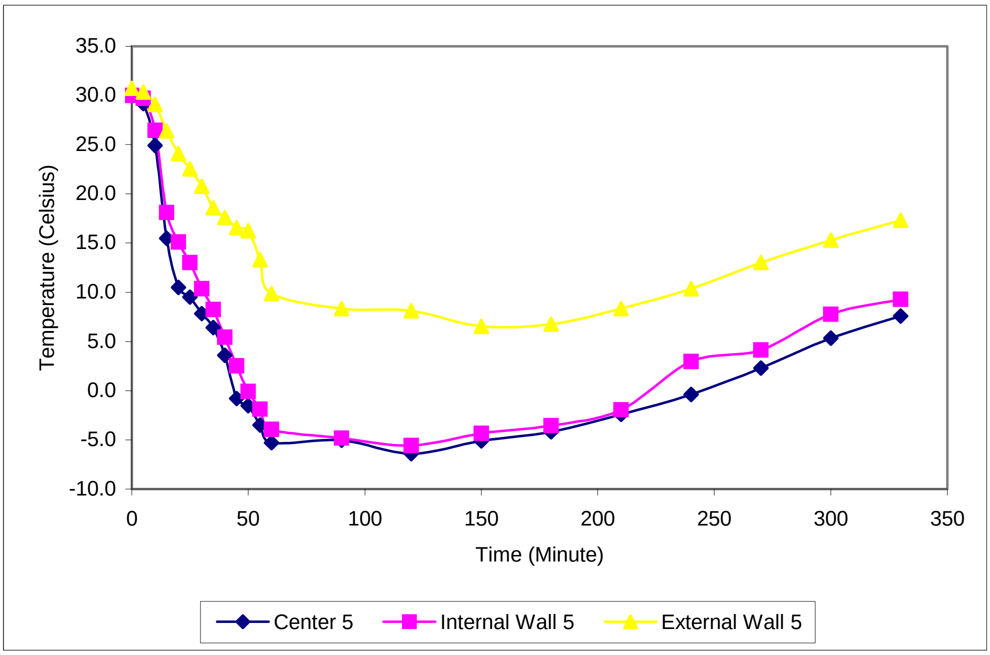


Figure A53: Temperature Profile at Difference Sensor Location of Level 5 Probe for Flow rate 70 liter/minute at Composition of 4060, Weight of 6 kg and Surrounding Temperature of 30°C

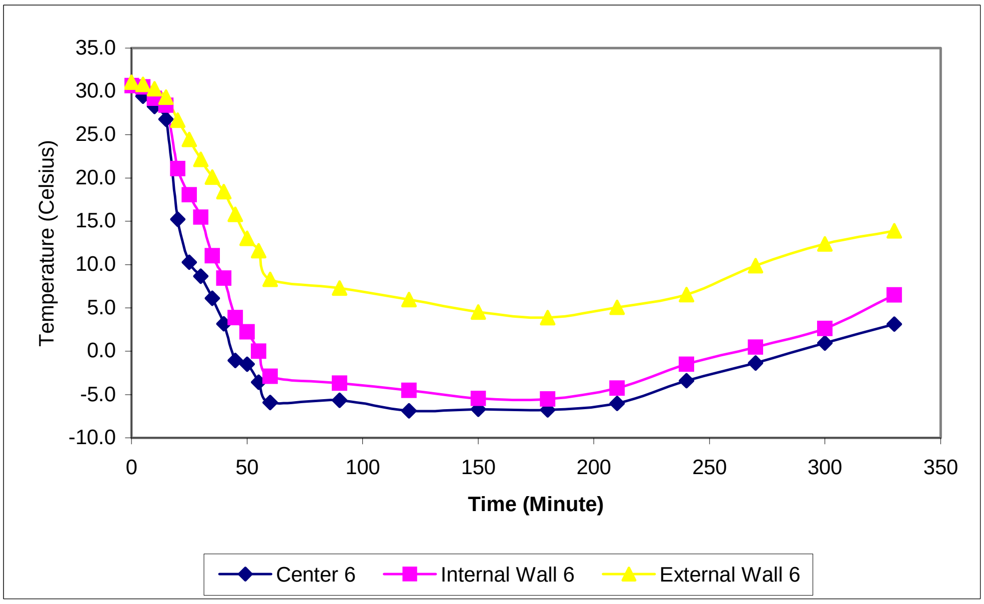


Figure A54: Temperature Profile at Difference Sensor Location of Level 6 Probe for Flow rate 70 liter/minute at Composition of 4060, Weight of 6 kg and Surrounding Temperature of 30°C

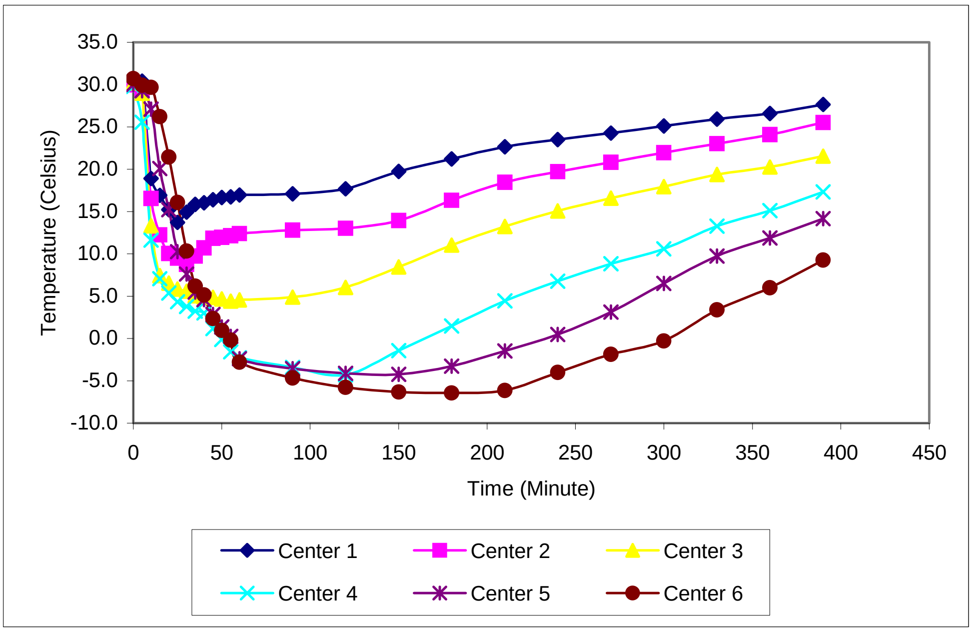


Figure A55: Temperature Profile at Center of the Cylinder for Flow rate 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

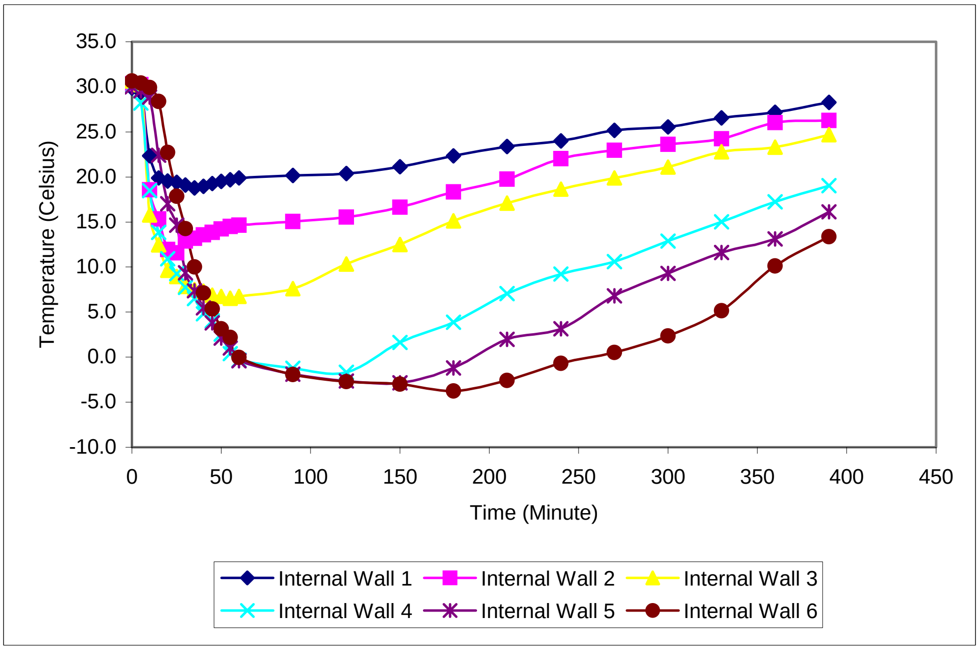


Figure A56: Temperature Profile at Internal Wall of the Cylinder for Flow rate 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

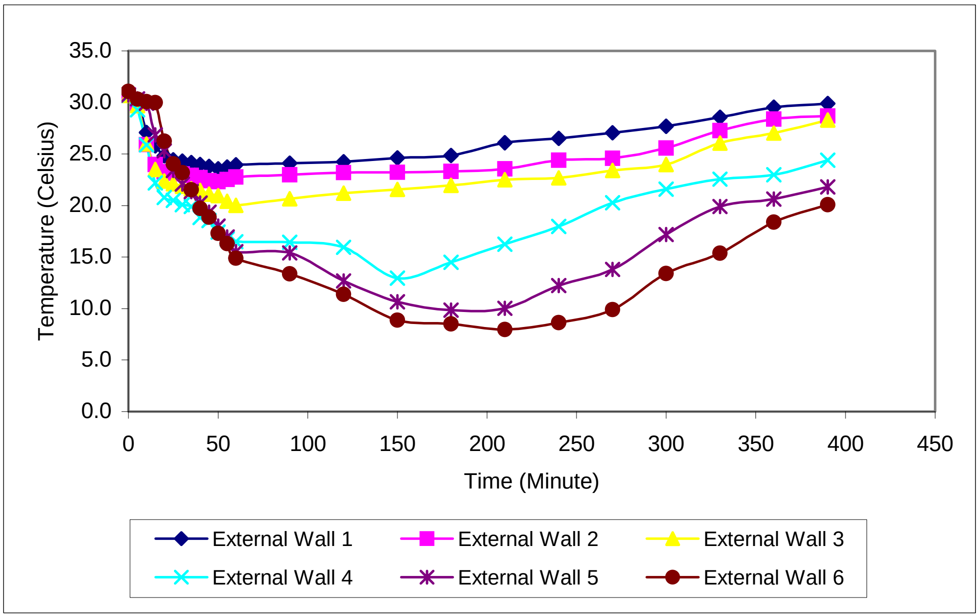


Figure A57: Temperature Profile at External Wall of the Cylinder for Flow rate 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

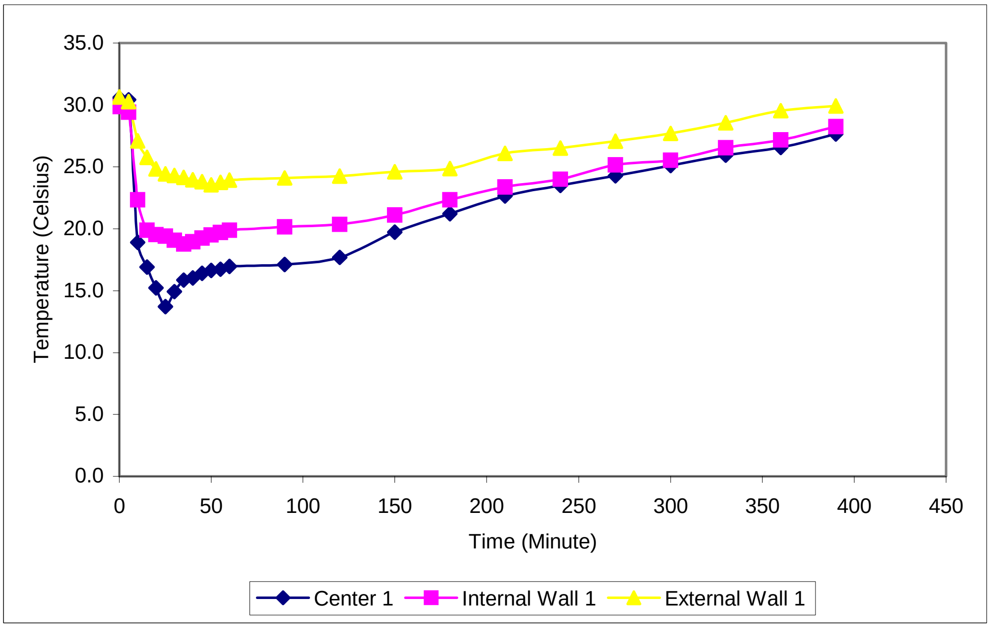


Figure A58: Temperature Profile at Difference Sensor Location of Level 1 Probe for Flow rate 60 liter/minute at Composition of 4060, Weight of 6 kg and Surrounding Temperature of 30°C

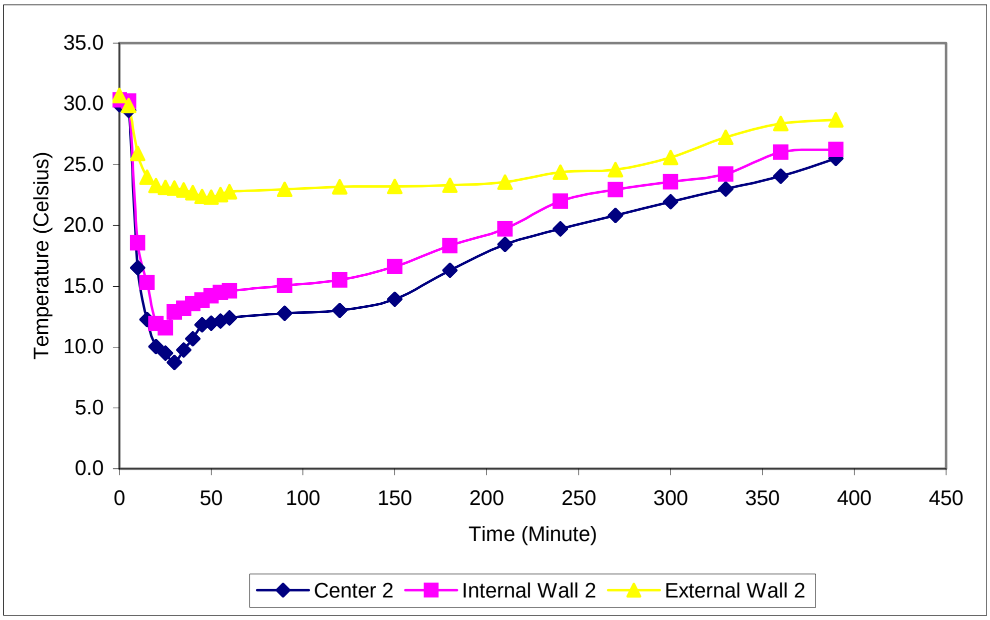


Figure A59: Temperature Profile at Difference Sensor Location of Level 2 Probe for Flow rate 60 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

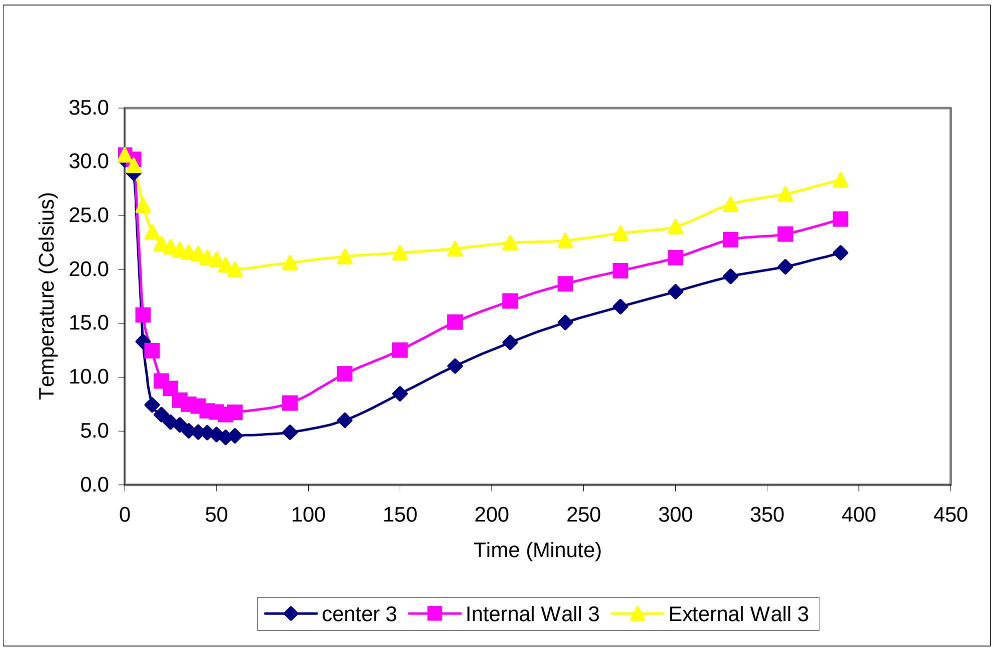


Figure A60: Temperature Profile at Difference Sensor Location of Level 3 Probe for Flow rate 60 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

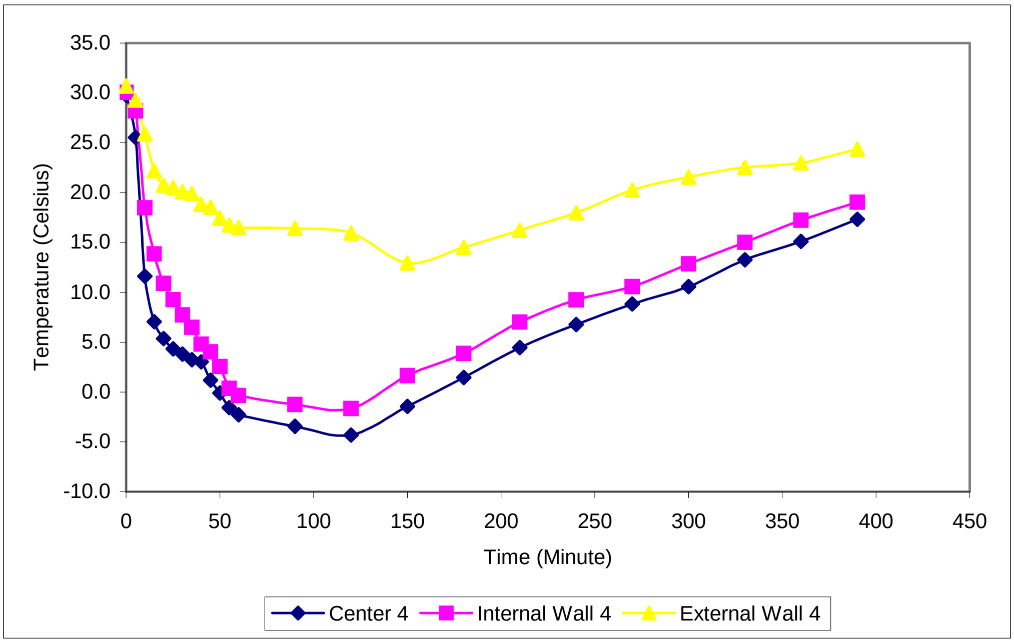


Figure A61: Temperature Profile at Difference Sensor Location of Level 4 Probe for Flow rate 60 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

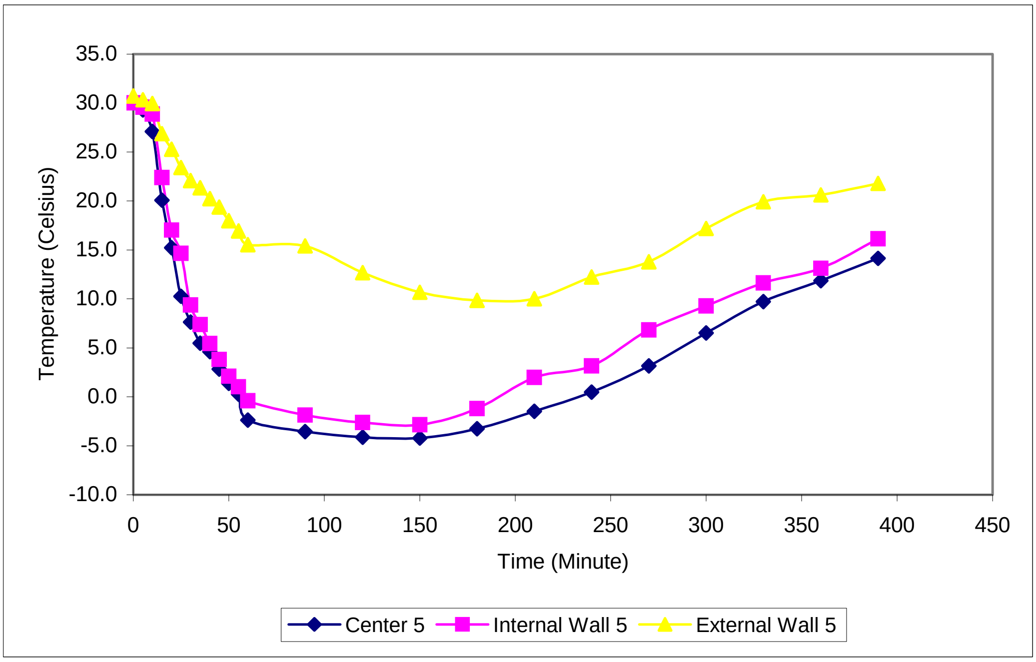


Figure A62: Temperature Profile at Difference Sensor Location of Level 5 Probe for Flow rate 60 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

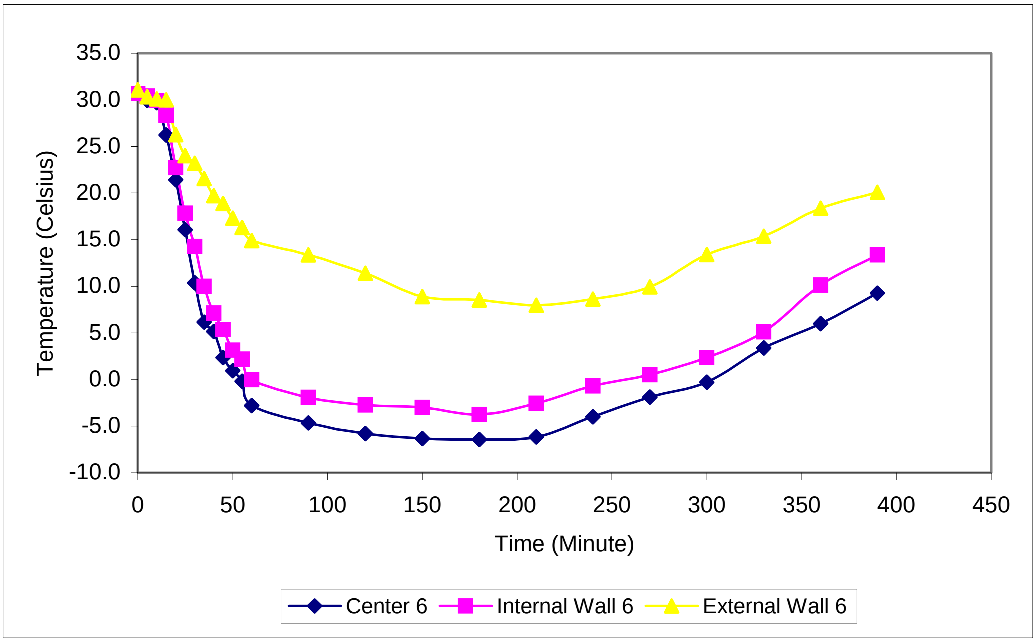


Figure A63: Temperature Profile at Difference Sensor Location of Level 6 Probe for Flow rate 60 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

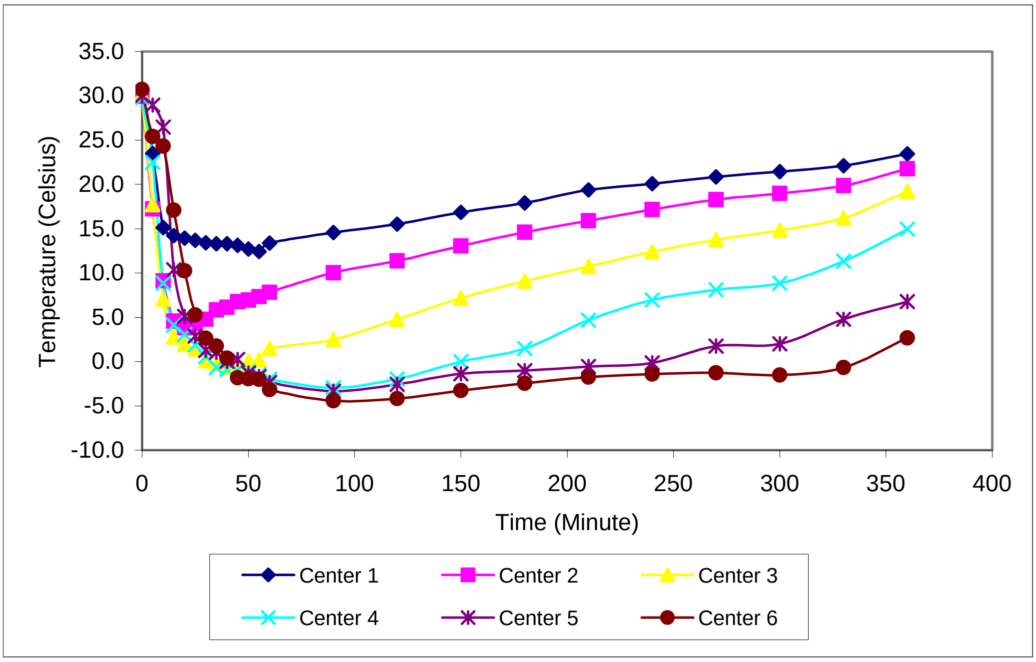


Figure A64: Temperature Profile at Center of the Cylinder for Flow rate 48 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

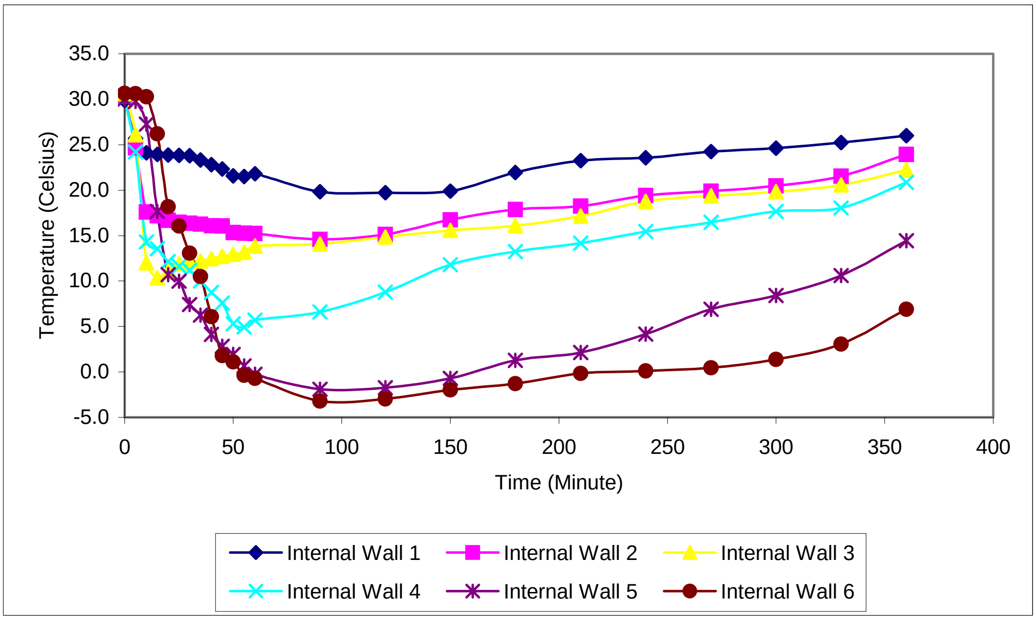


Figure A65: Temperature Profile at Internal Wall of the Cylinder for Flow rate 48 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

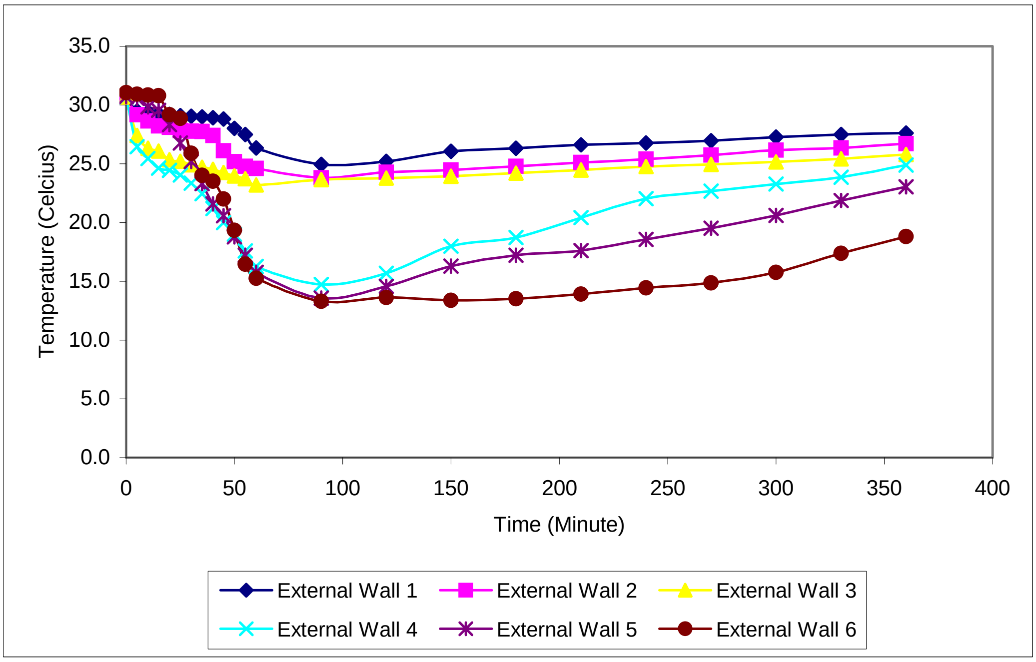


Figure A66: Temperature Profile at External Wall of the Cylinder for Flow rate 48 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

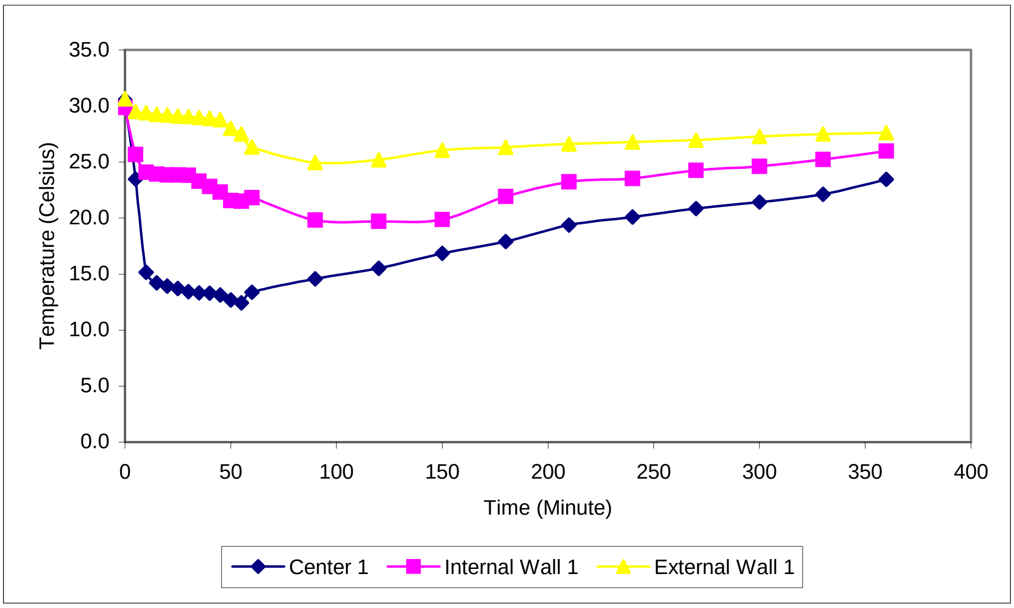


Figure A67: Temperature Profile at Difference Sensor Location of Level 1 Probe for Flow rate 48 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

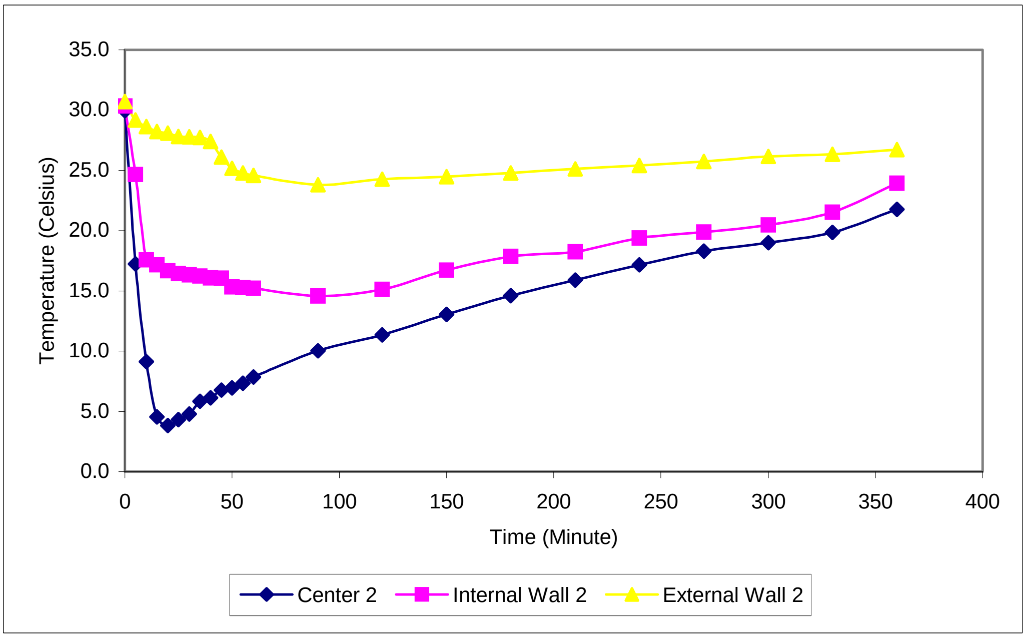


Figure A68: Temperature Profile at Difference Sensor Location of Level 2 Probe for Flow rate 48 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

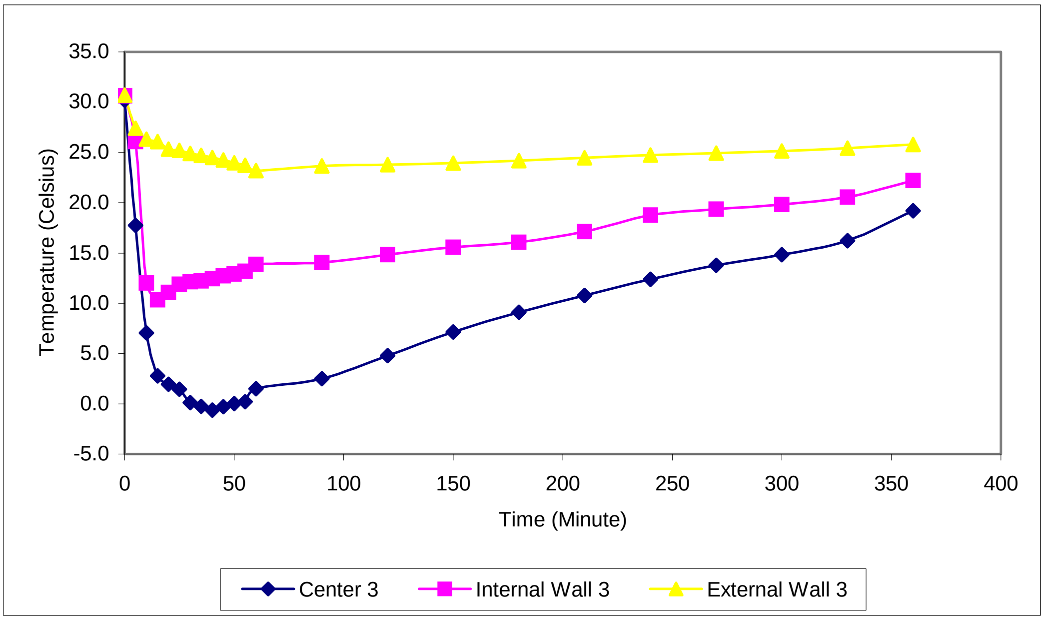


Figure A69: Temperature Profile at Difference Sensor Location of Level 3 Probe for Flow rate 48 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

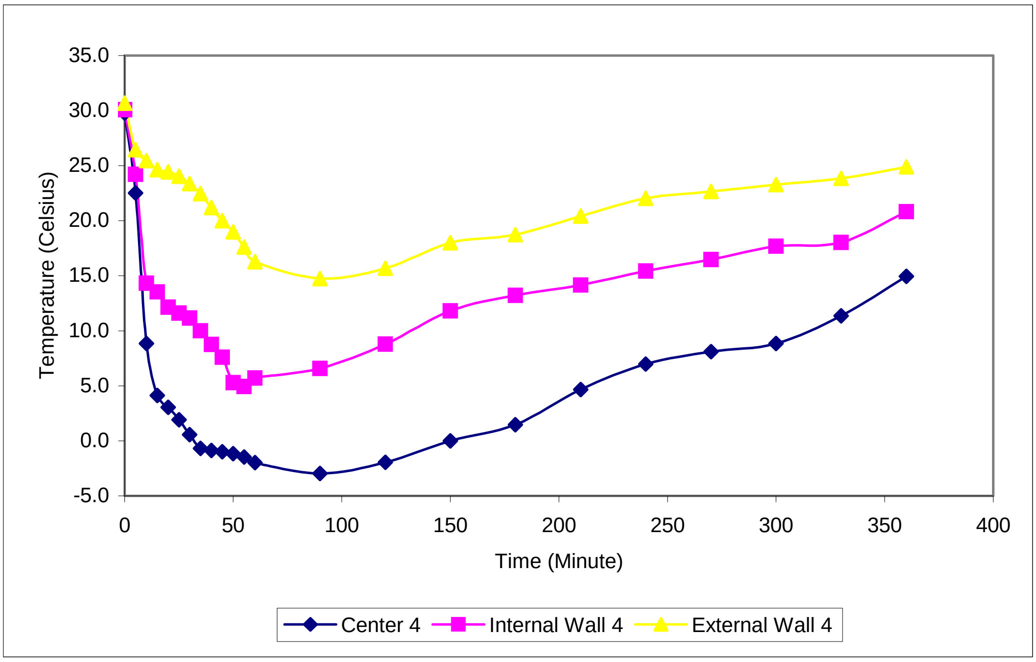


Figure A70: Temperature Profile at Difference Sensor Location of Level 4 Probe for Flow rate 48 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

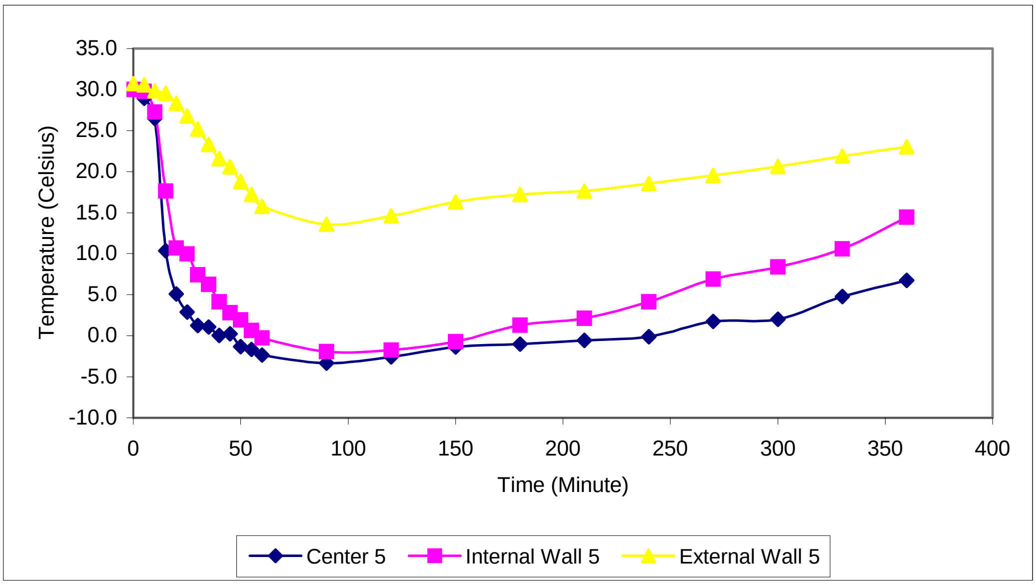


Figure A71: Temperature Profile at Difference Sensor Location of Level 5 Probe for Flow rate 48 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

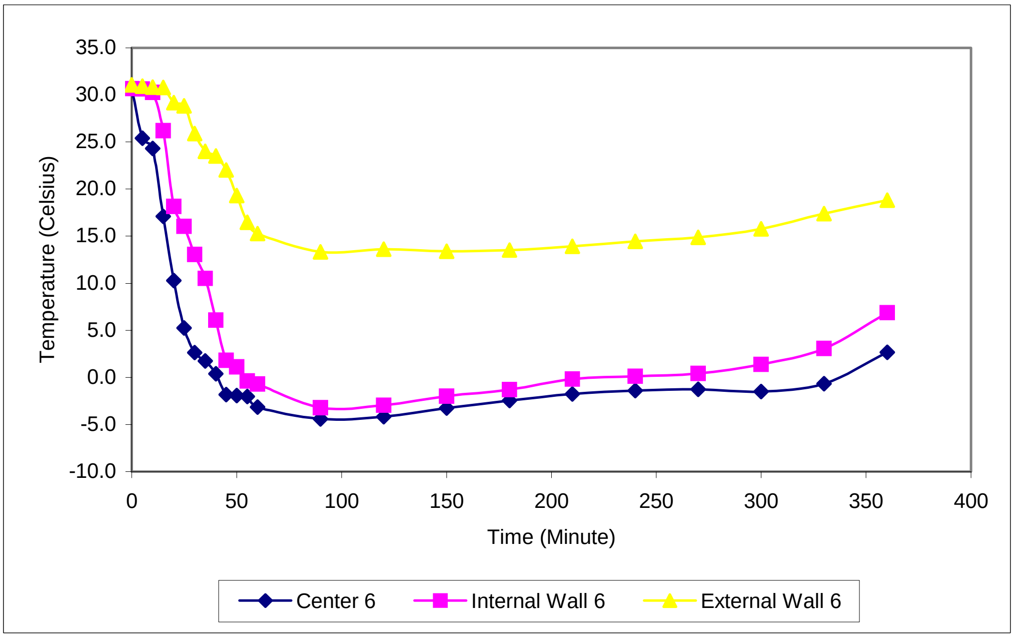


Figure A72: Temperature Profile at Difference Sensor Location of Level 6 Probe for Flow rate 48 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

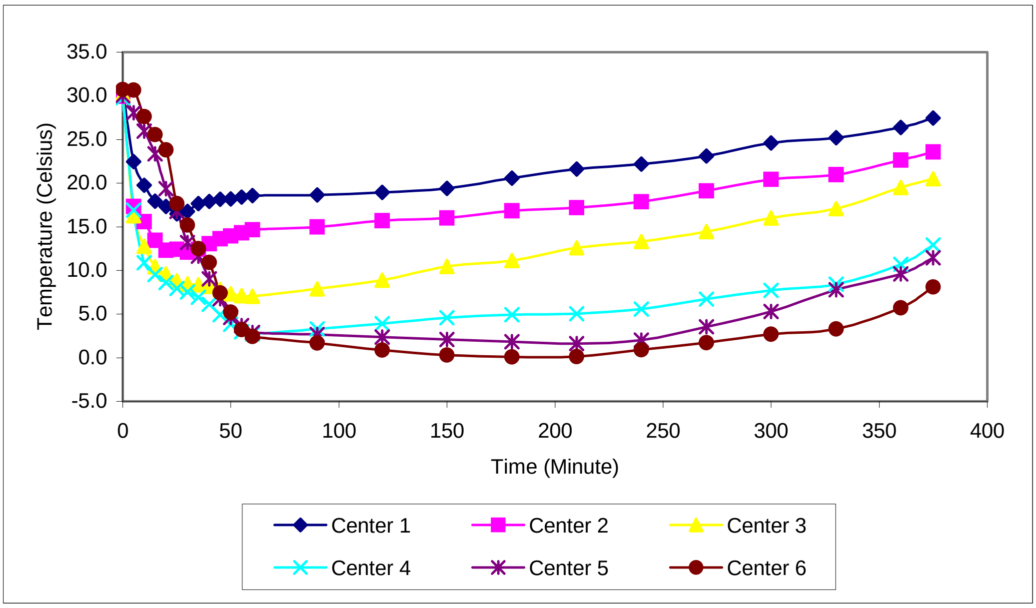


Figure A73: Temperature Profile at Center of the Cylinder for Flow rate 30 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

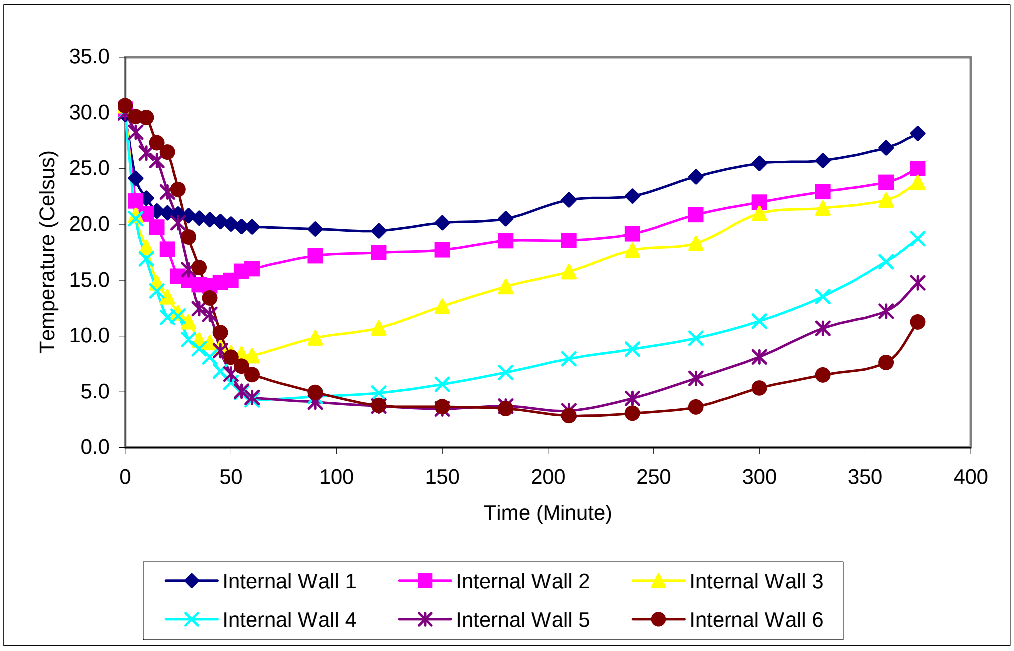


Figure A74: Temperature Profile at Internal Wall of the Cylinder for Flow rate 30 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

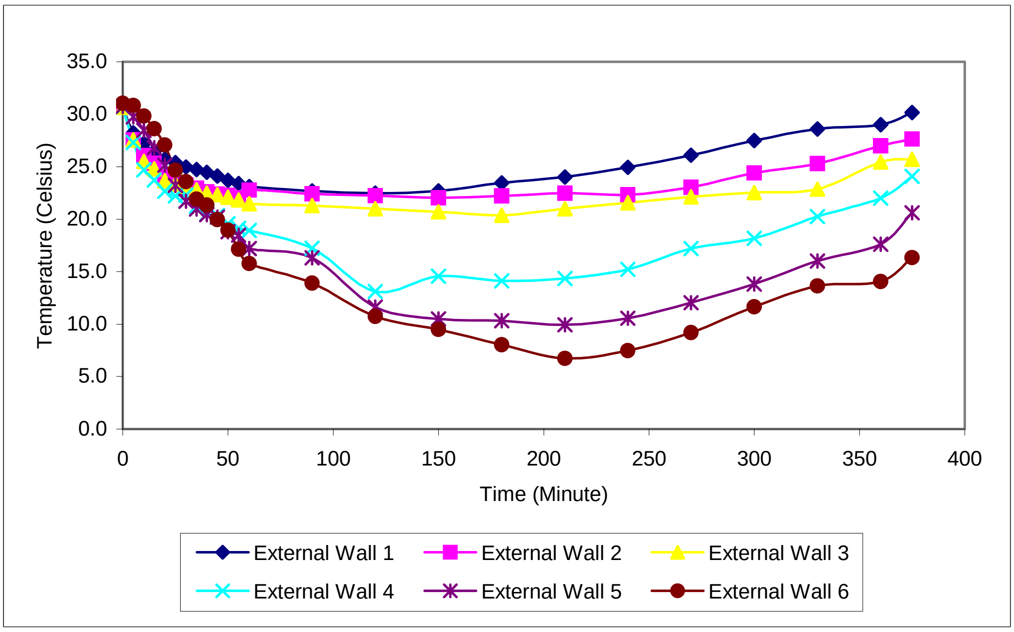


Figure A75: Temperature Profile at External Wall of the Cylinder for Flow rate 30 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

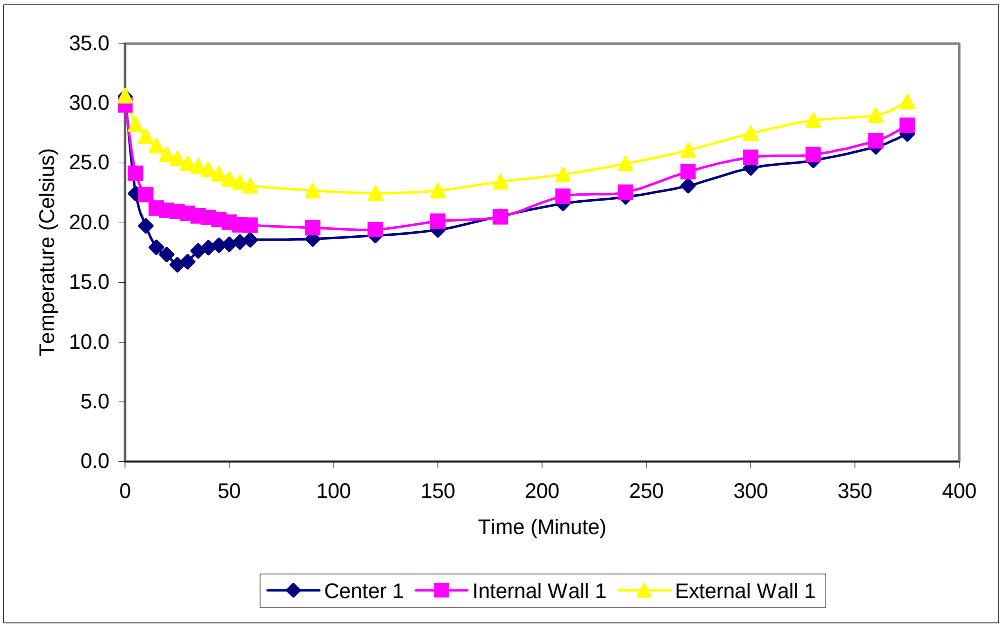


Figure A76: Temperature Profile at Difference Sensor Location of Level 1 Probe for Flow rate 30 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

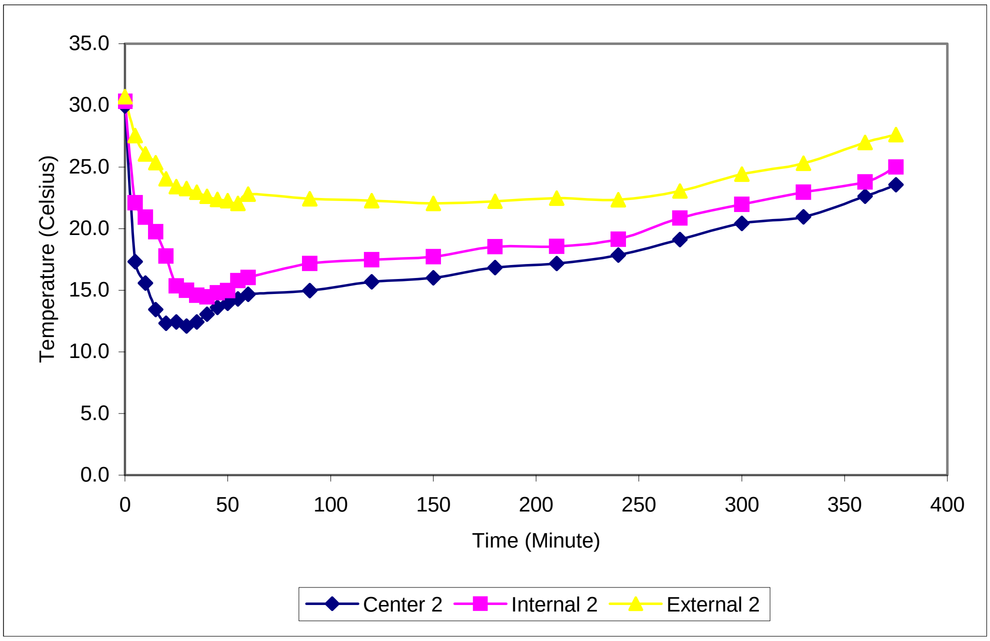


Figure A77: Temperature Profile at Difference Sensor Location of Level 2 Probe for Flow rate 30 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

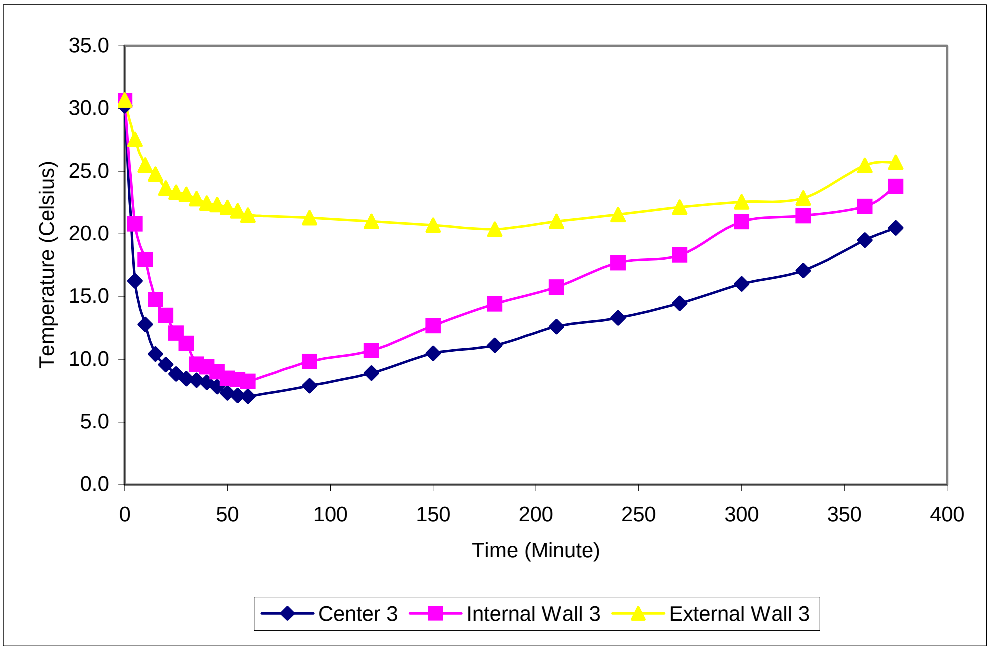


Figure A78: Temperature Profile at Difference Sensor Location of Level 3 Probe for Flow rate 30 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

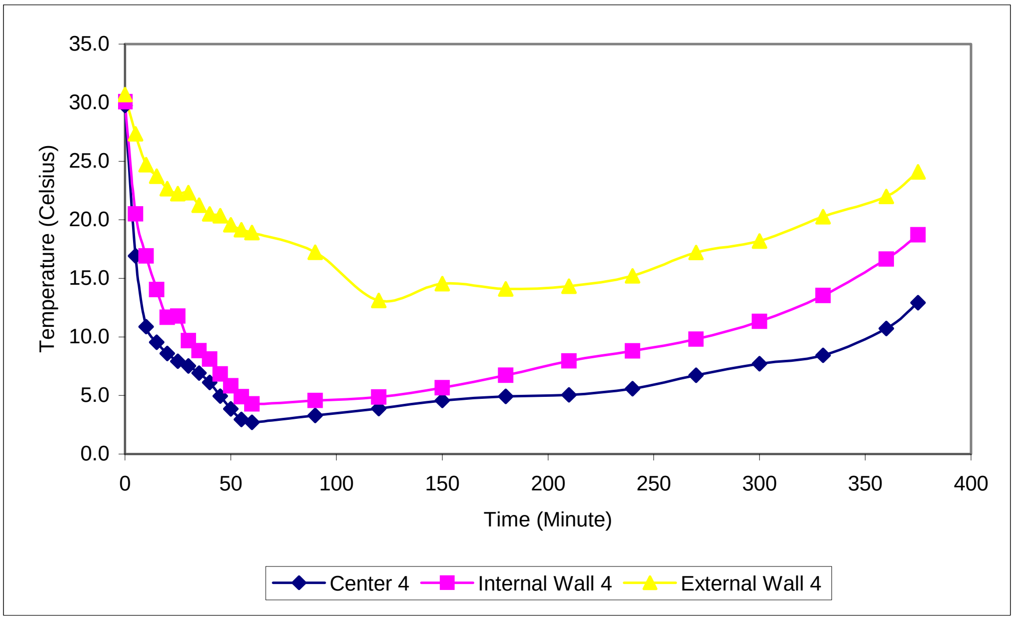


Figure A79: Temperature Profile at Difference Sensor Location of Level 4 Probe for Flow rate 30 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

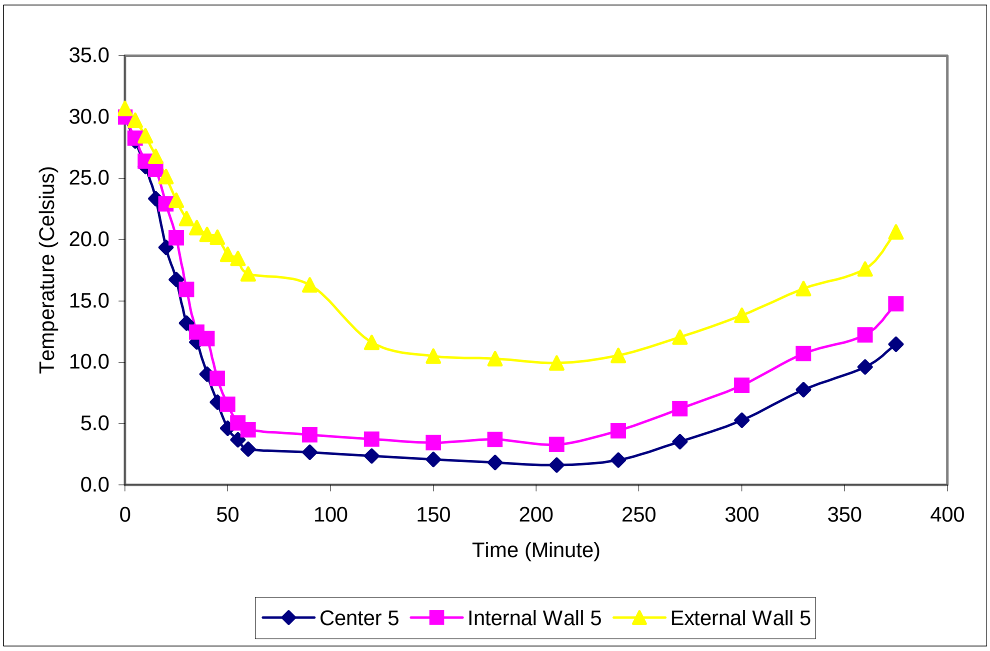


Figure A80: Temperature Profile at Difference Sensor Location of Level 5 Probe for Flow rate 30 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

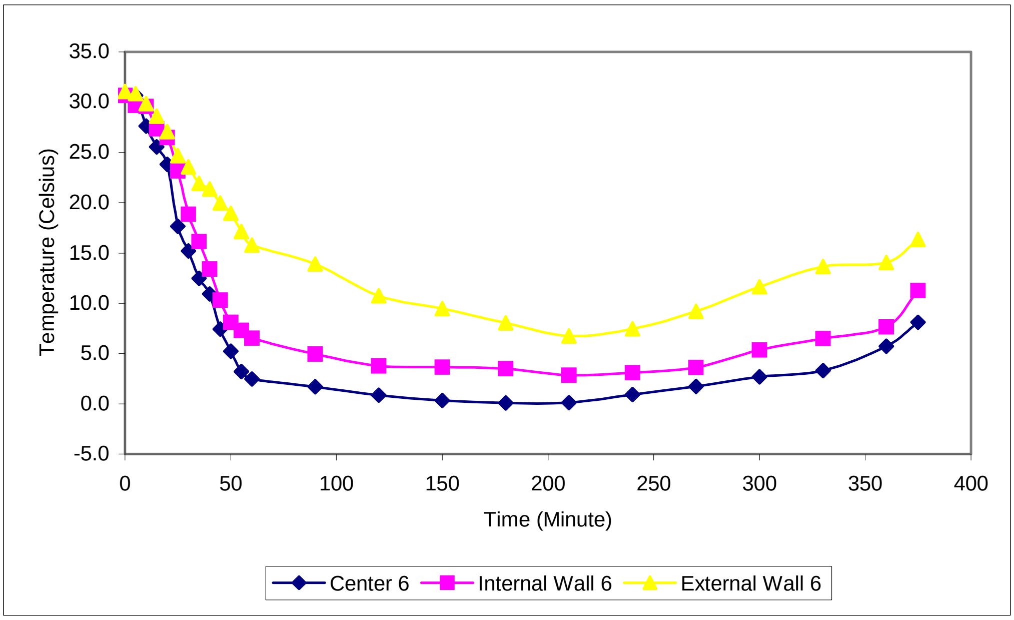


Figure A81: Temperature Profile at Difference Sensor Location of Level 6 Probe for Flow rate 30 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

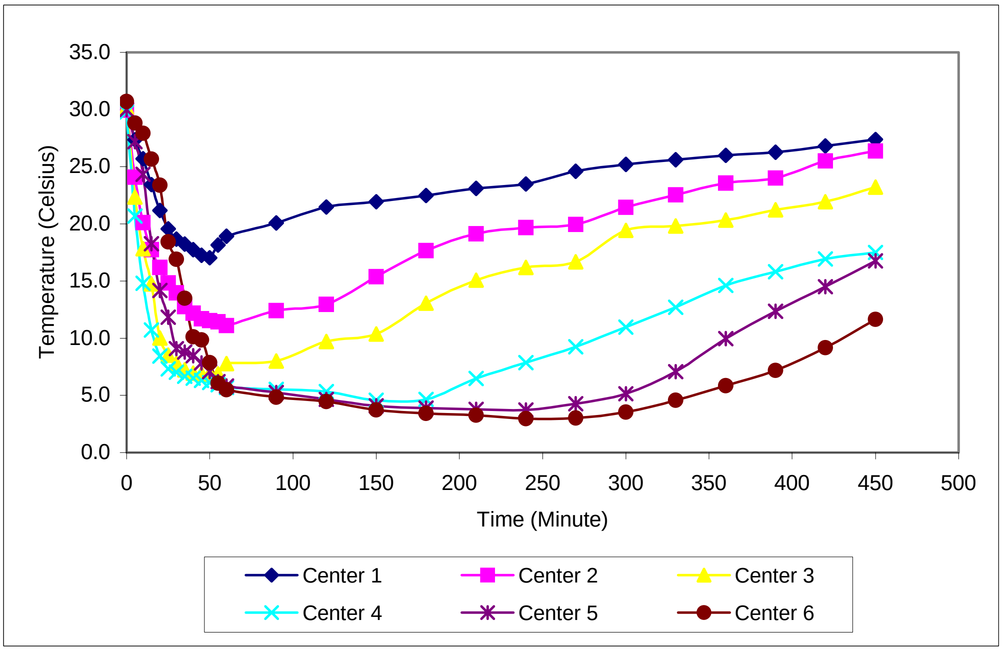


Figure A82: Temperature Profile at Center of the Cylinder for Flow rate 20 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

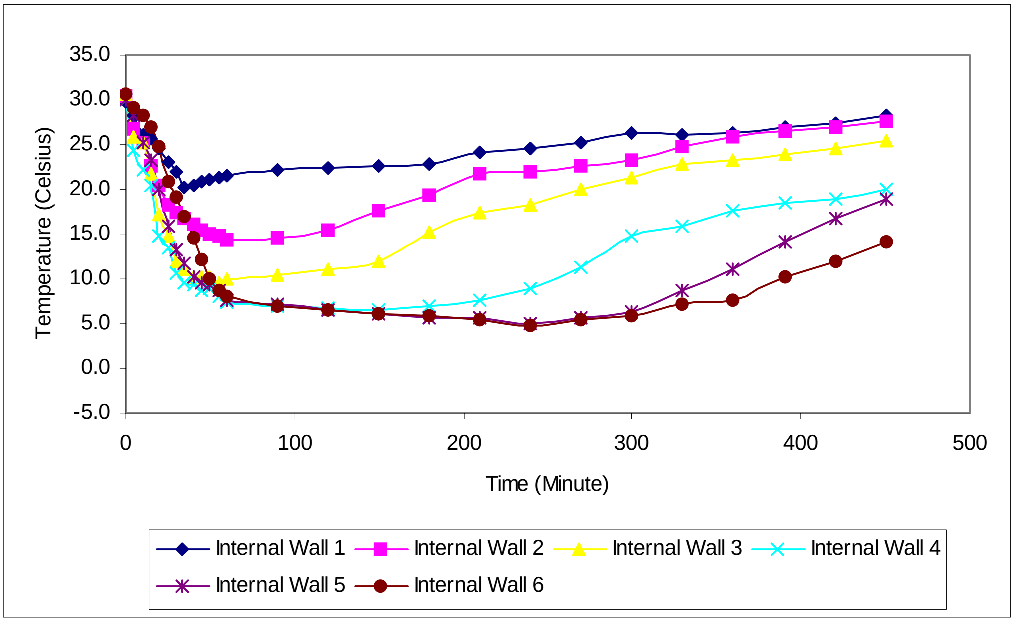


Figure A83: Temperature Profile at Internal Wall of the Cylinder for Flow rate 20 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

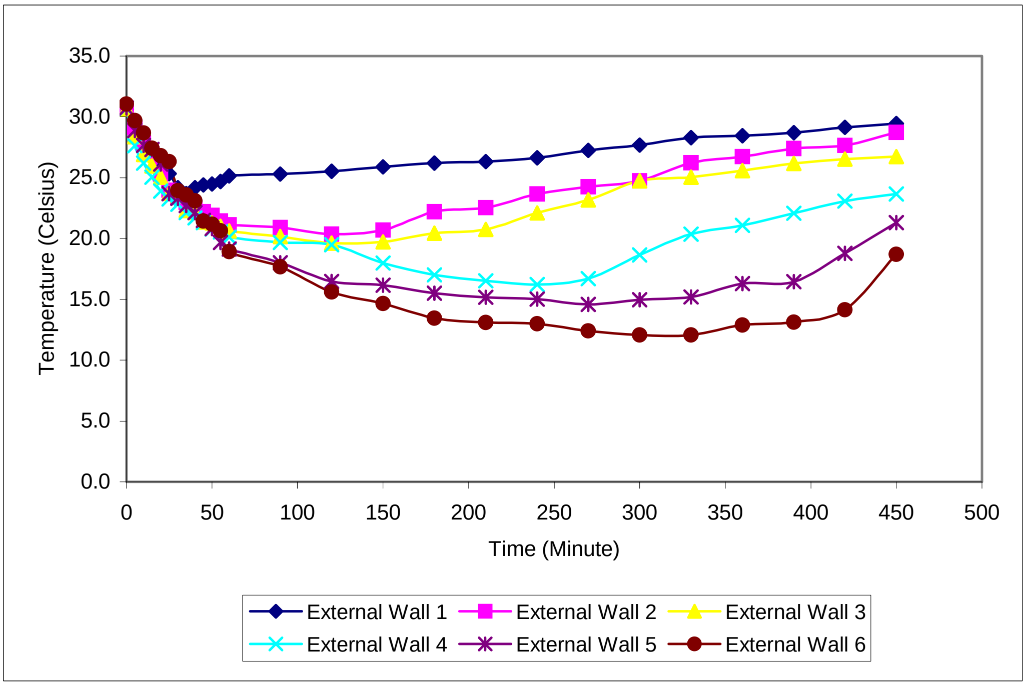


Figure A84: Temperature Profile at External Wall of the Cylinder for Flow rate 20 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

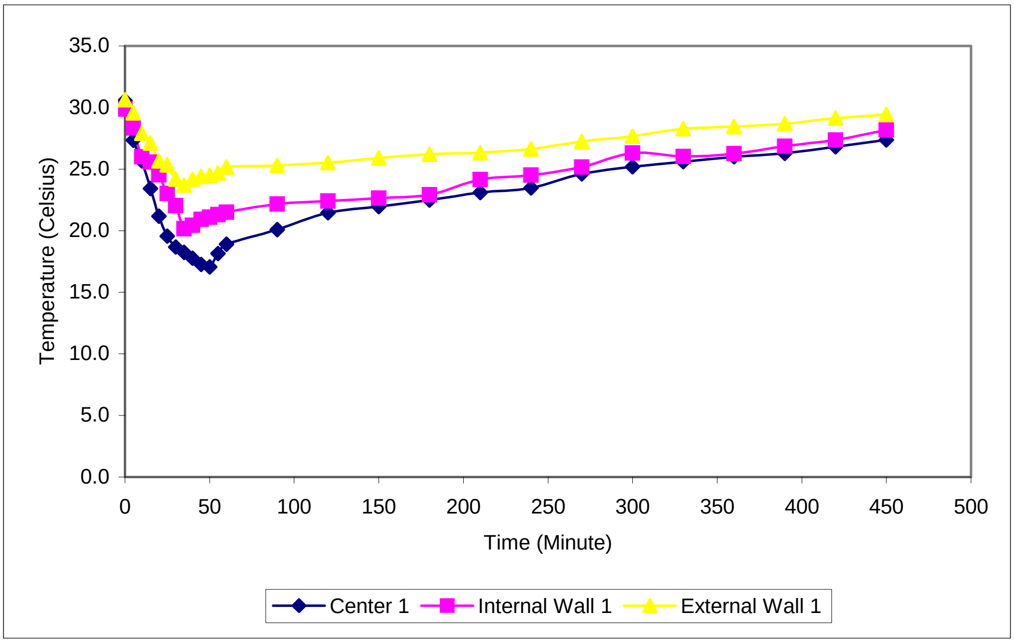


Figure A85: Temperature Profile at Difference Sensor Location of Level 1 Probe for Flow rate 20 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

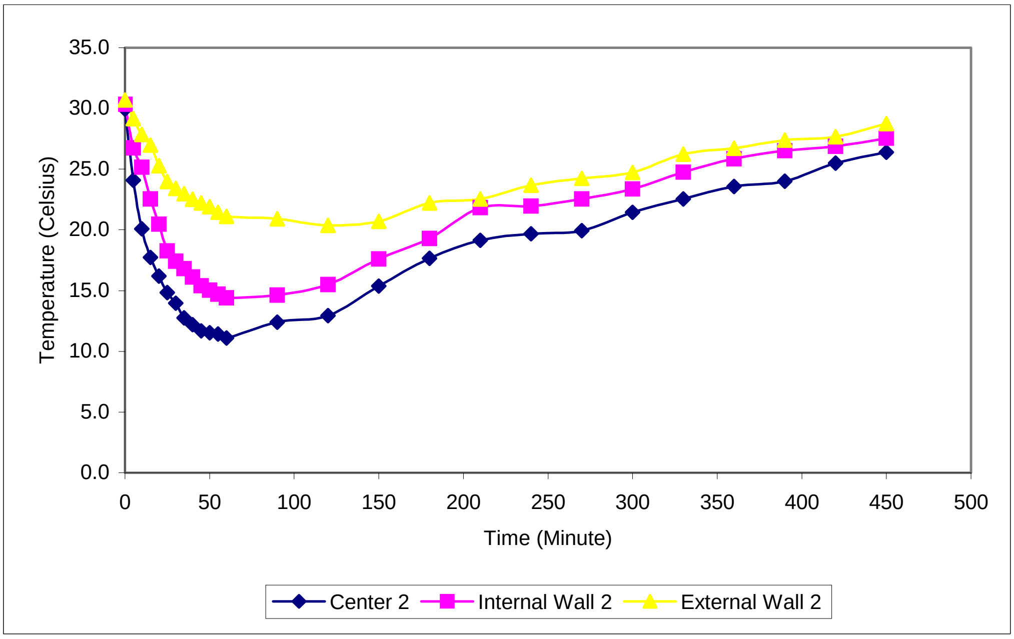


Figure A86: Temperature Profile at Difference Sensor Location of Level 2 Probe for Flow rate 20 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

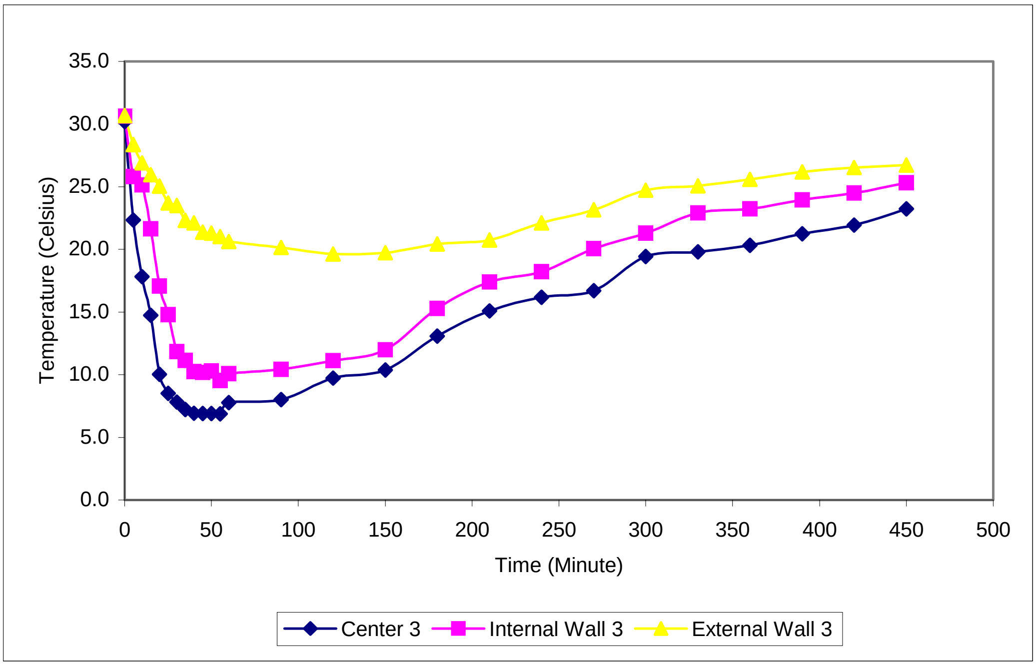


Figure A87: Temperature Profile at Difference Sensor Location of Level 3 Probe for Flow rate 20 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

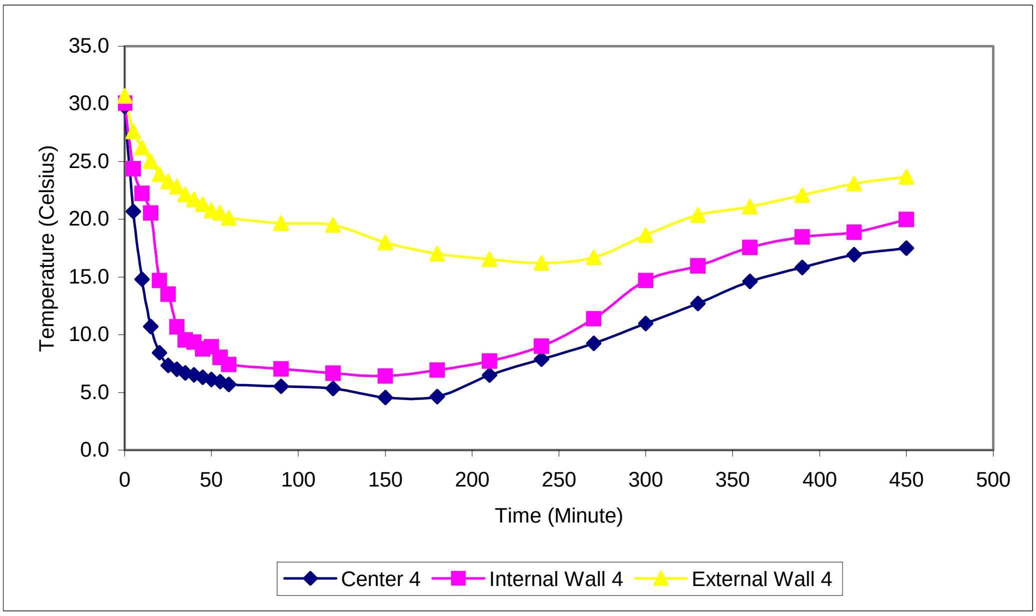


Figure A88: Temperature Profile at Difference Sensor Location of Level 4 Probe for Flow rate 20 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

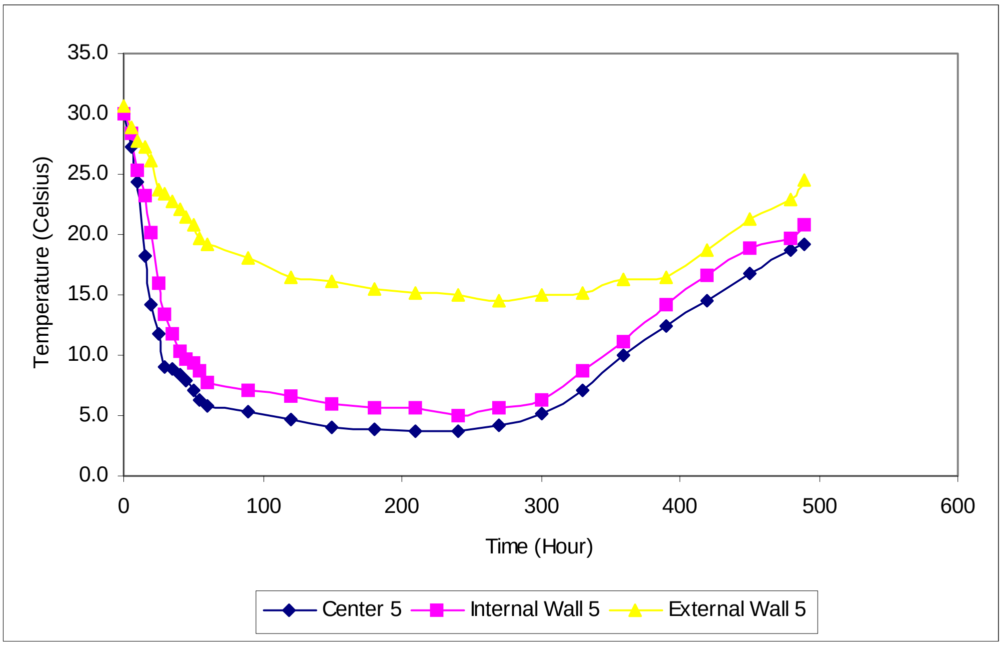


Figure A89: Temperature Profile at Difference Sensor Location of Level 5 Probe for Flow rate 20 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

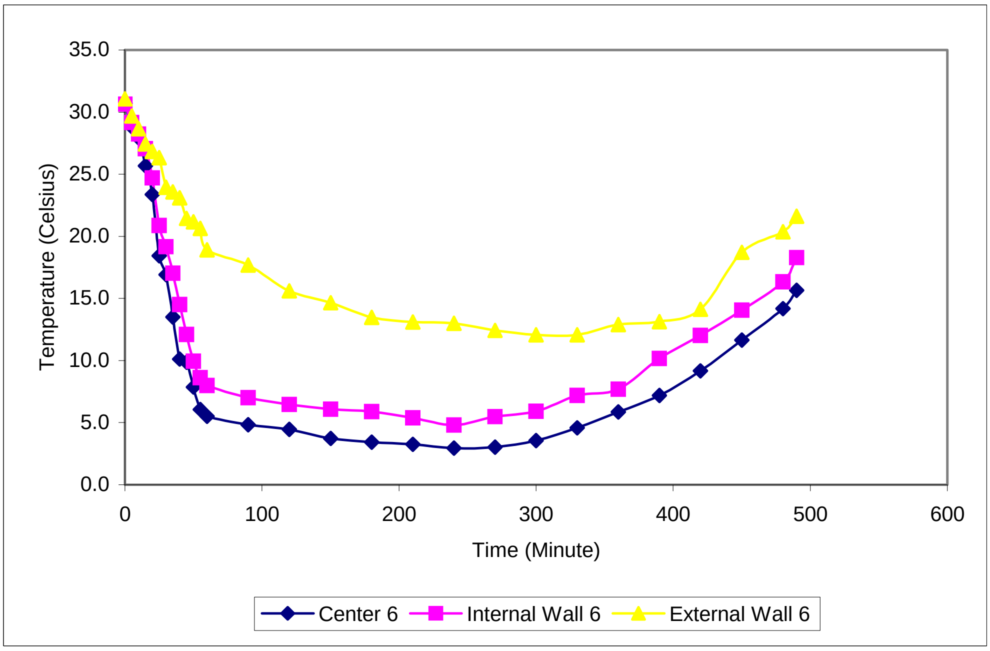


Figure A90: Temperature Profile at Difference Sensor Location of Level 6 Probe for Flow rate 20 liter/minute at Composition of 4060 Surrounding Temperature of 30°C and Weight of 6 kg

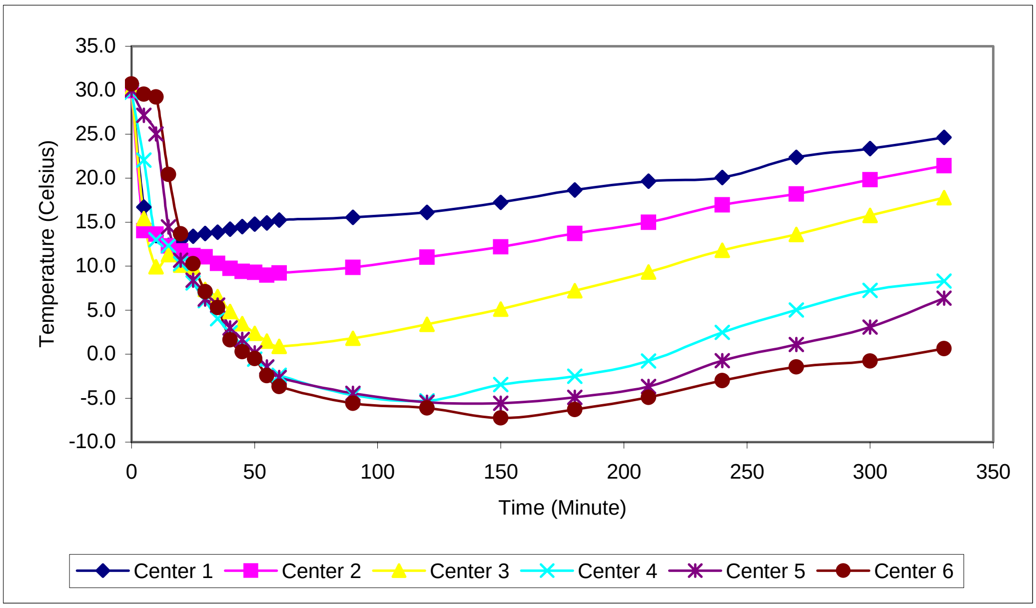


Figure A145: Temperature Profile at Center of the Cylinder for Weight of 7 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

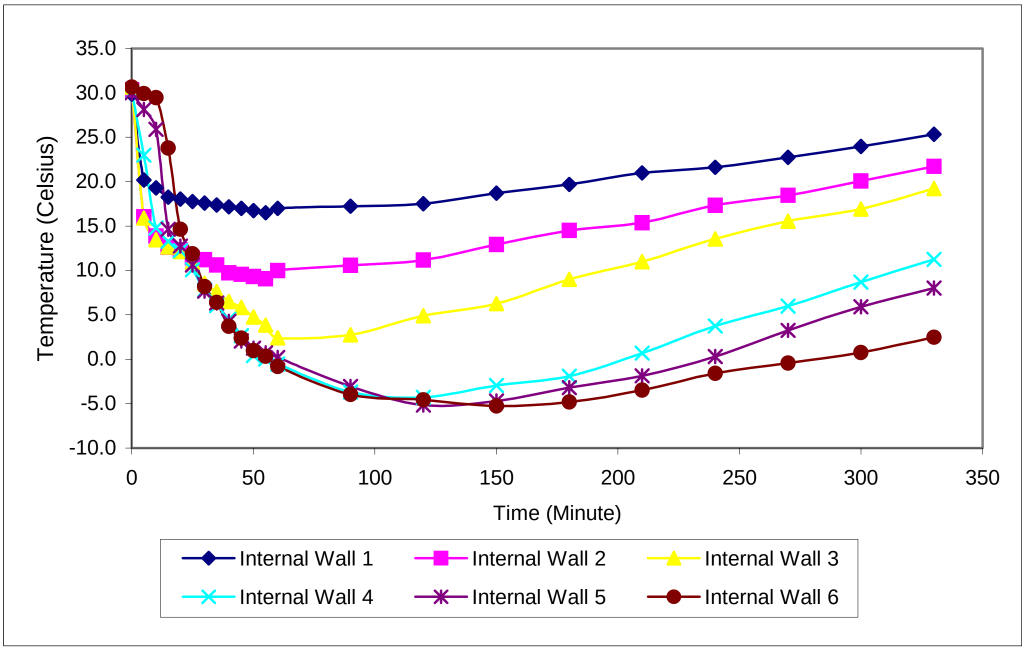


Figure A146: Temperature Profile at Internal Wall of the Cylinder for Weight of 7 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

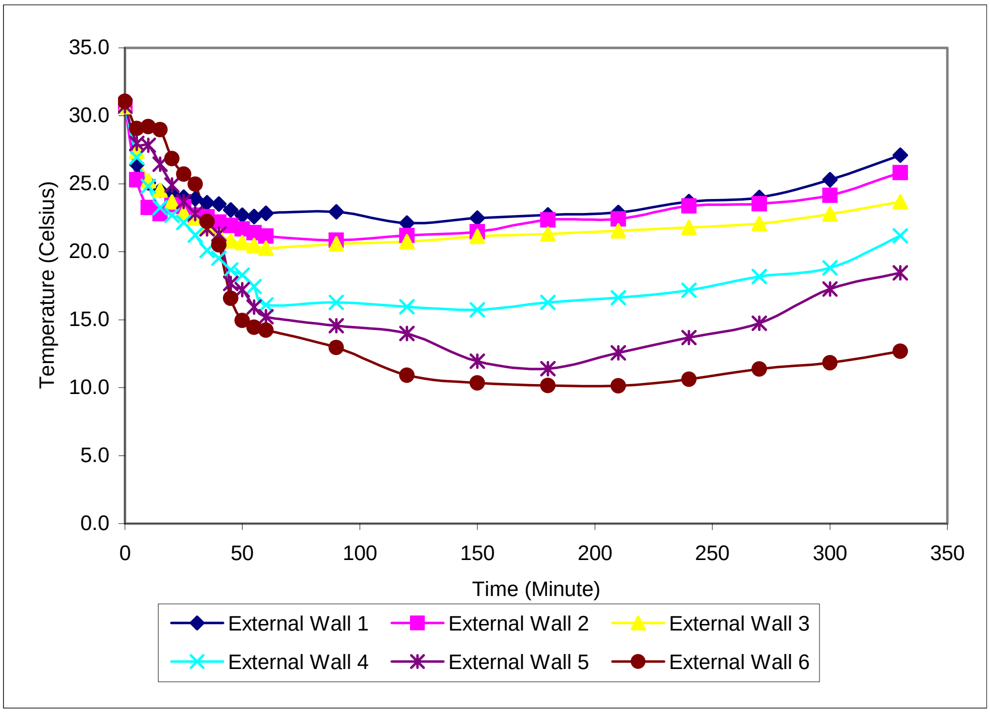


Figure A147: Temperature Profile at External Wall of the Cylinder for Weight of 7 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

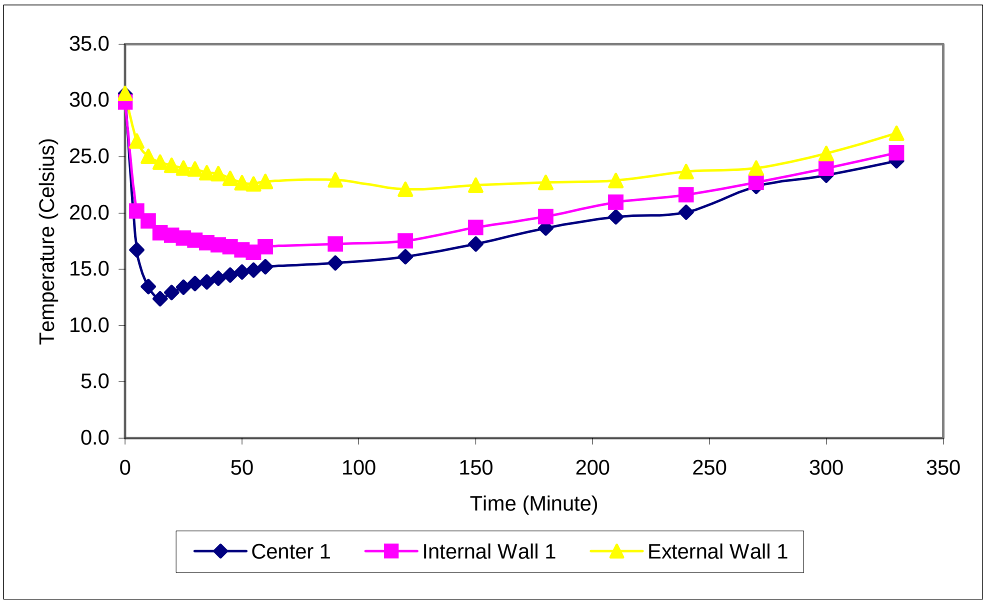


Figure A148: Temperature Profile at Difference Sensor Location of Level 1 Probe for Weight of 7 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

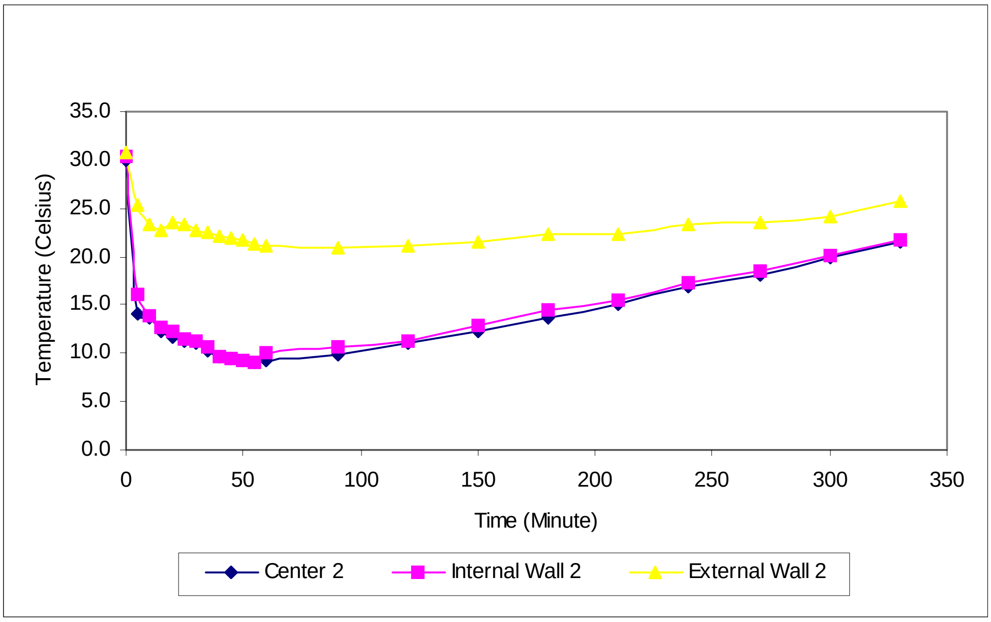


Figure A149: Temperature Profile at Difference Sensor Location of Level 2 Probe for Weight of 7 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

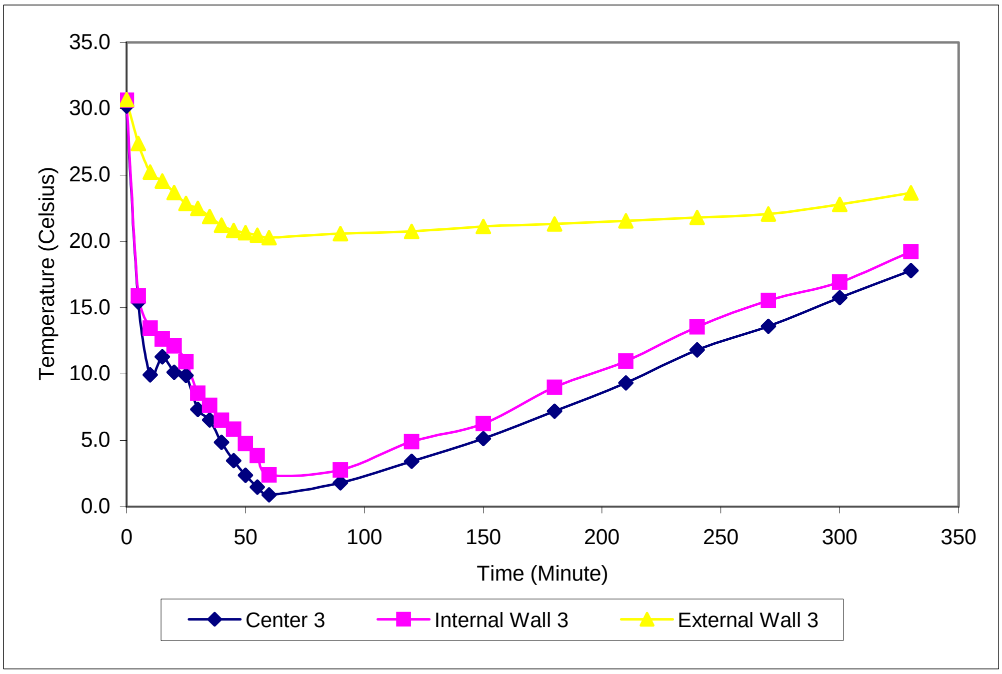


Figure A150: Temperature Profile at Difference Sensor Location of Level 3 Probe for Weight of 7 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

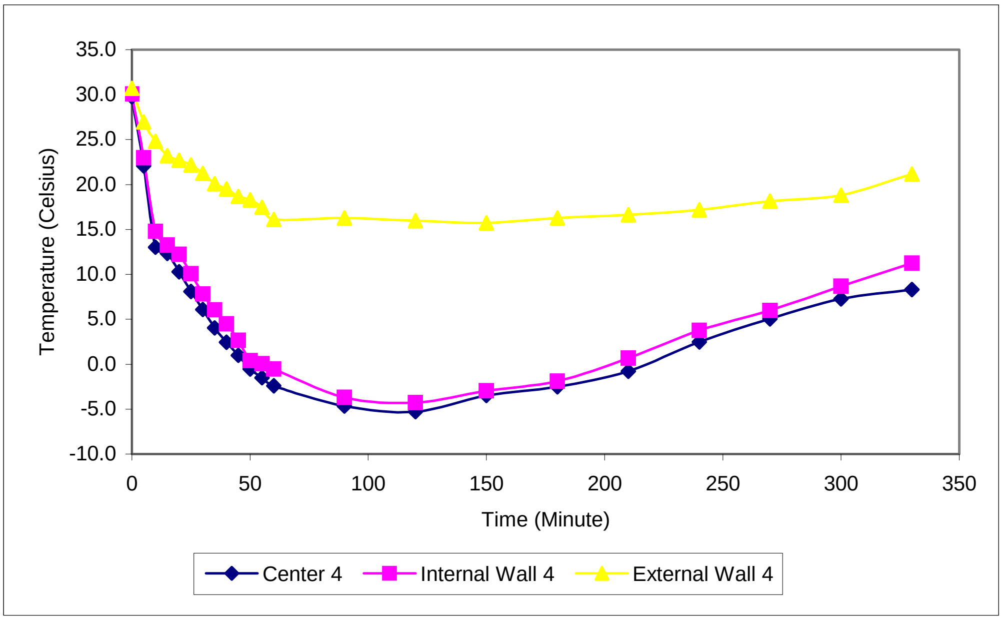


Figure A151: Temperature Profile at Difference Sensor Location of Level 4 Probe for Weight of 7 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

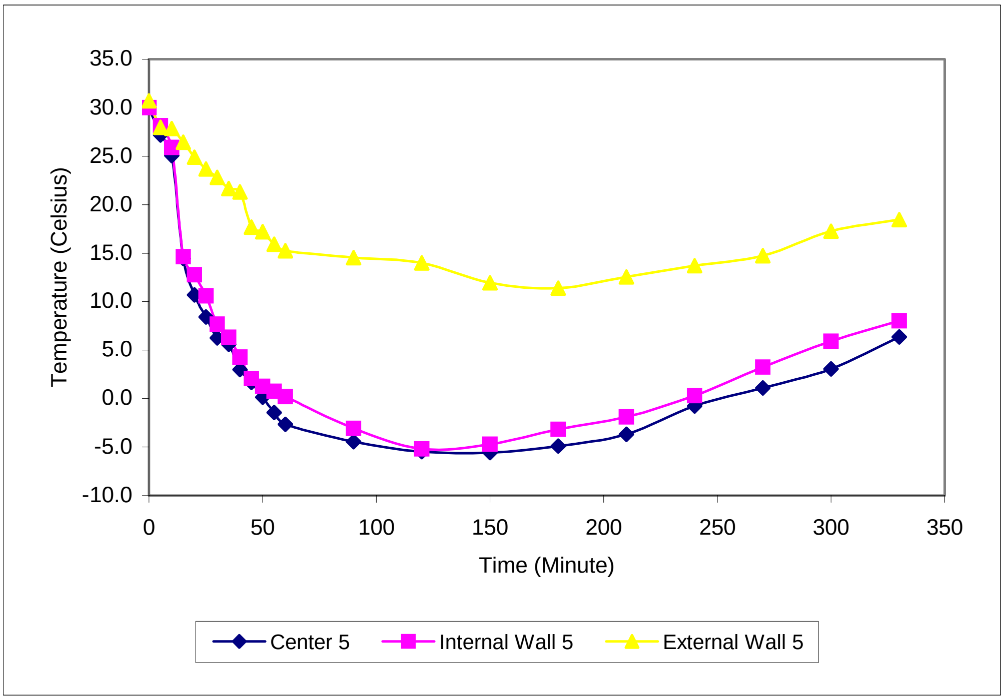


Figure A152: Temperature Profile at Difference Sensor Location of Level 5 Probe for Weight of 7 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

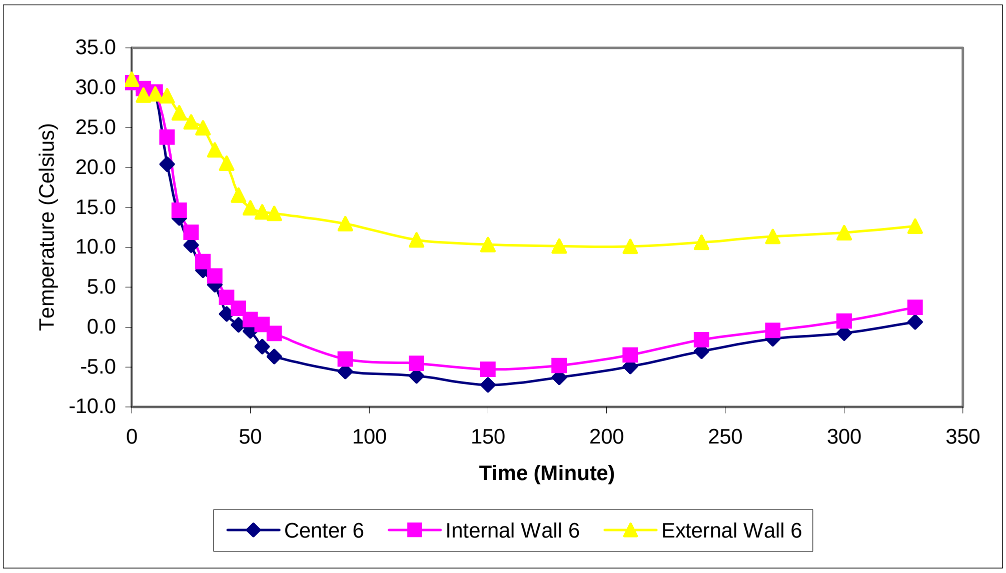


Figure A153: Temperature Profile at Difference Sensor Location of Level 6 Probe for Weight of 7 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

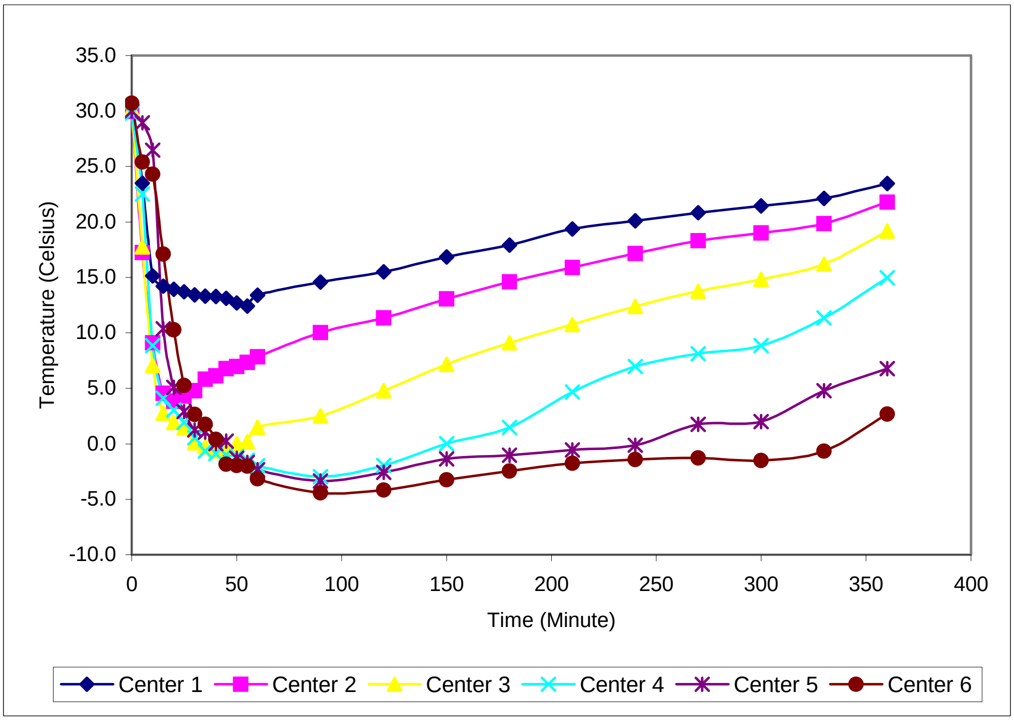


Figure A154: Temperature Profile at Center of the Cylinder for Weight of 6 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

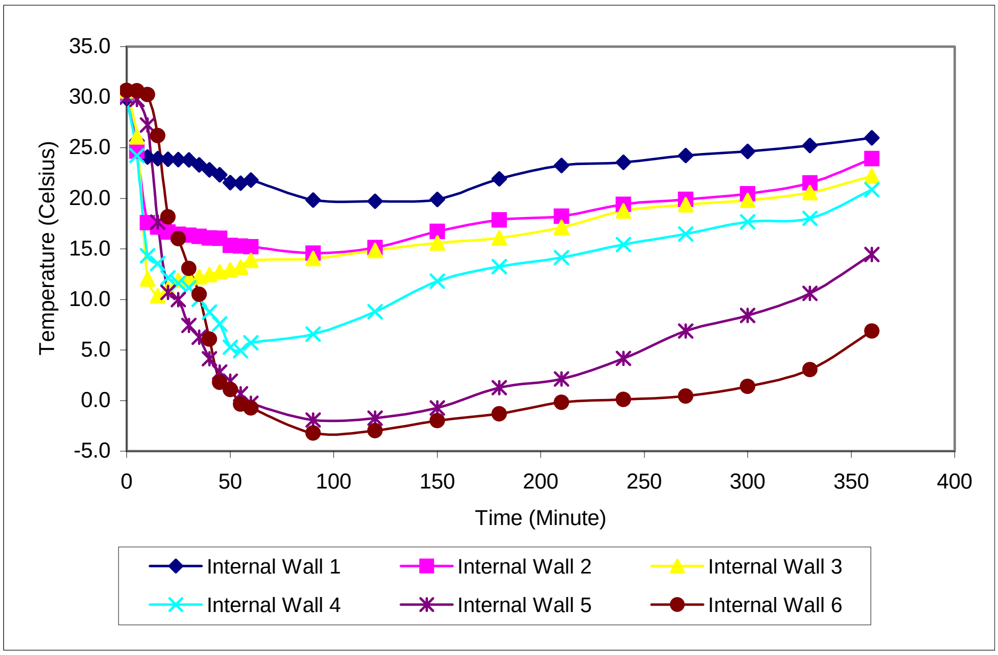


Figure A155: Temperature Profile at Internal Wall of the Cylinder for Weight of 6 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C

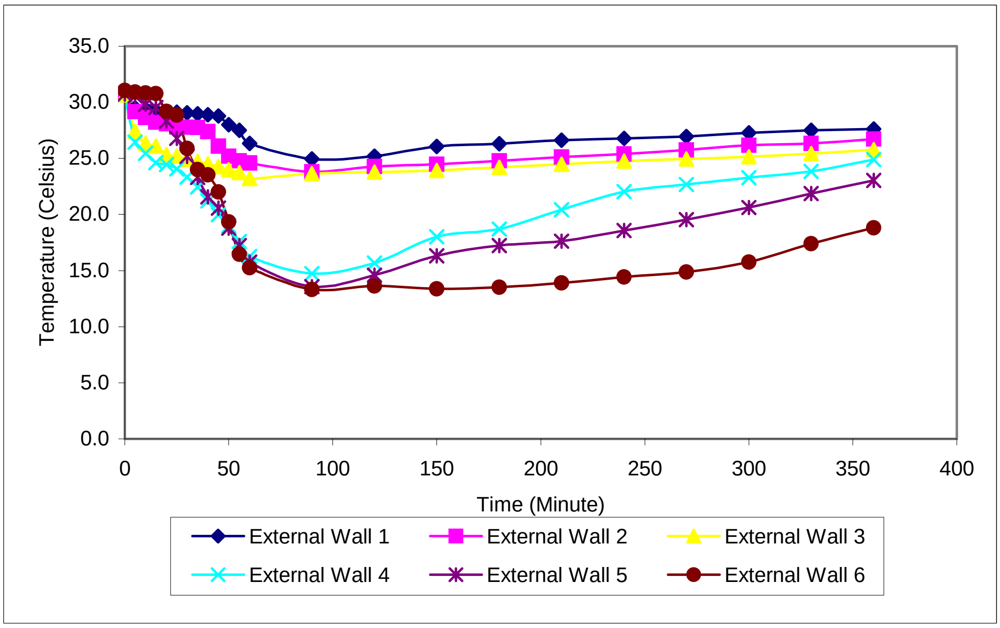


Figure A156: Temperature Profile at External Wall of the Cylinder for Weight of 6 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C

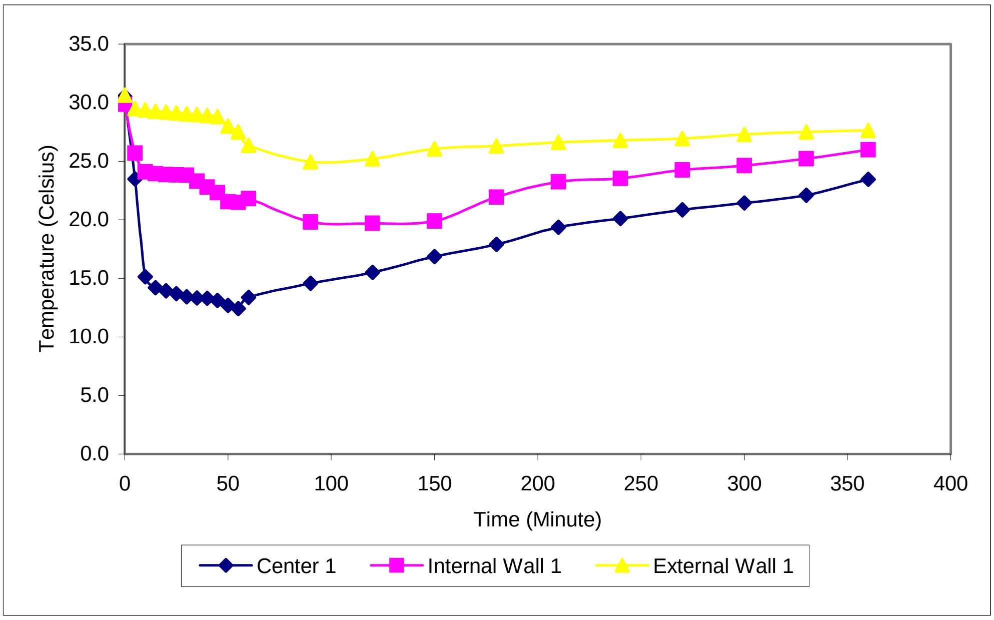


Figure A157: Temperature Profile at Difference Sensor Location of Level 1 Probe for Weight of 6 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

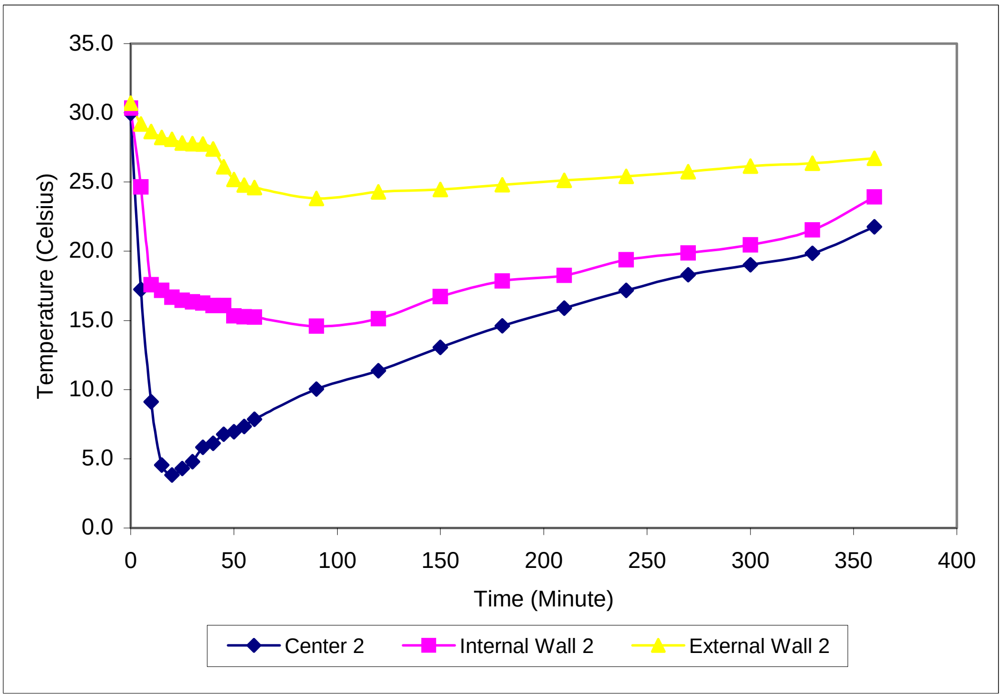


Figure A158: Temperature Profile at Difference Sensor Location of Level 2 Probe for Weight of 6 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

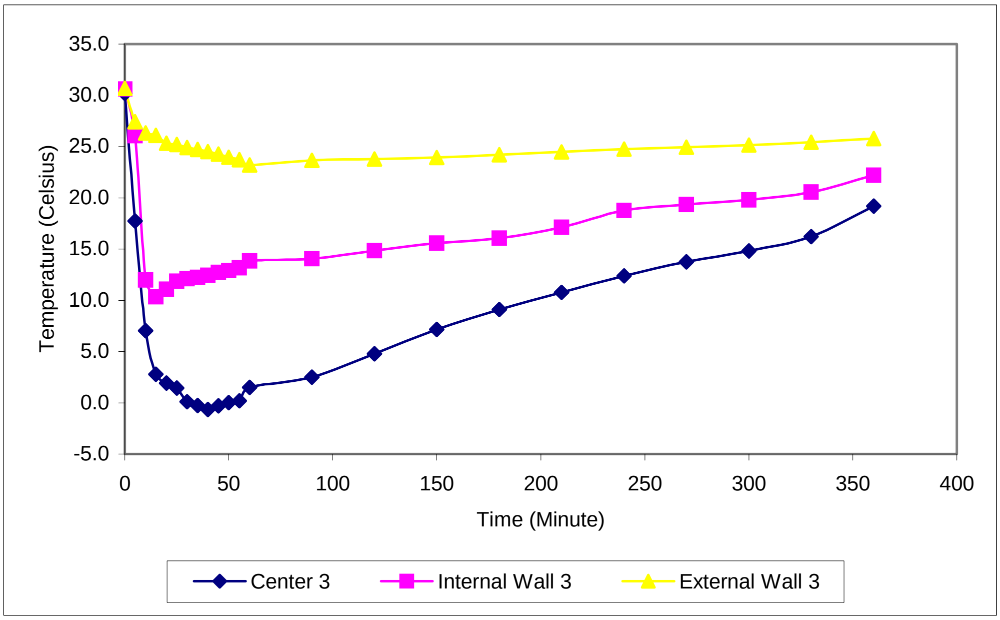


Figure A159: Temperature Profile at Difference Sensor Location of Level 3 Probe for Weight of 6 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

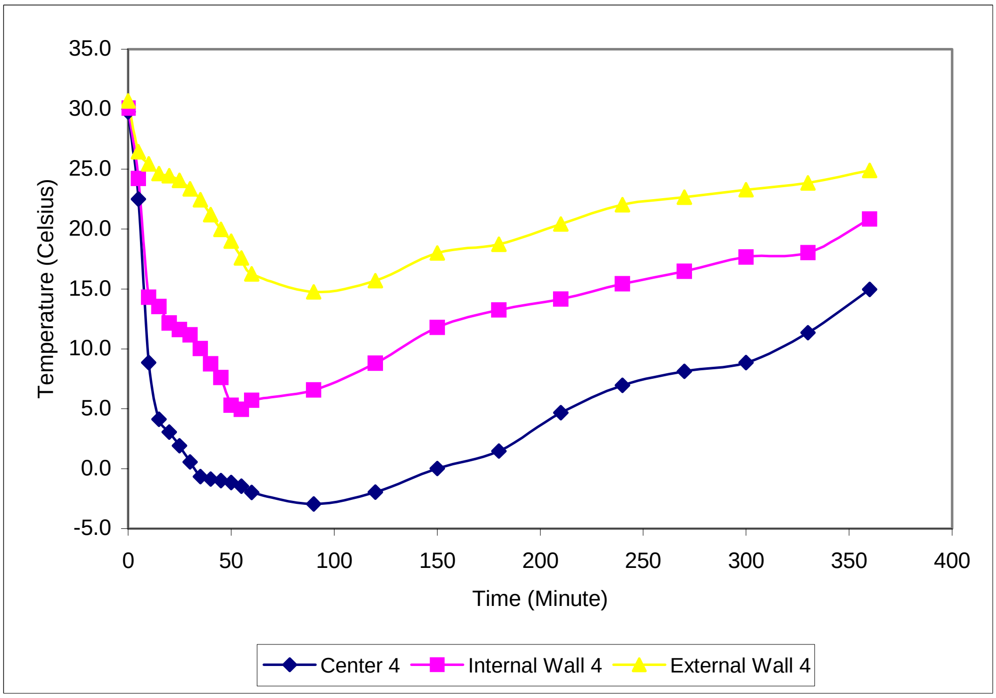


Figure A160: Temperature Profile at Difference Sensor Location of Level 4 Probe for Weight of 6 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

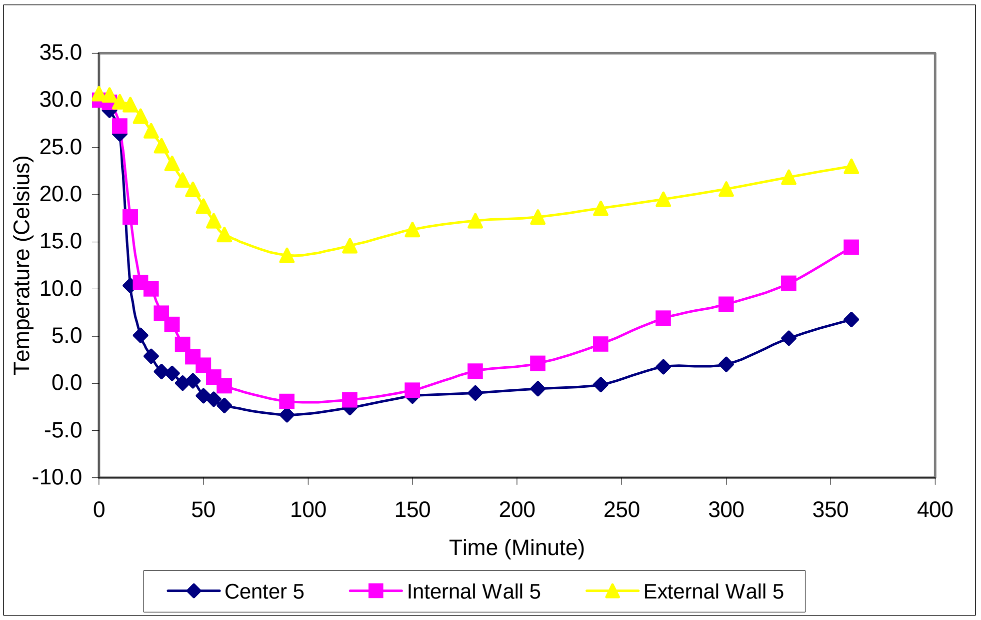


Figure A161: Temperature Profile at Difference Sensor Location of Level 5 Probe for Weight of 6 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

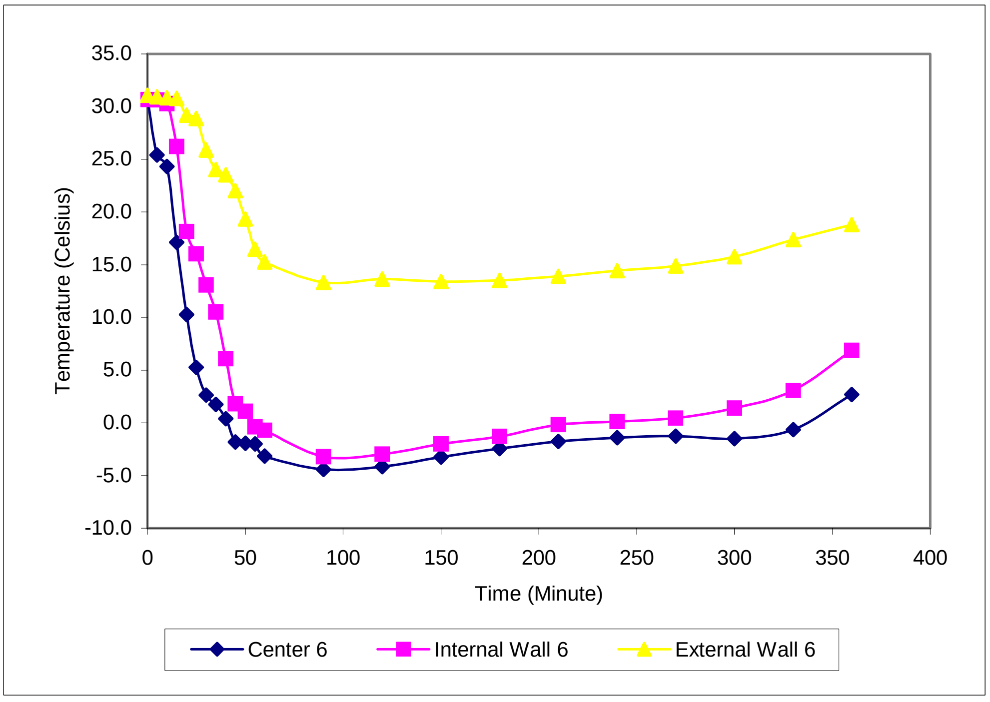


Figure A162: Temperature Profile at Difference Sensor Location of Level 6 Probe for Weight of 6 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

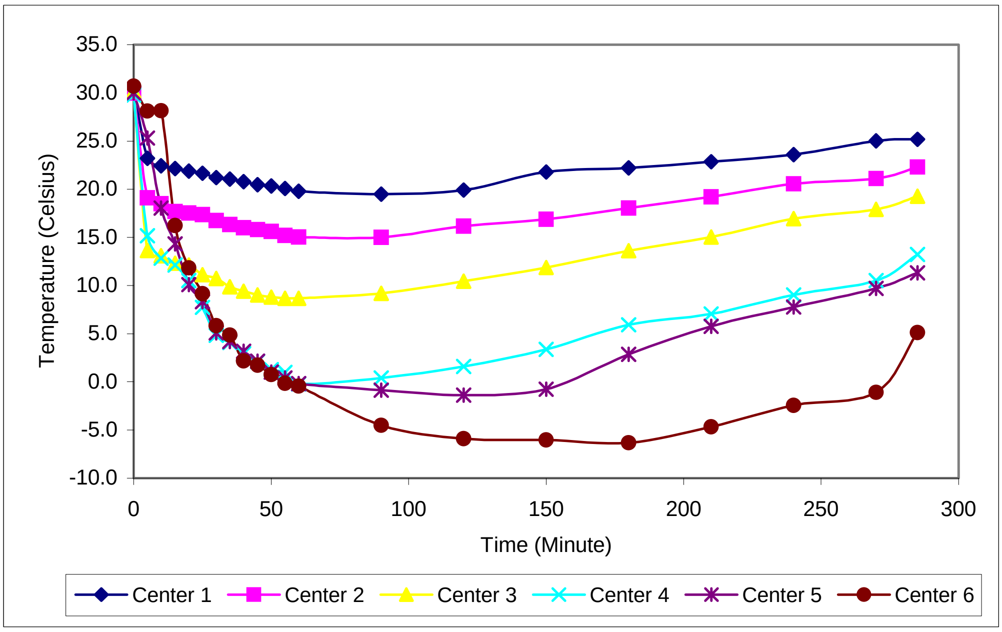


Figure A163: Temperature Profile at Center of the Cylinder for Weight of 5 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

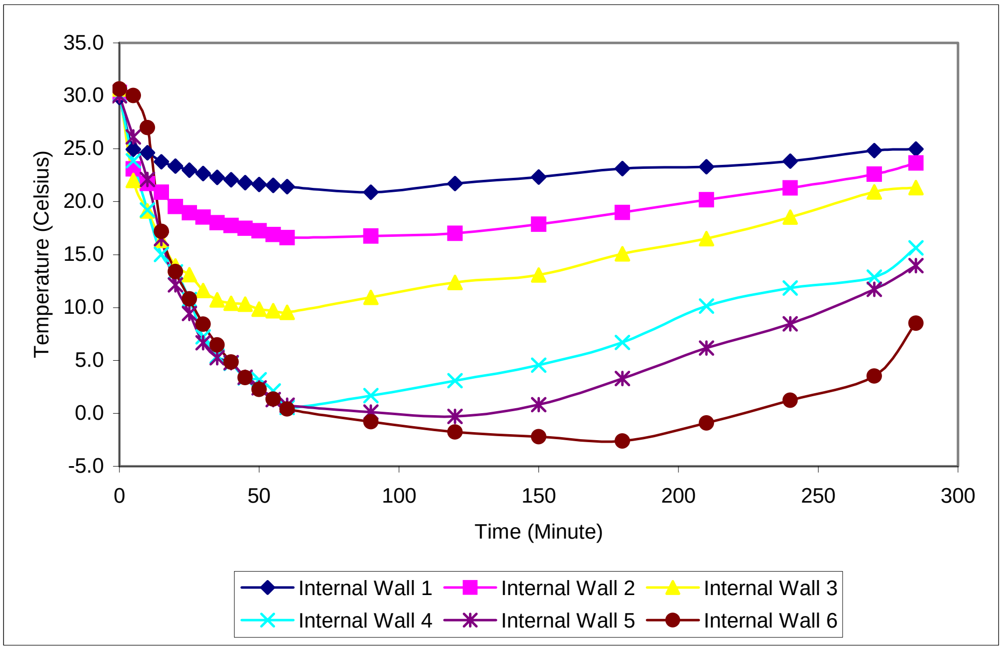


Figure A164: Temperature Profile at Internal Wall of the Cylinder for Weight of 5 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

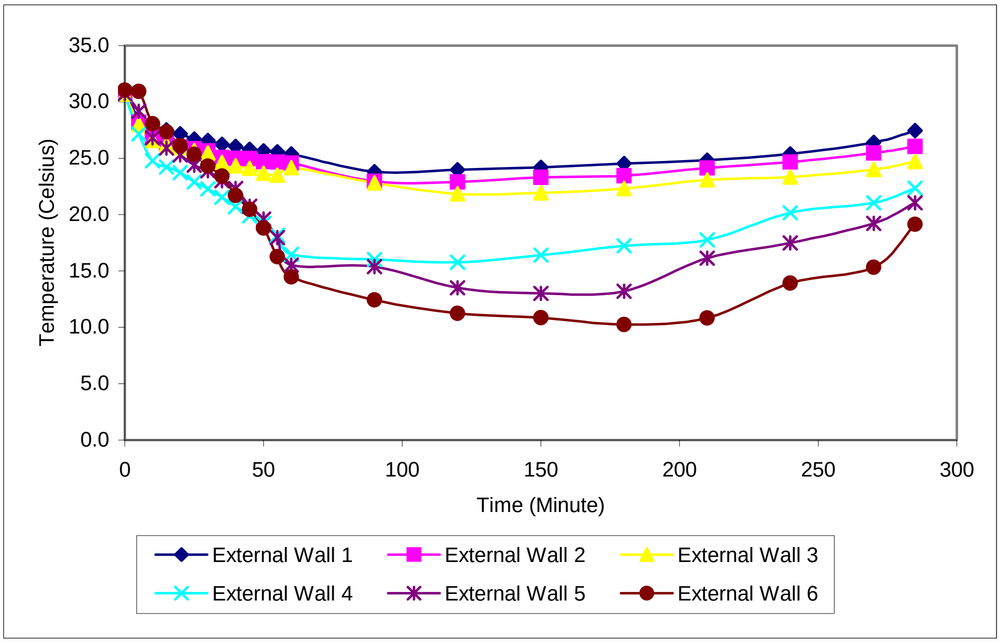


Figure A165: Temperature Profile at External Wall of the Cylinder for Weight of 5 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

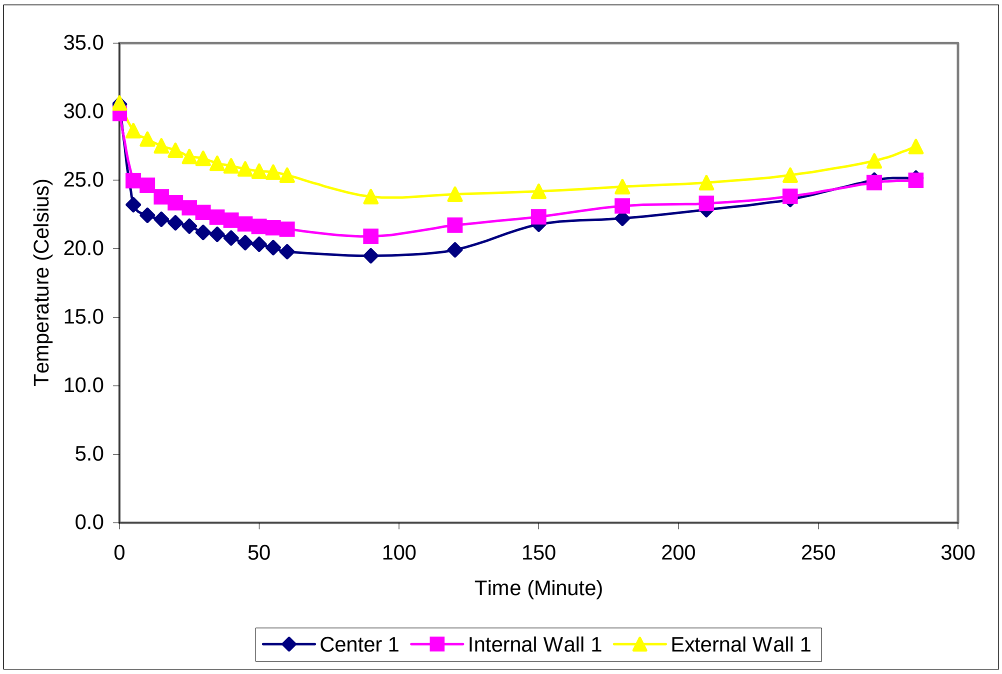


Figure A166: Temperature Profile at Difference Sensor Location of Level 1 Probe for Weight of 5 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

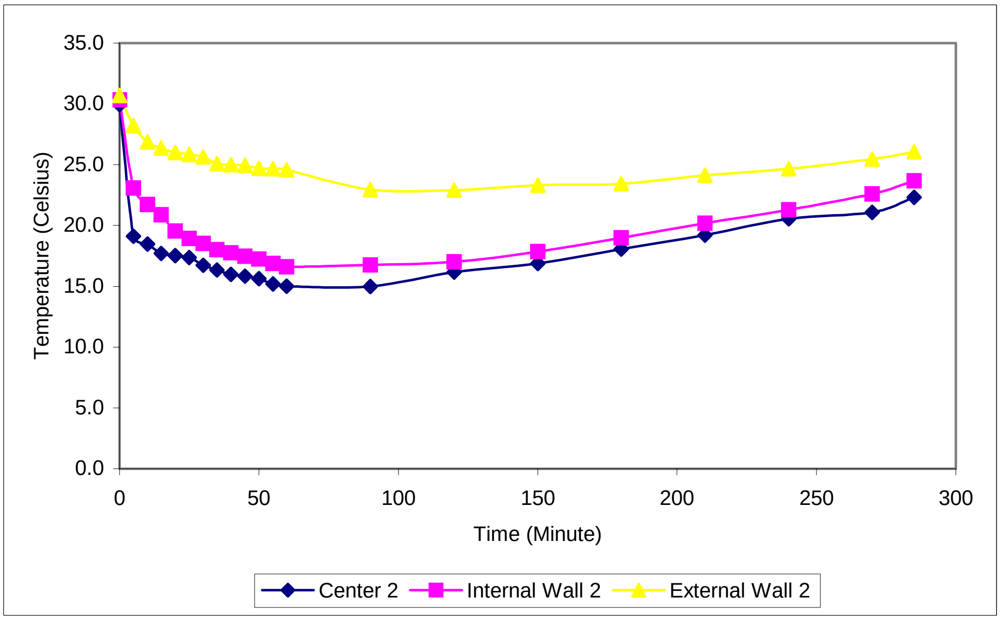


Figure A167: Temperature Profile at Difference Sensor Location of Level 2 Probe for Weight of 5 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

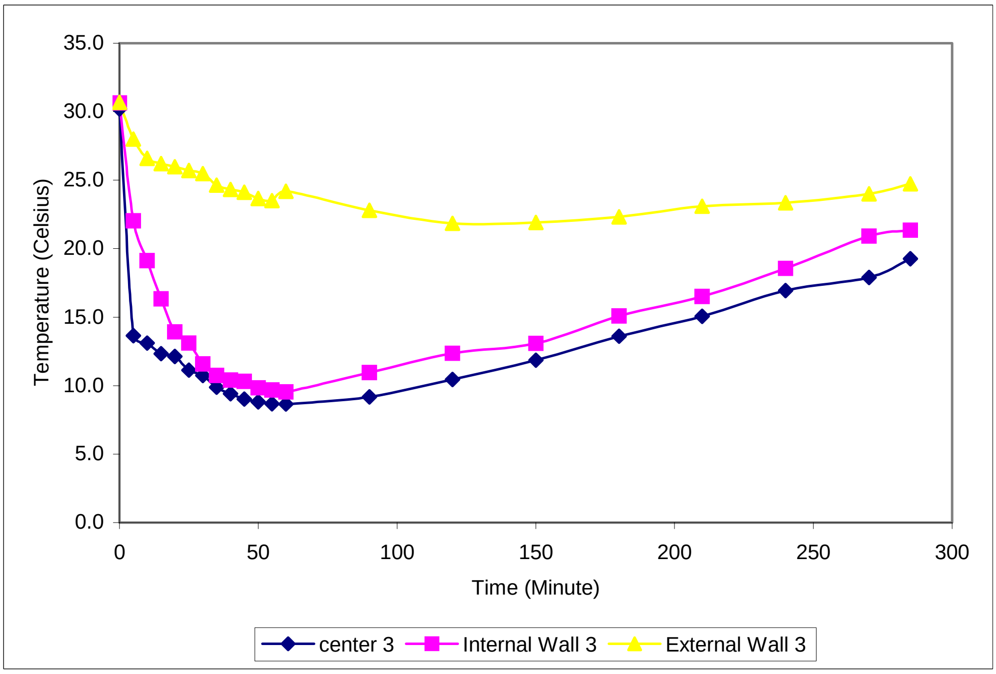


Figure A168: Temperature Profile at Difference Sensor Location of Level 3 Probe for Weight of 5 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

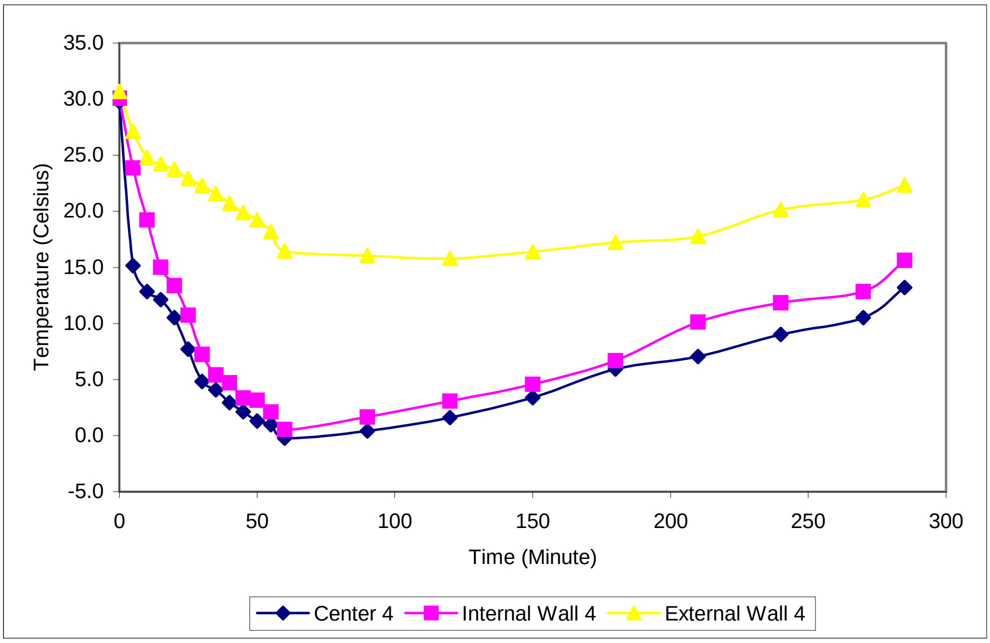


Figure A169: Temperature Profile at Difference Sensor Location of Level 4 Probe for Weight of 5 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

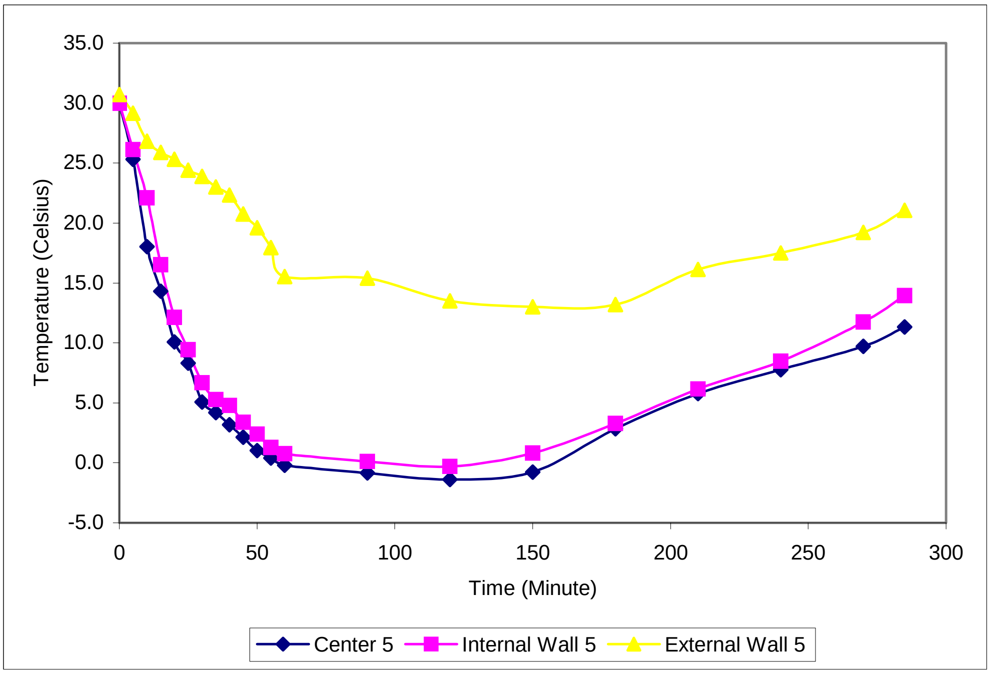


Figure A170: Temperature Profile at Difference Sensor Location of Level 5 Probe for Weight of 5 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

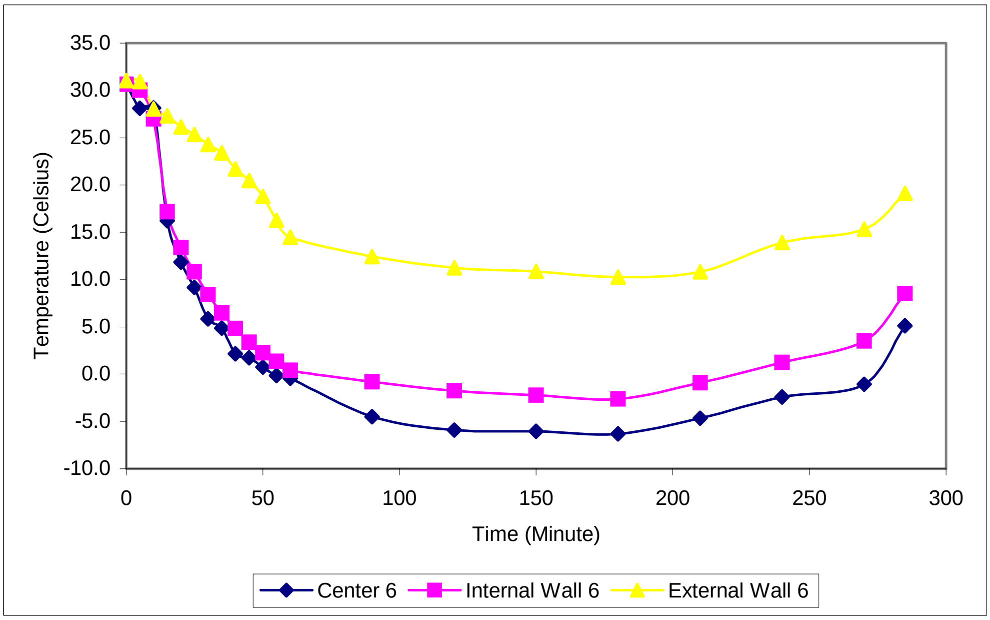


Figure A171: Temperature Profile at Difference Sensor Location of Level 6 Probe for Weight of 5 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

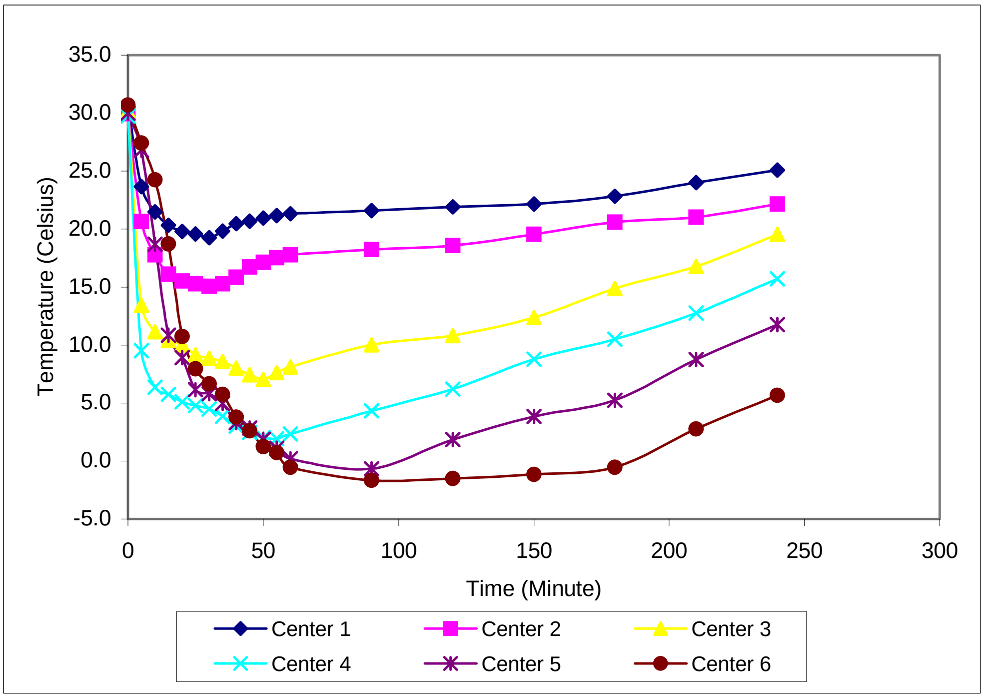


Figure A172: Temperature Profile at Center of the Cylinder for Weight of 4 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

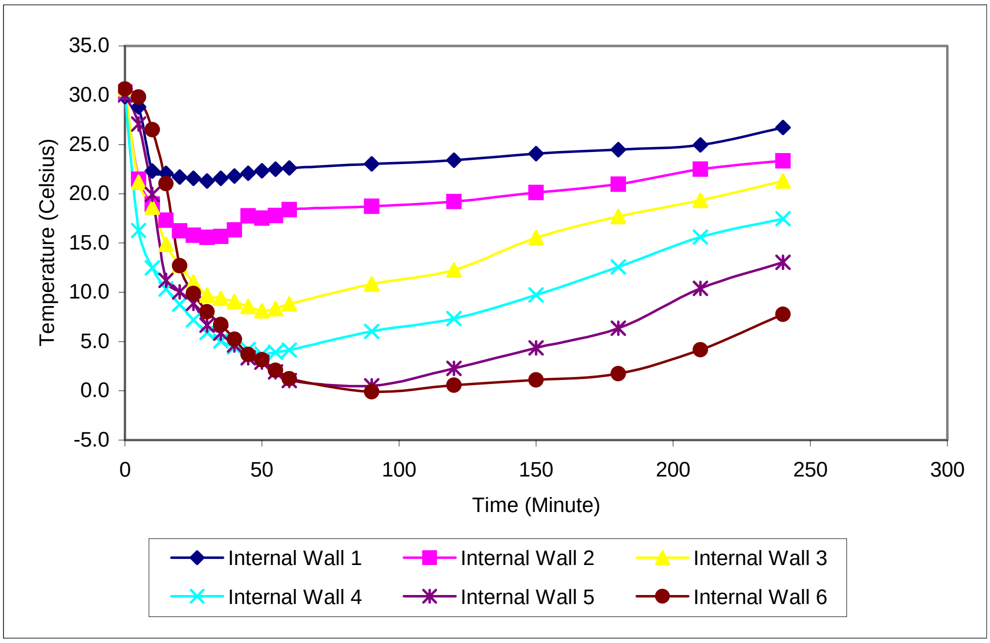


Figure A173: Temperature Profile at Internal Wall of the Cylinder for Weight of 4 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

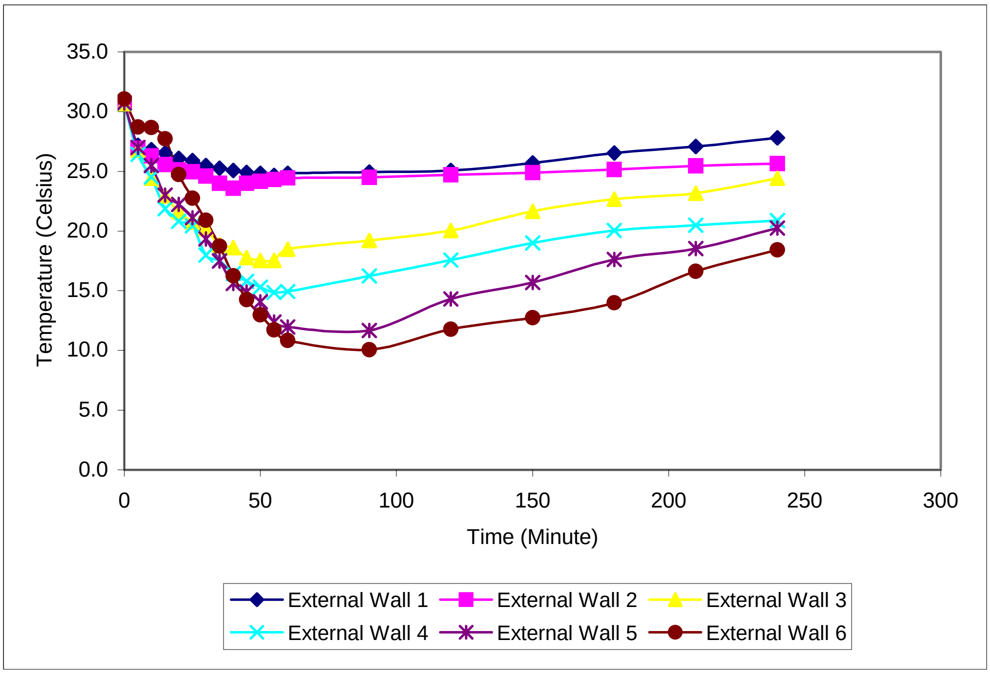


Figure A174: Temperature Profile at External Wall of the Cylinder for Weight of 4 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

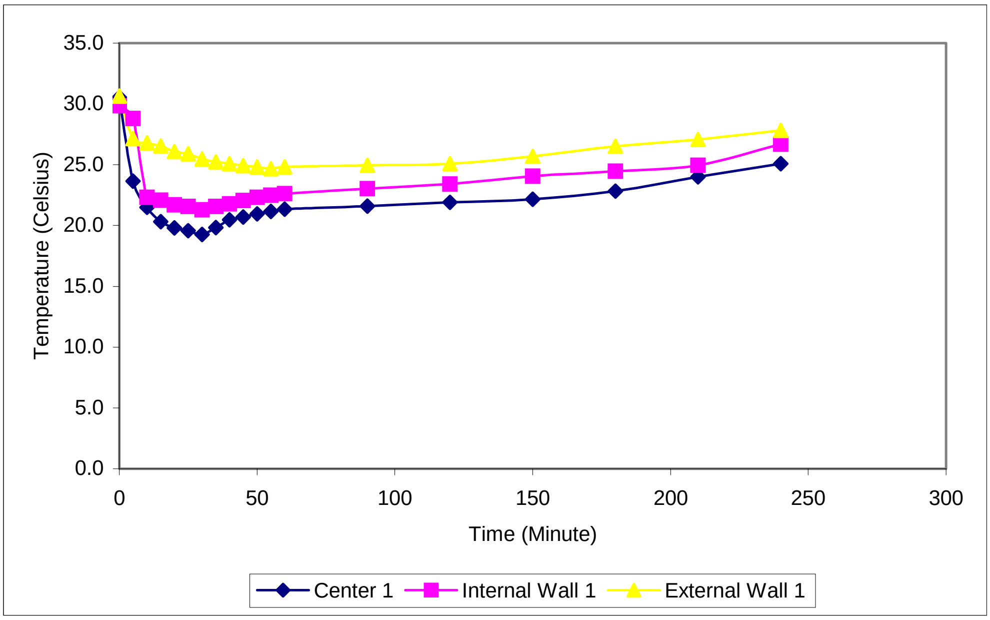


Figure A175: Temperature Profile at Difference Sensor Location of Level 1 Probe for Weight of 4 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

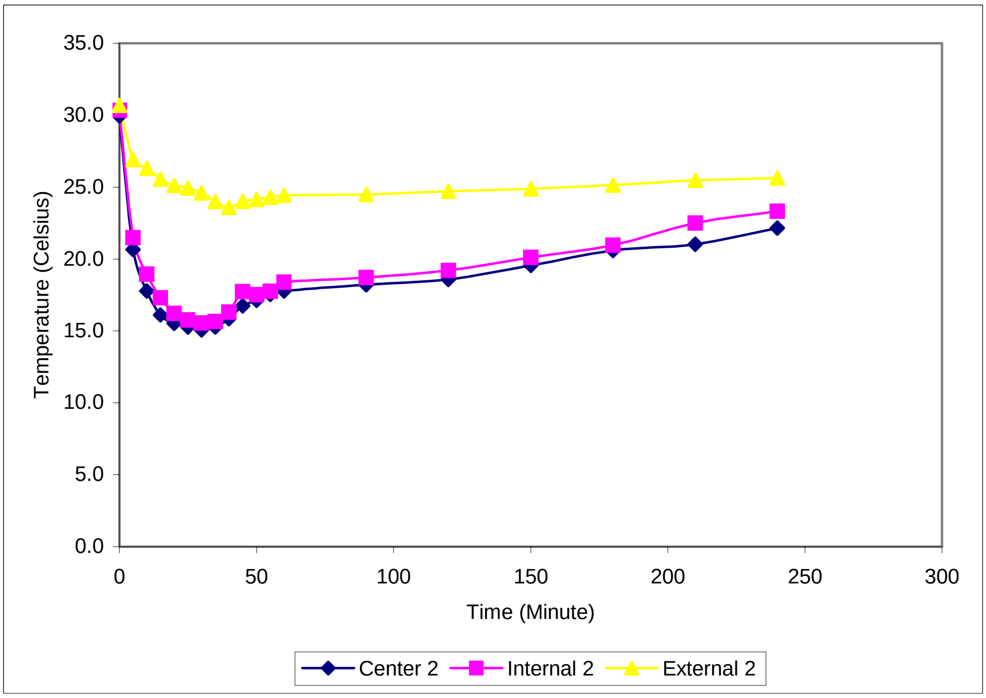


Figure A176: Temperature Profile at Difference Sensor Location of Level 2 Probe for Weight of 4 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

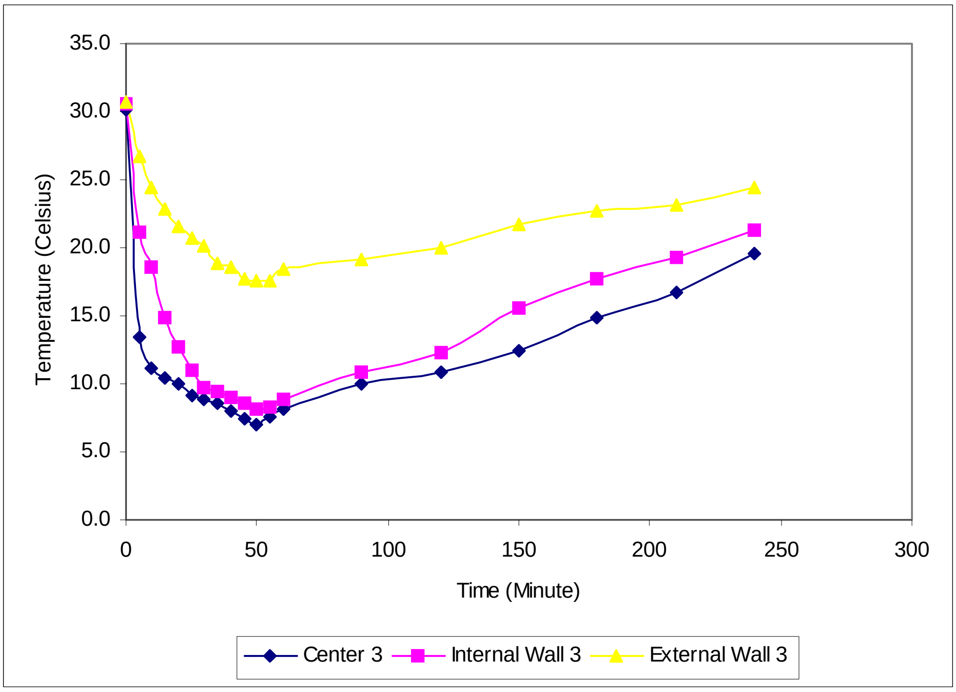


Figure A177: Temperature Profile at Difference Sensor Location of Level 3 Probe for Weight of 4 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

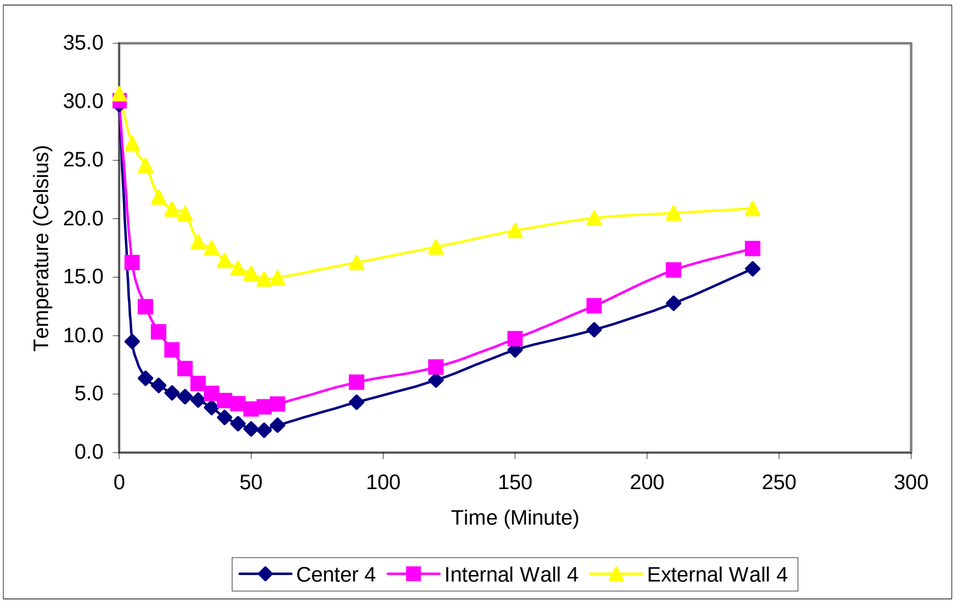


Figure A178: Temperature Profile at Difference Sensor Location of Level 4 Probe for Weight of 4 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

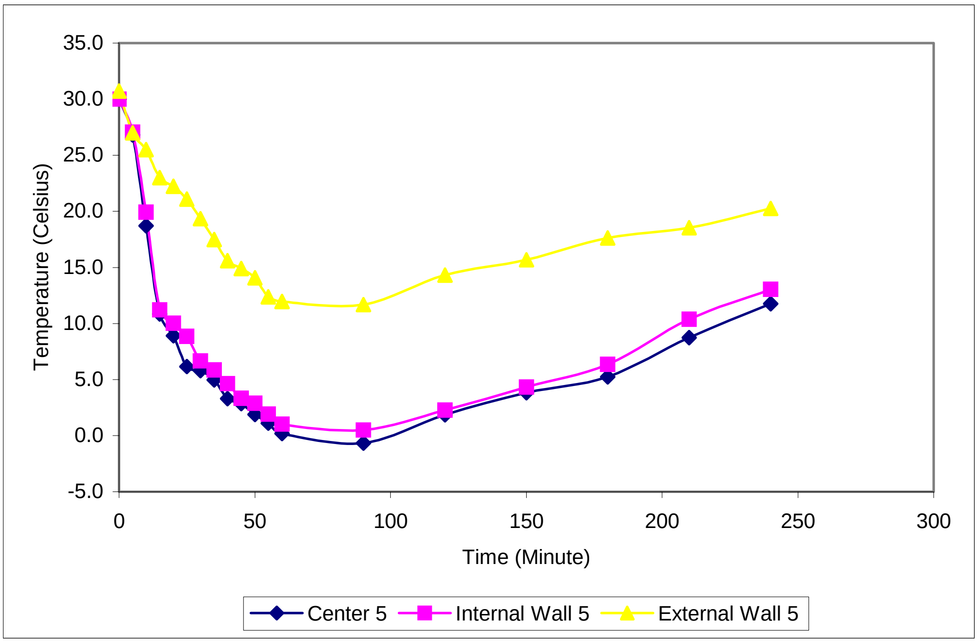


Figure A179: Temperature Profile at Difference Sensor Location of Level 5 Probe for Weight of 4 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

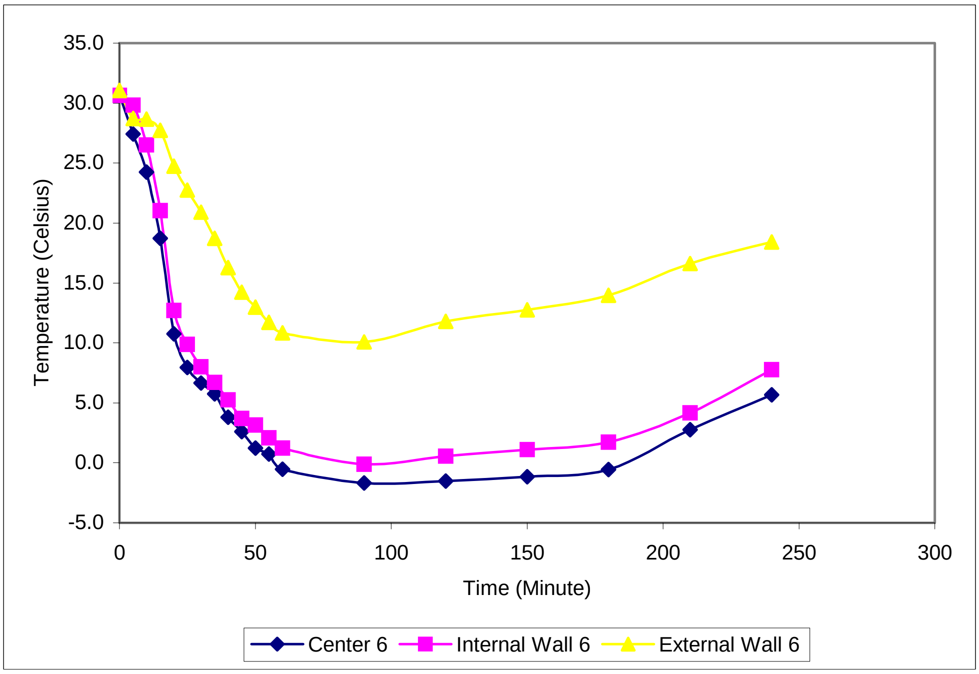


Figure A180: Temperature Profile at Difference Sensor Location of Level 6 Probe for Weight of 4 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

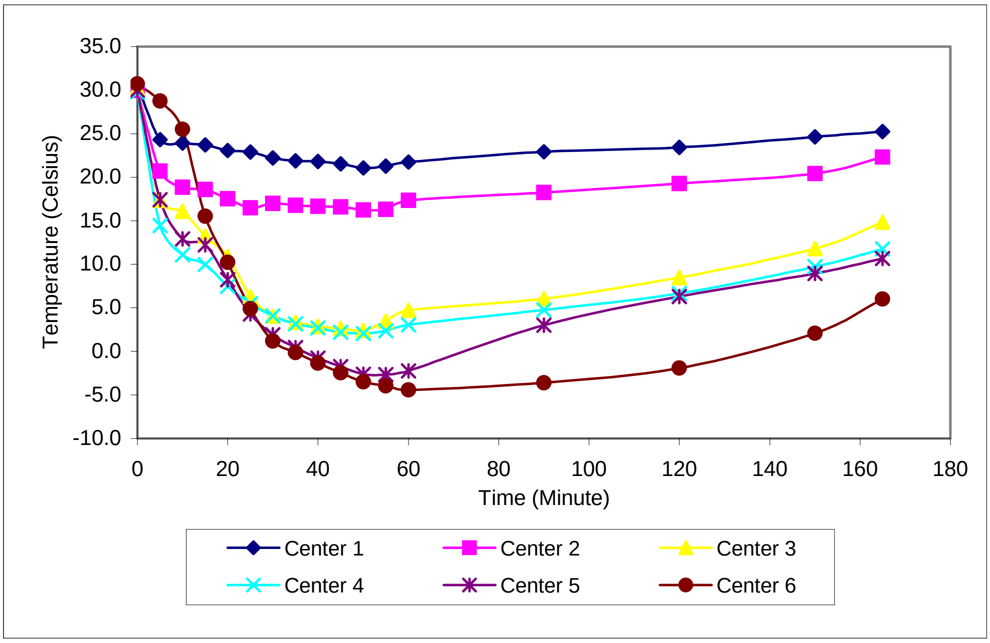


Figure A181: Temperature Profile at Center of the Cylinder for Weight of 3 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

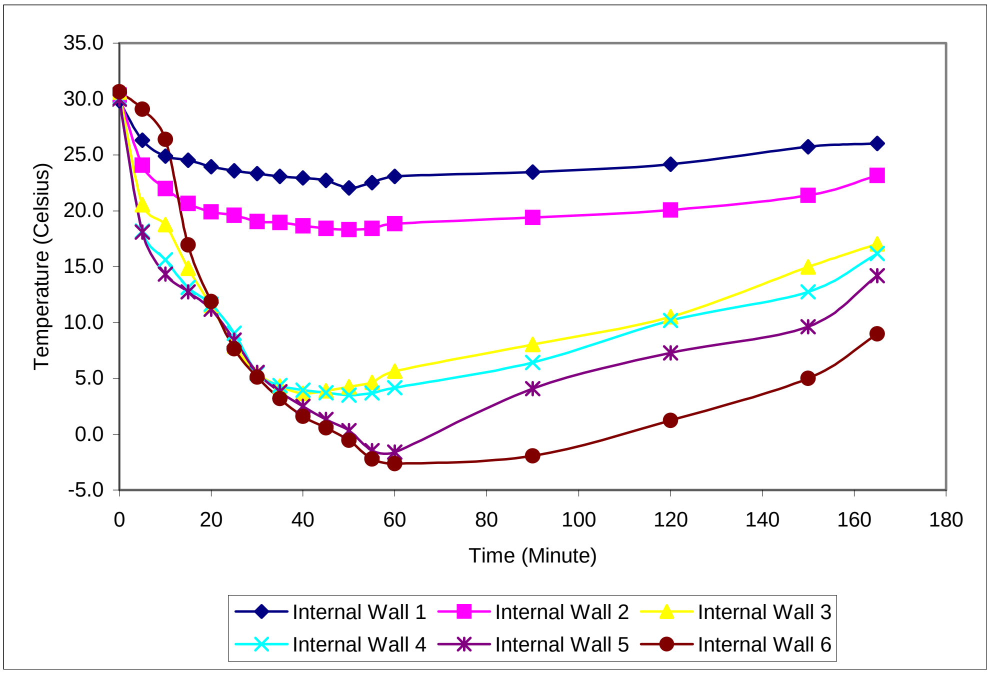


Figure A182: Temperature Profile at Internal Wall of the Cylinder for Weight of 3 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

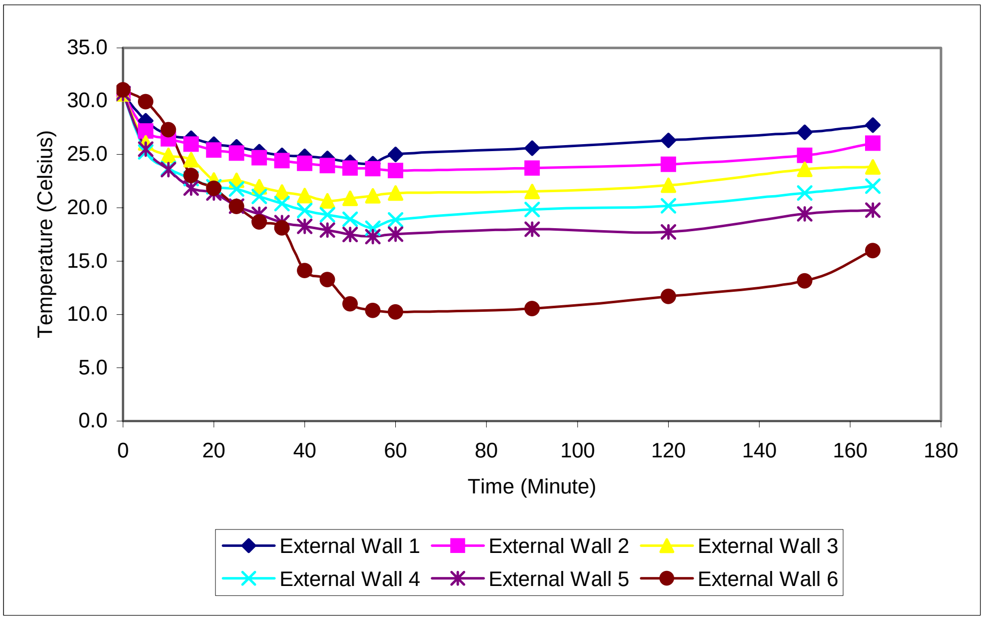


Figure A183: Temperature Profile at External Wall of the Cylinder for Weight of 3 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

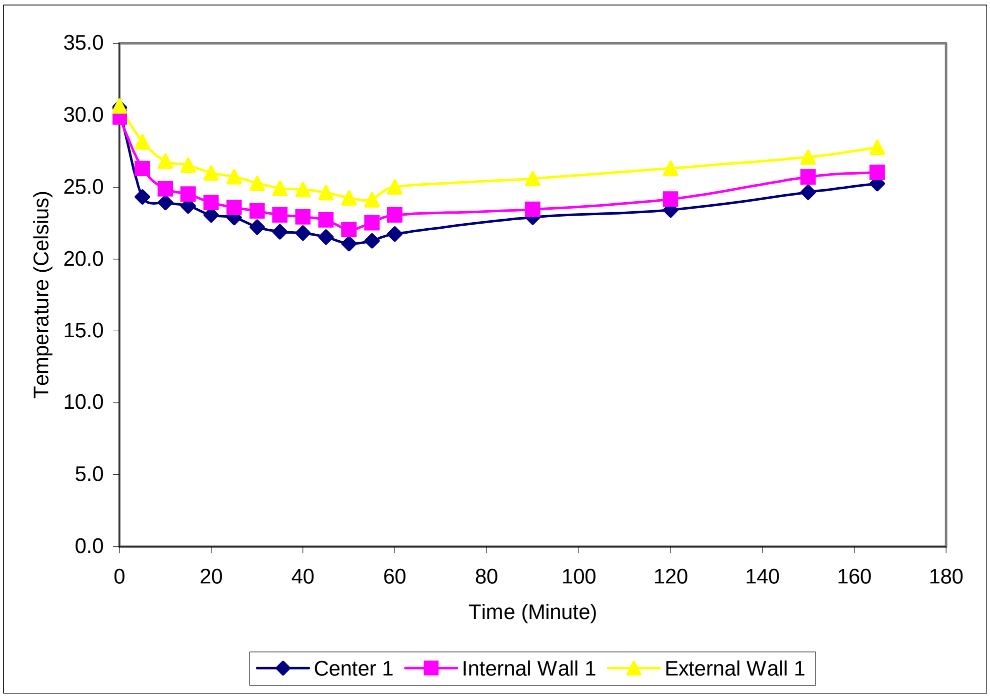


Figure A184: Temperature Profile at Difference Sensor Location of Level 1 Probe for Weight of 3 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

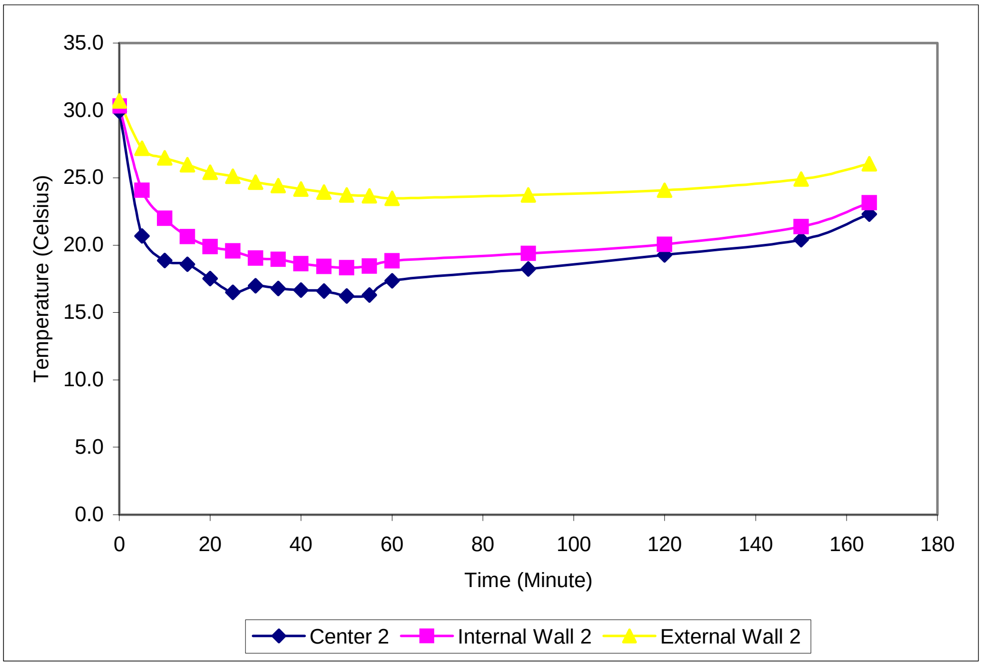


Figure A185: Temperature Profile at Difference Sensor Location of Level 2 Probe for Weight of 3 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

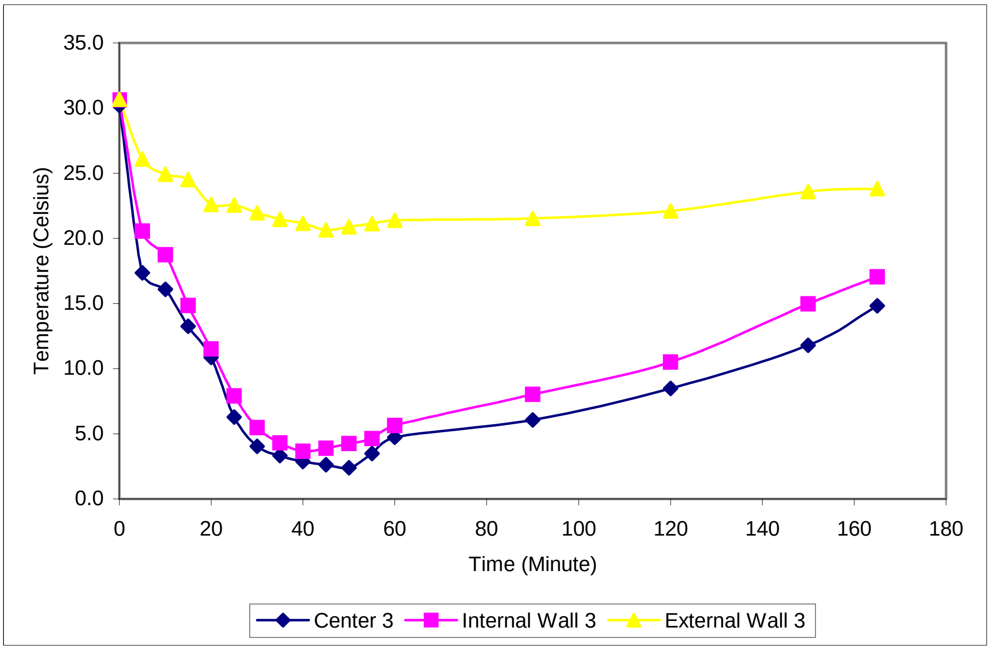


Figure A186: Temperature Profile at Difference Sensor Location of Level 3 Probe for Weight of 3 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

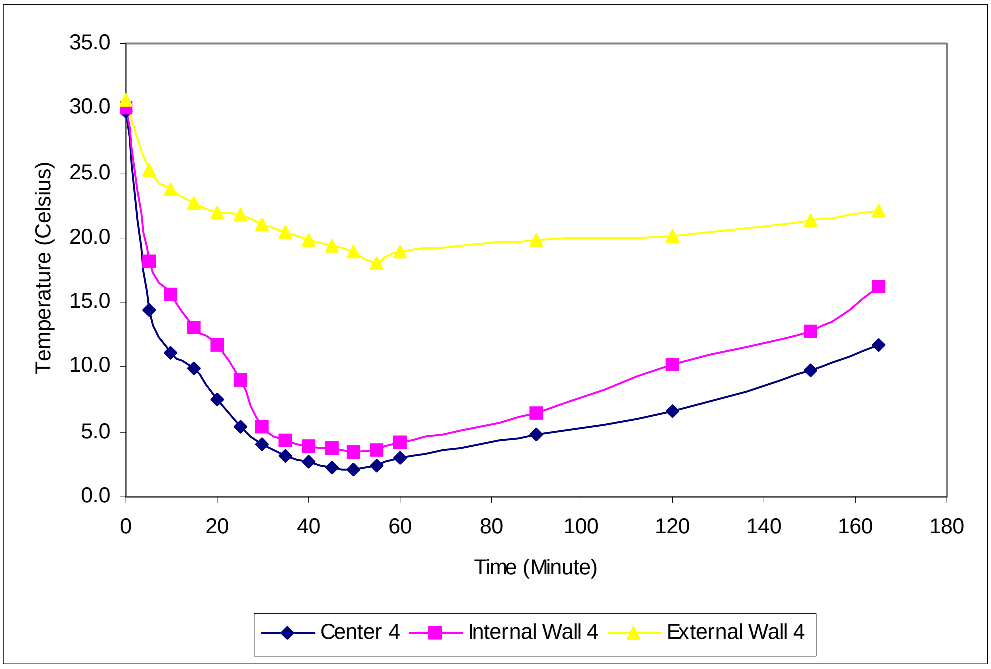


Figure A187: Temperature Profile at Difference Sensor Location of Level 4 Probe for Weight of 3 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

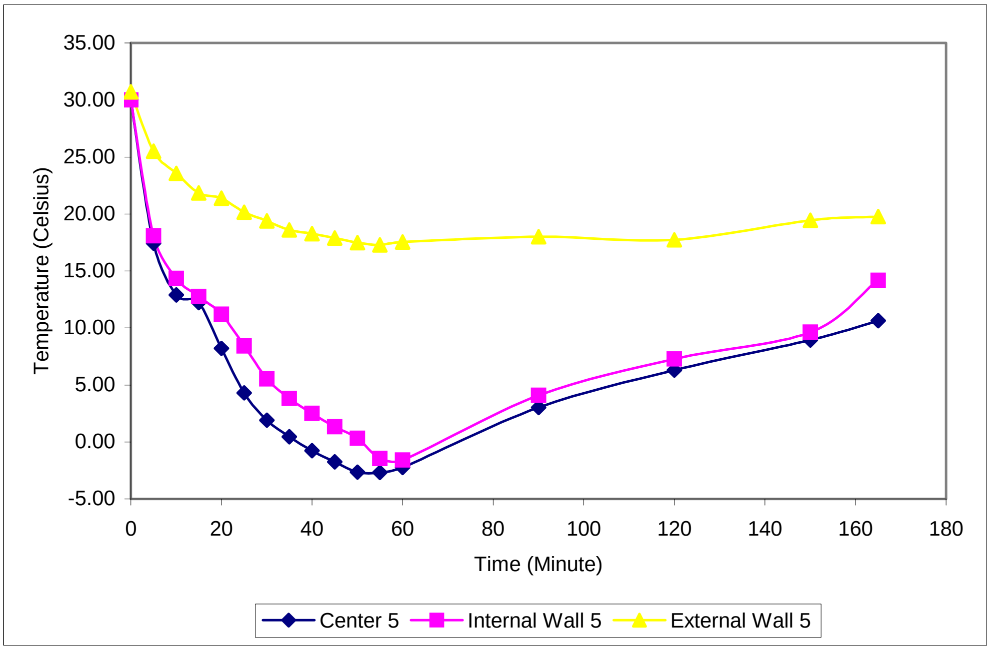


Figure A188: Temperature Profile at Difference Sensor Location of Level 5 Probe for Weight of 3 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

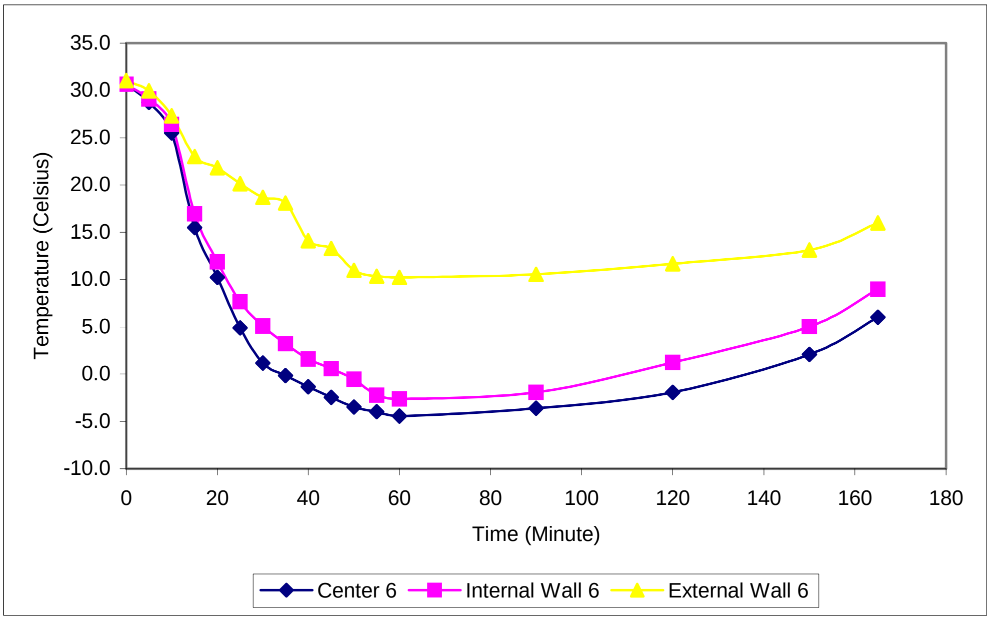


Figure A189: Temperature Profile at Difference Sensor Location of Level 6 Probe for Weight of 3 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

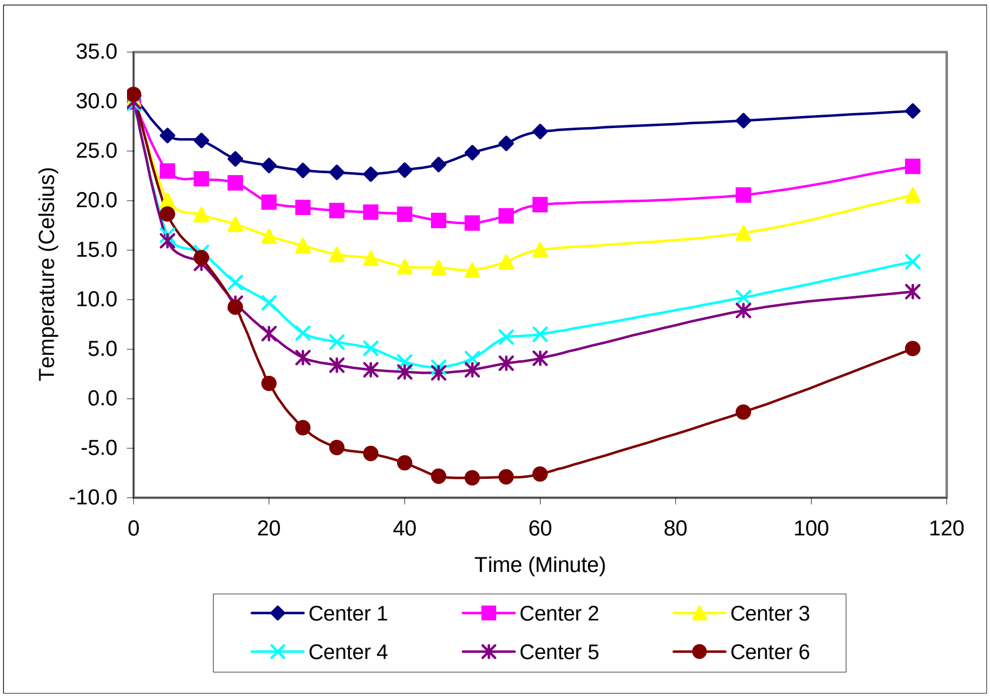


Figure A190: Temperature Profile at Center of the Cylinder for Weight of 2 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C

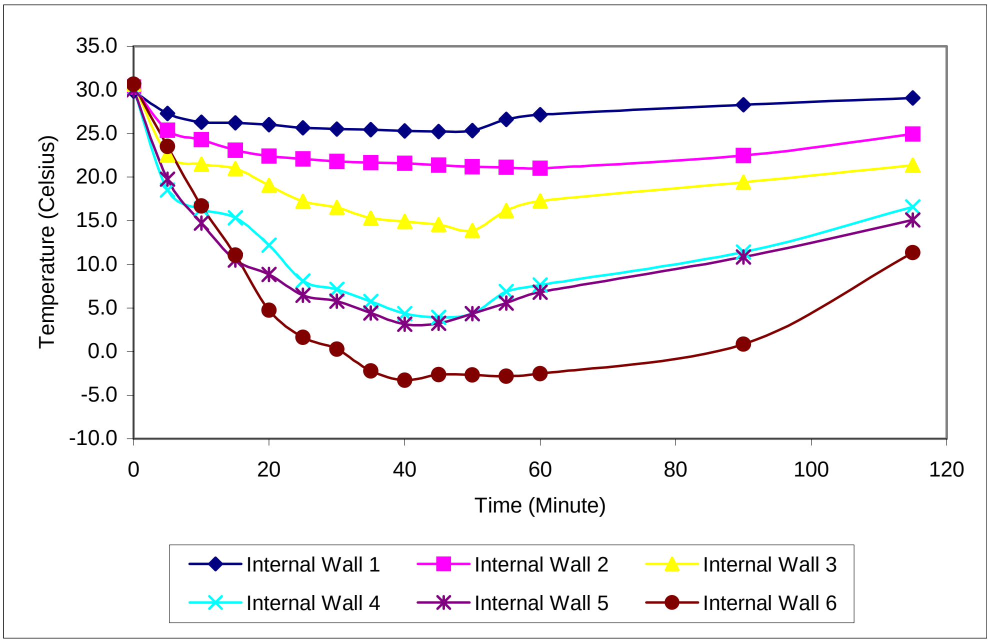


Figure A191: Temperature Profile at Internal Wall of the Cylinder for Weight of 2 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

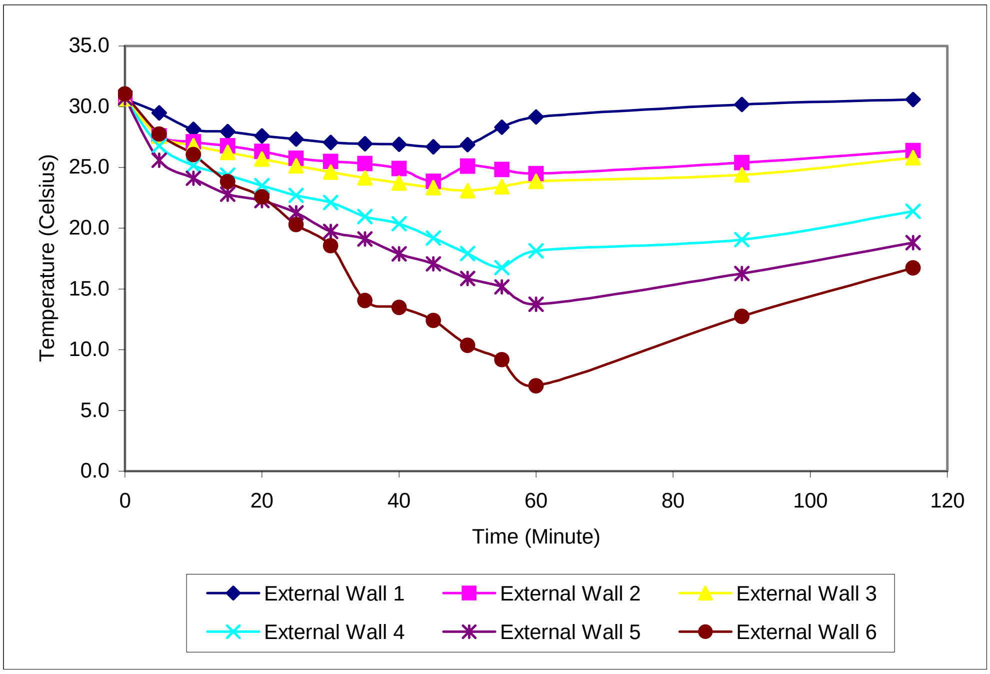


Figure A192: Temperature Profile at External Wall of the Cylinder for Weight of 2 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C

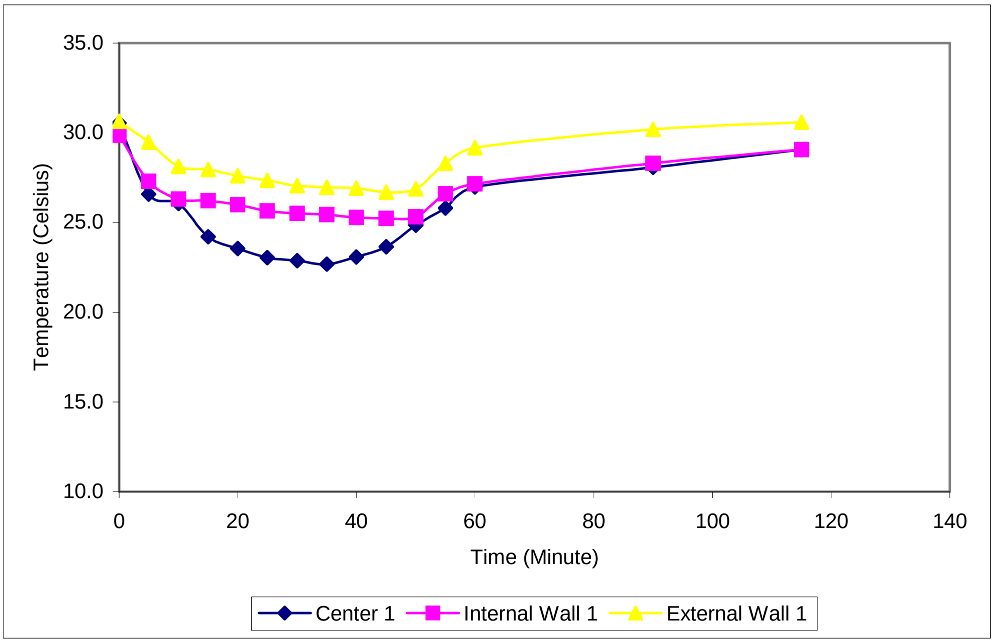


Figure A193: Temperature Profile at Difference Sensor Location of Level 1 Probe for Weight of 2 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

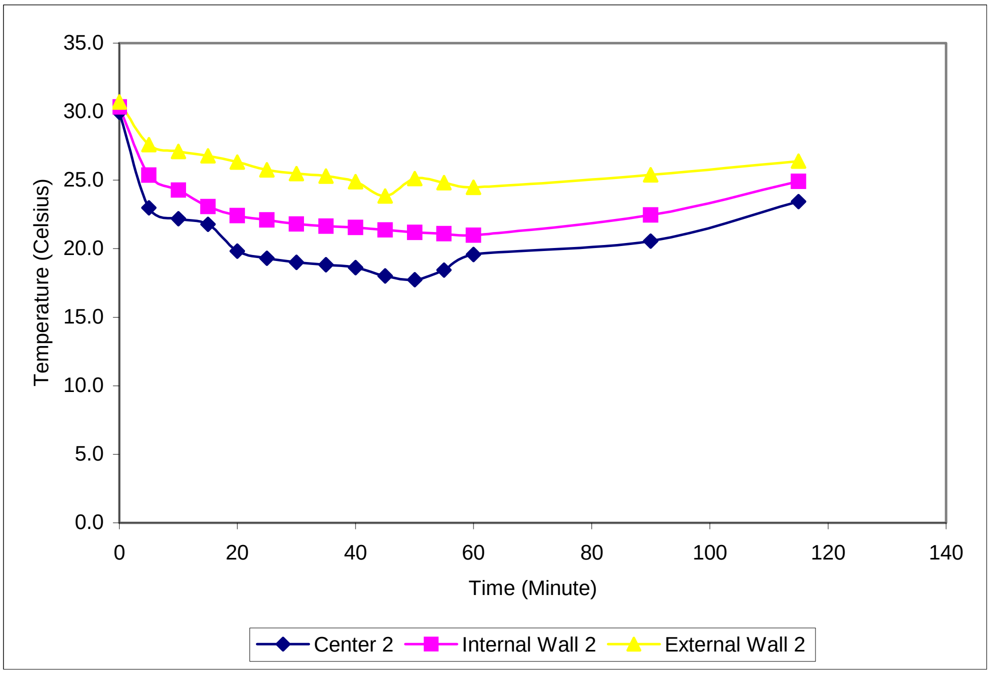


Figure A194: Temperature Profile at Difference Sensor Location of Level 2 Probe for Weight of 2 kg at Composition of 4060, Surrounding Temperature of 30^{o}C and Flow rate of 48 liter/minute

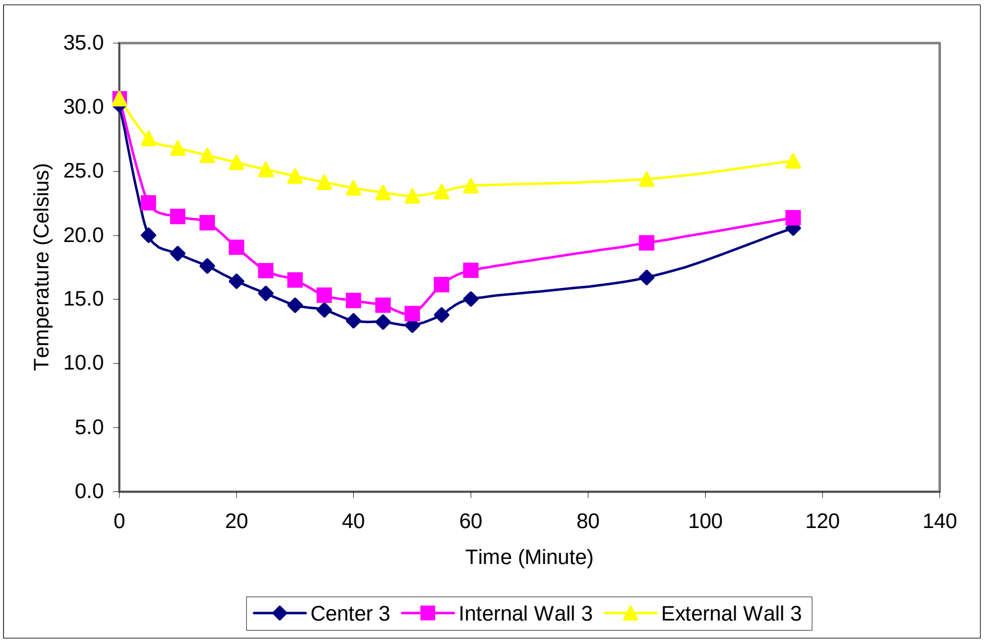


Figure A195: Temperature Profile at Difference Sensor Location of Level 3 Probe for Weight of 2 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

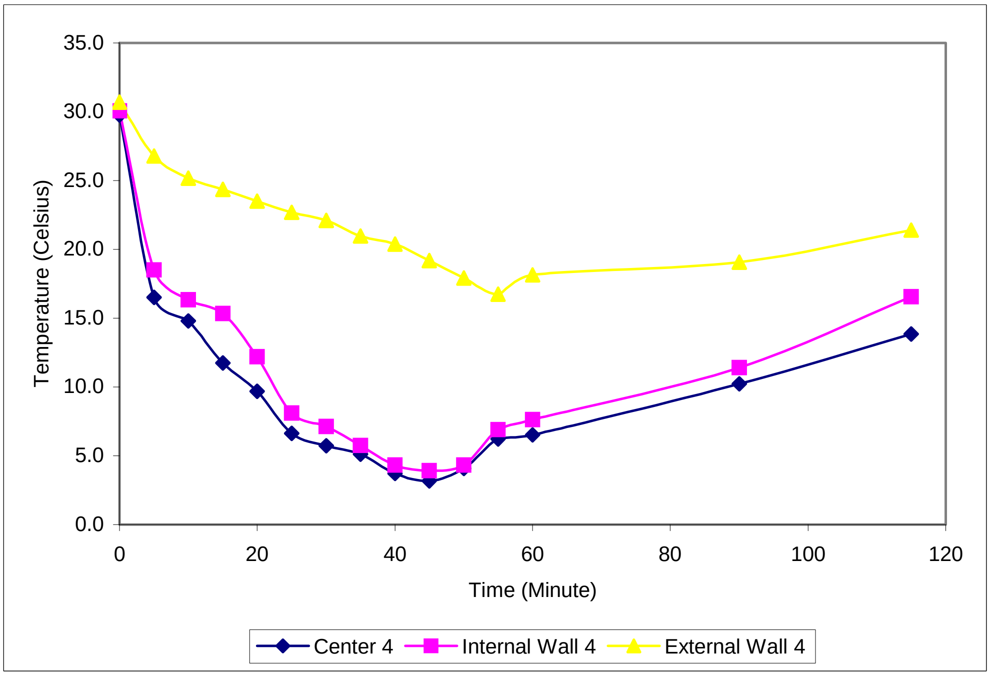


Figure A196: Temperature Profile at Difference Sensor Location of Level 4 Probe for Weight of 2 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

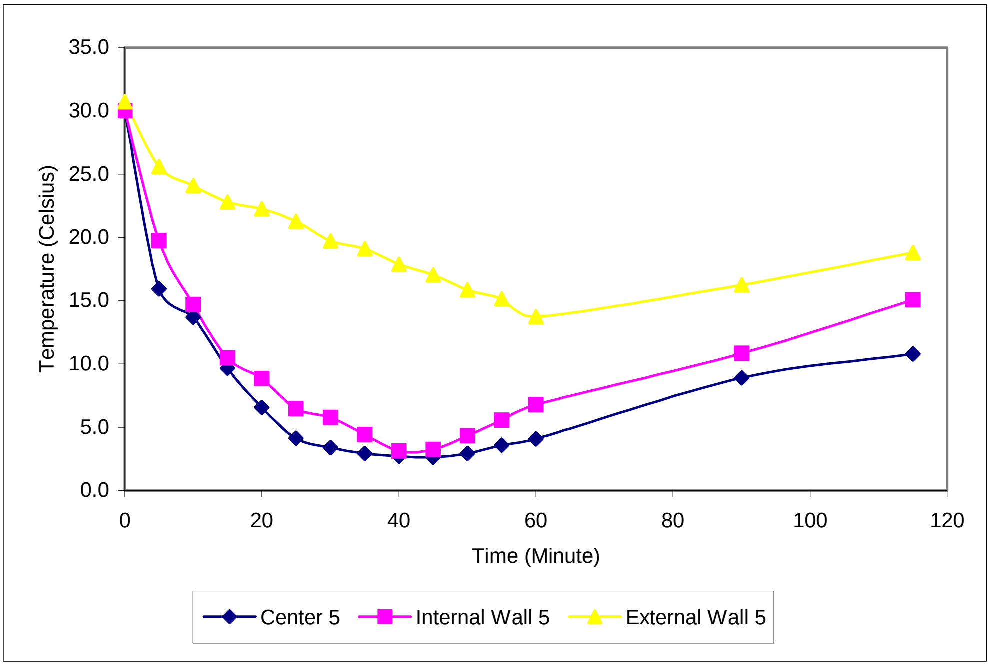


Figure A197: Temperature Profile at Difference Sensor Location of Level 5 Probe for Weight of 2 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute

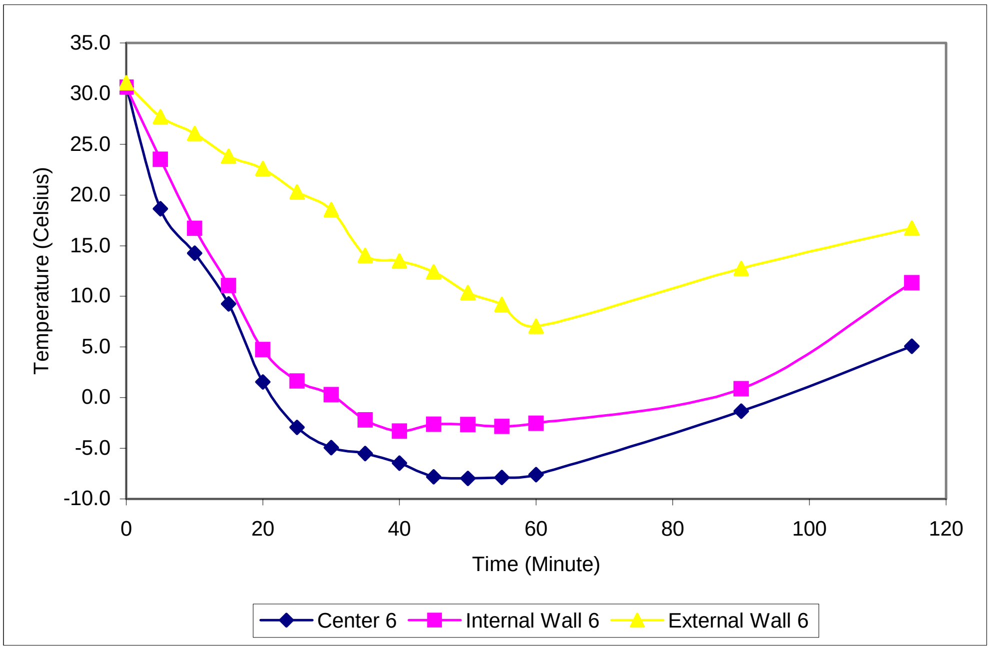
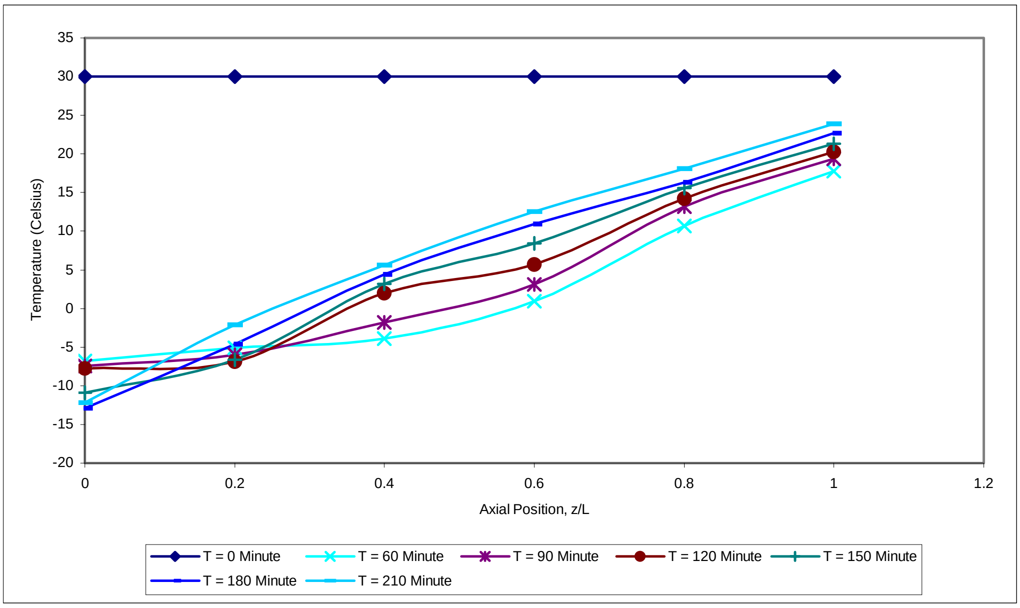
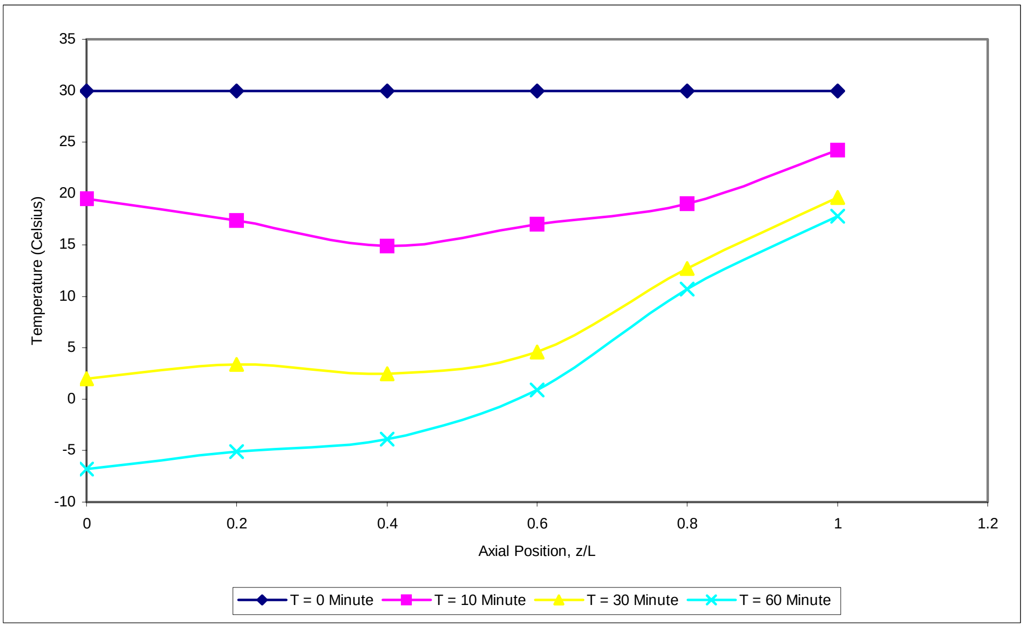


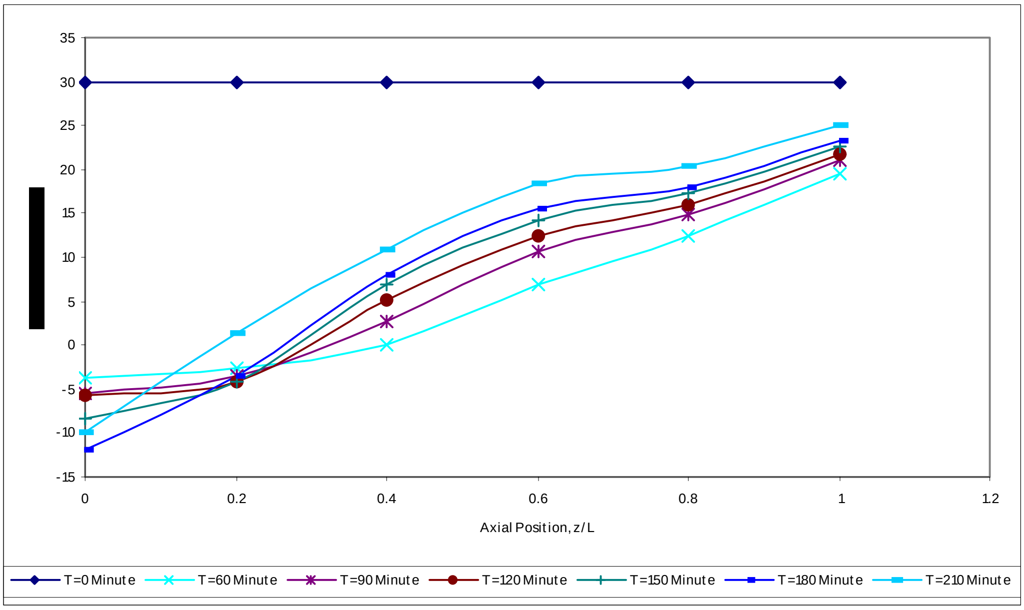
Figure A198: Temperature Profile at Difference Sensor Location of Level 6 Probe for Weight of 2 kg at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 liter/minute



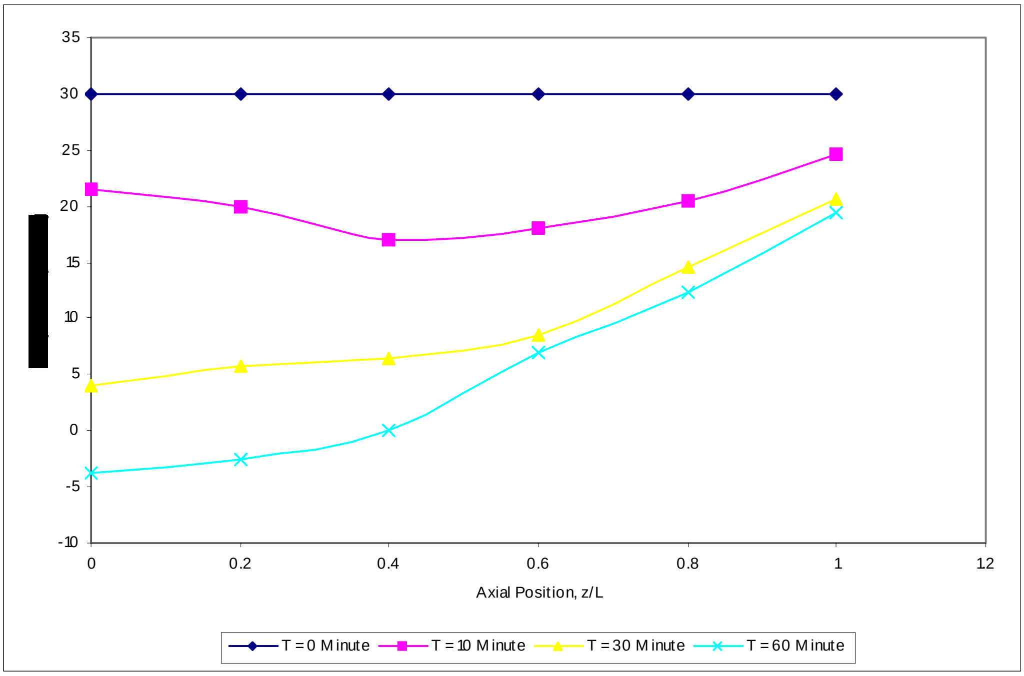
A199: Dimensionless Axial Profile of Temperature at Center of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



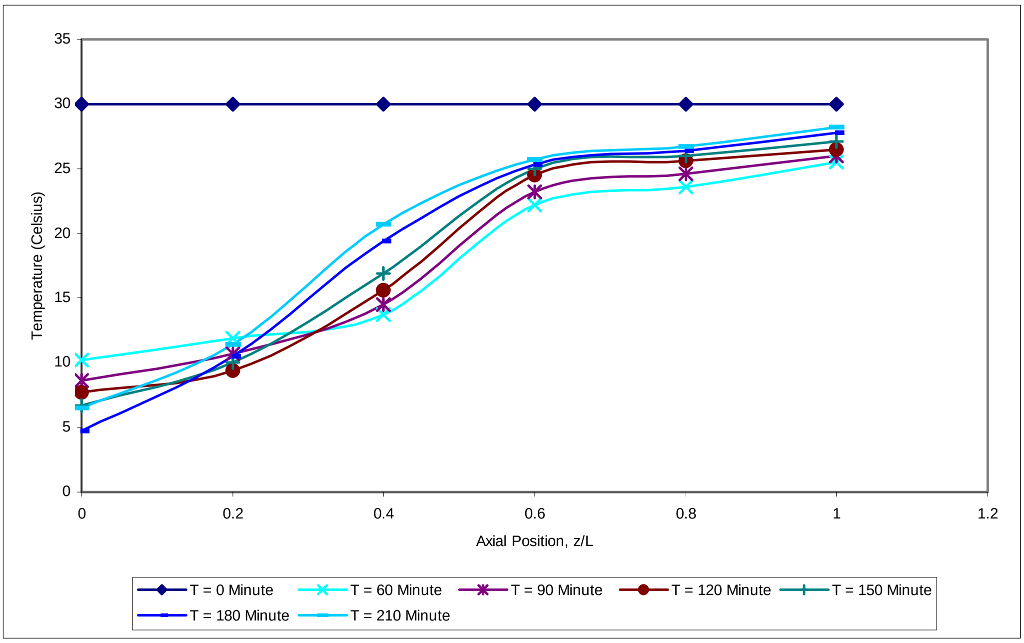
A200: Dimensionless Axial Profile of Temperature at Early Stage at Center of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



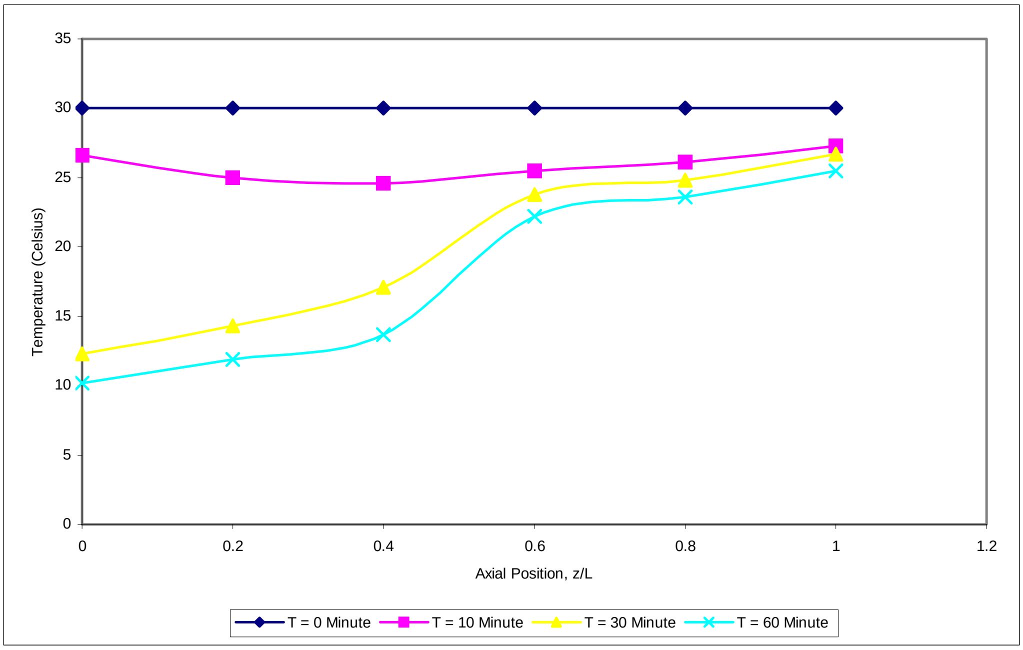
A201: Dimensionless Axial Profile of Temperature at Internal Wall of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



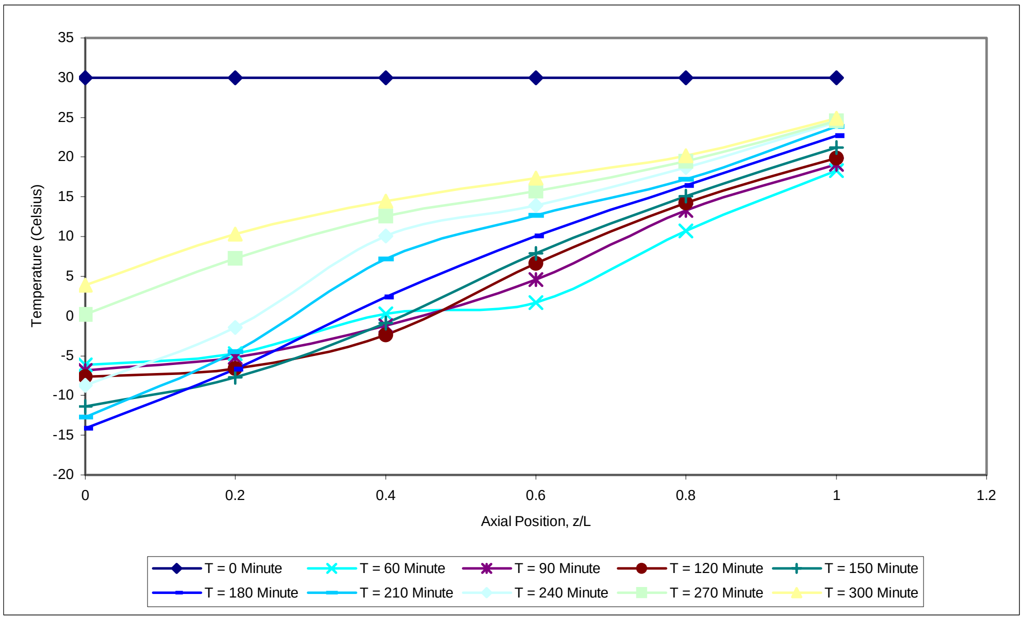
A202: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



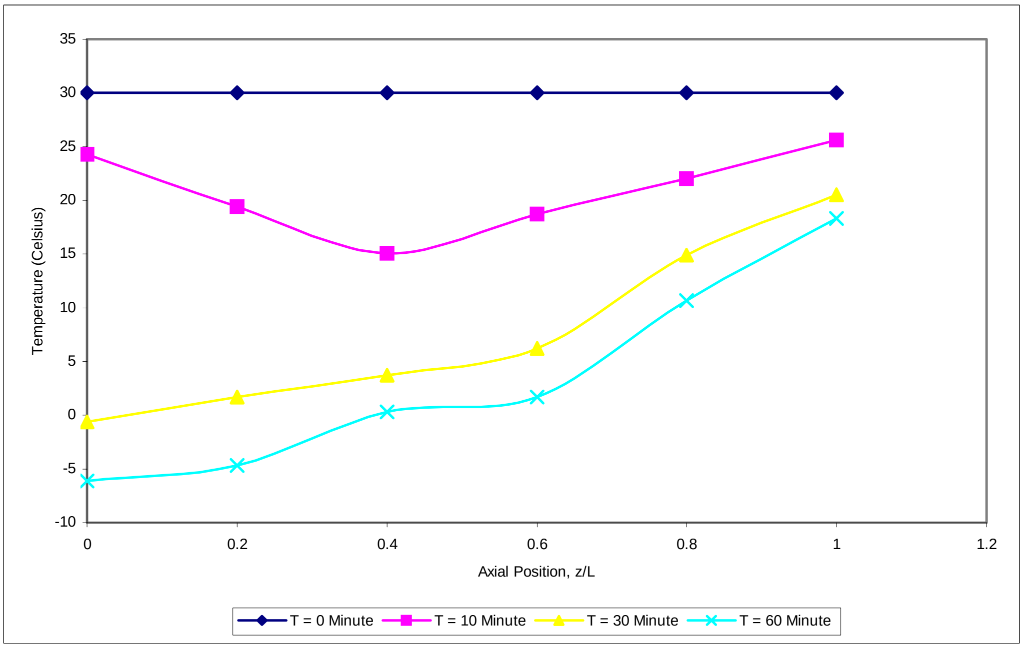
A203: Dimensionless Axial Profile of Temperature at External Wall of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



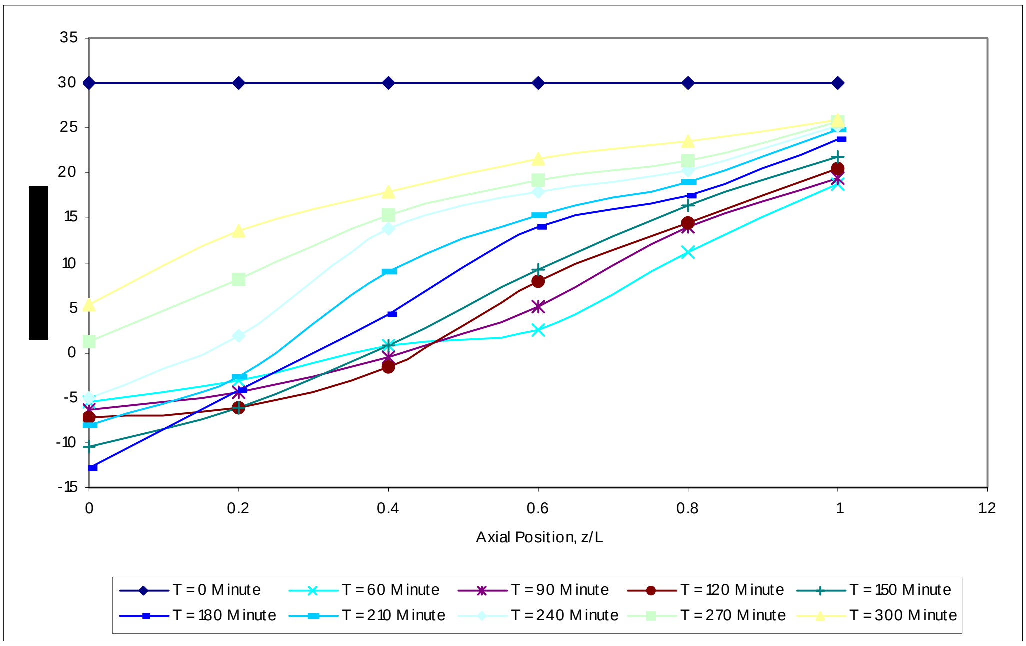
A204: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



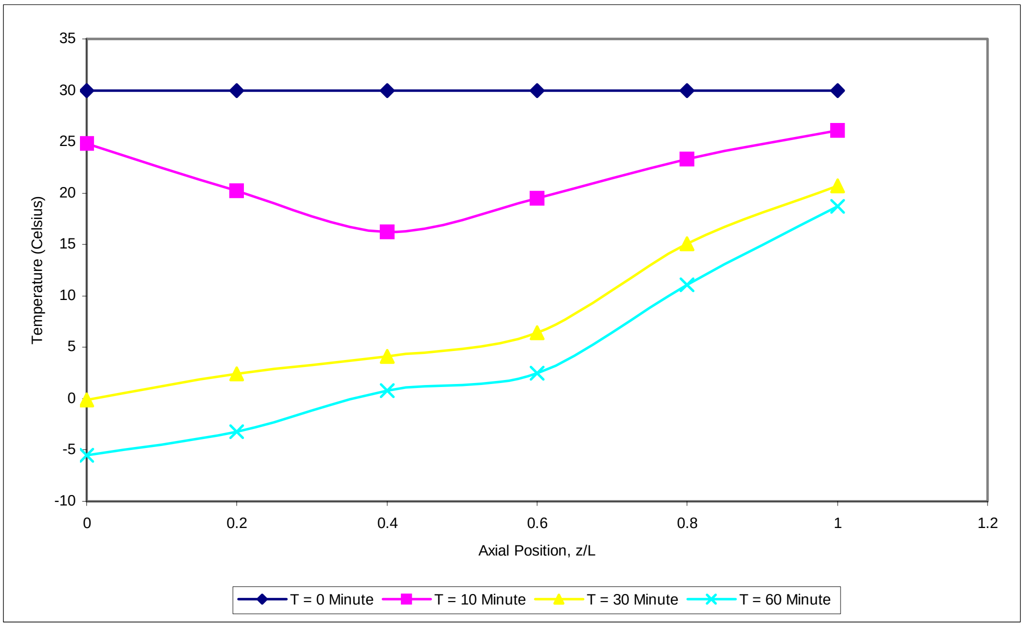
A205: Dimensionless Axial Profile of Temperature at Center of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



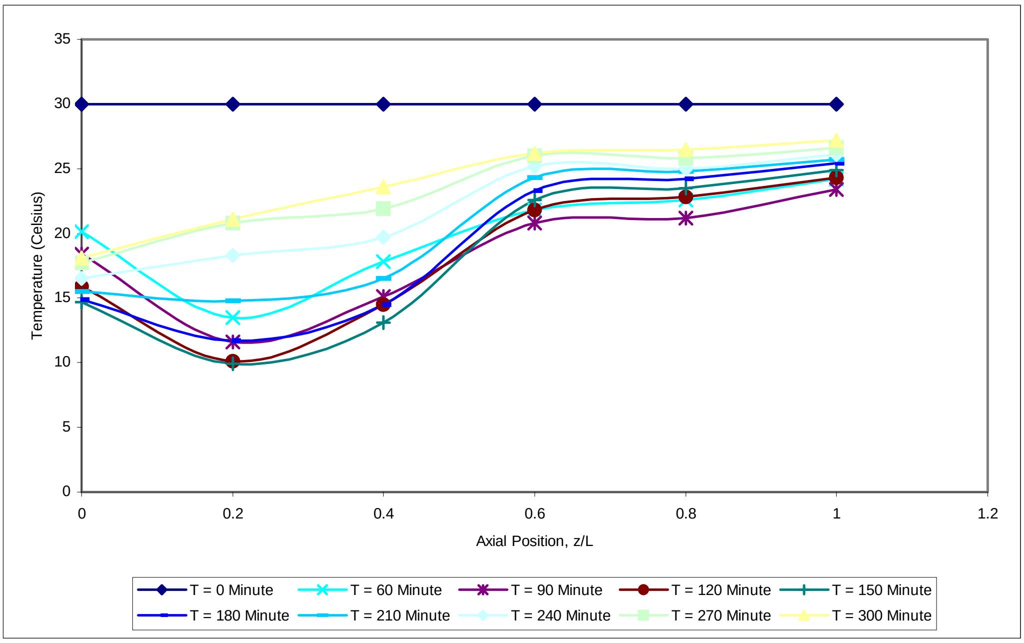
A206: Dimensionless Axial Profile of Temperature at Early Stage at Center of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



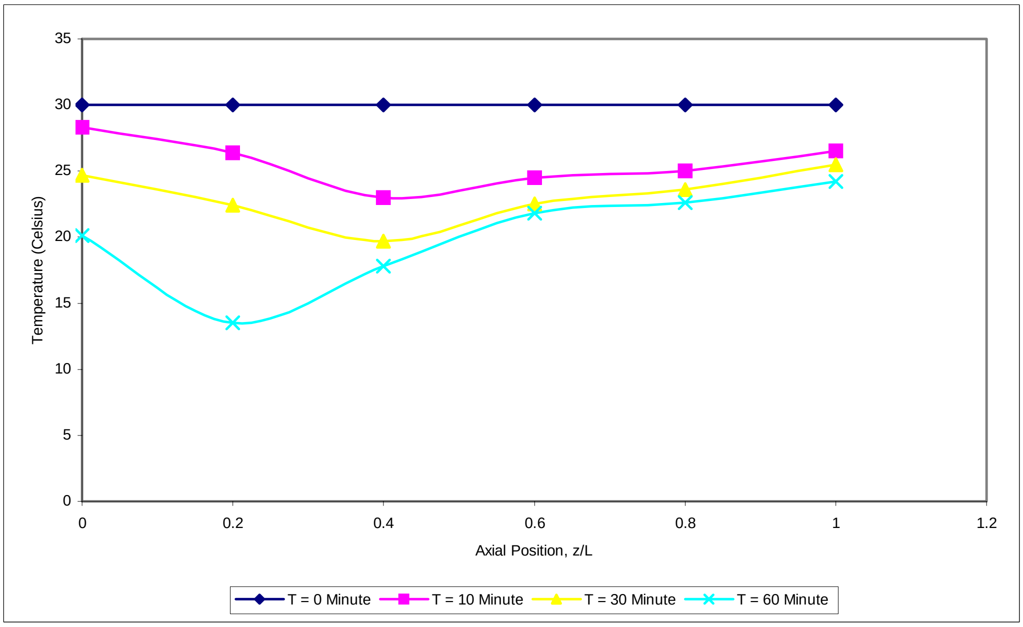
A207: Dimensionless Axial Profile of Temperature at Internal Wall of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



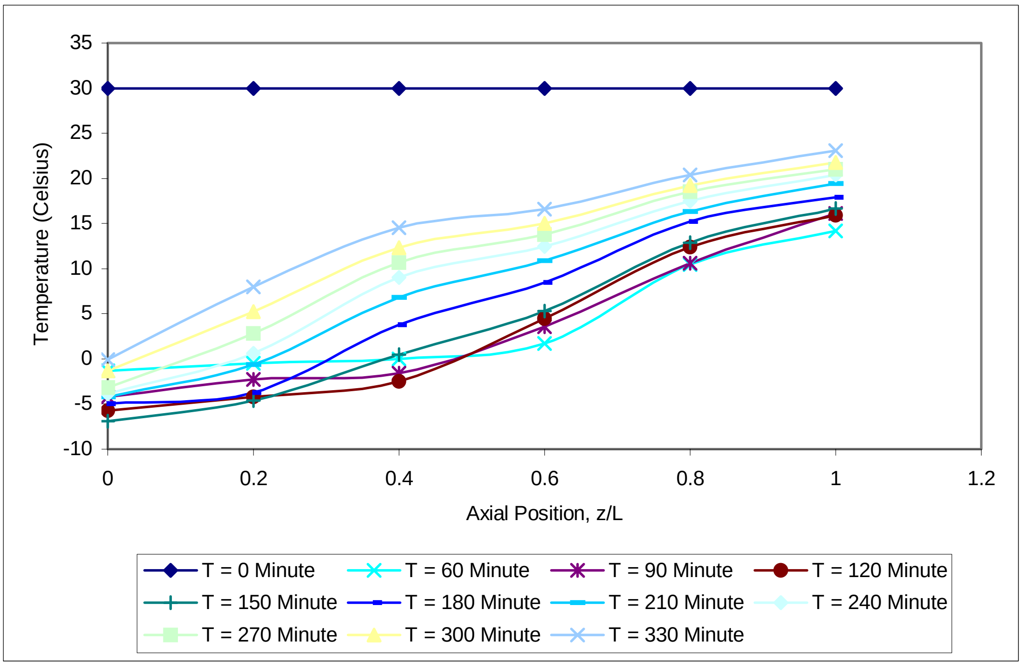
A208: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



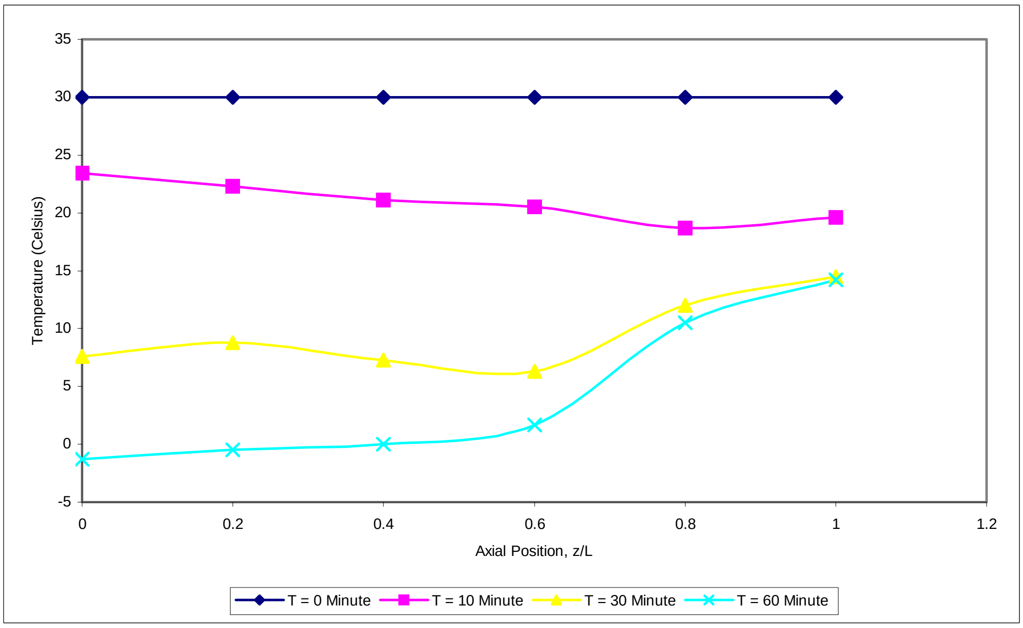
A209: Dimensionless Axial Profile of Temperature at External Wall of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



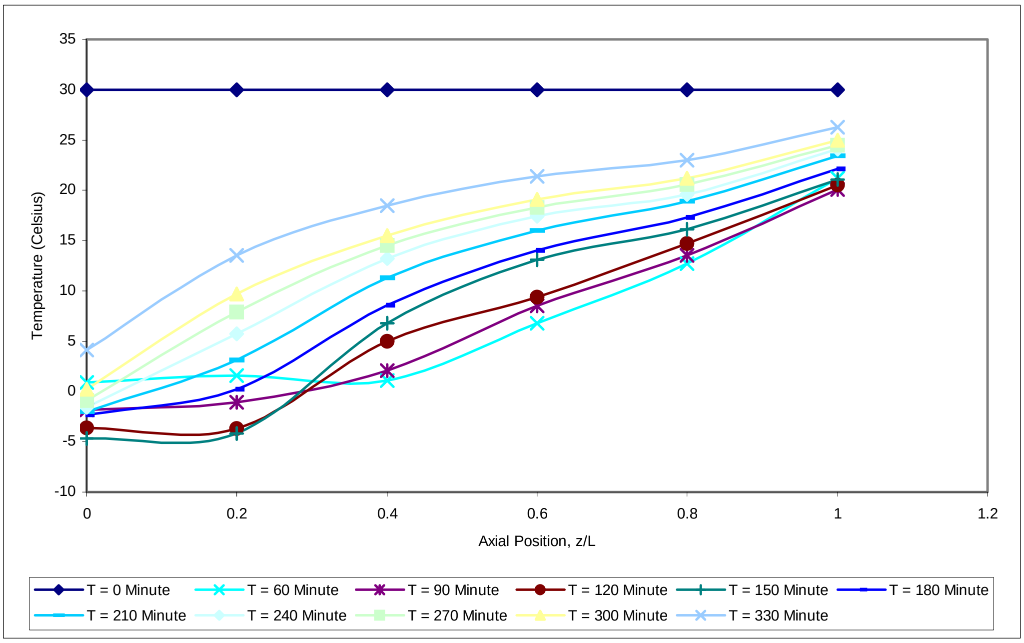
A210: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



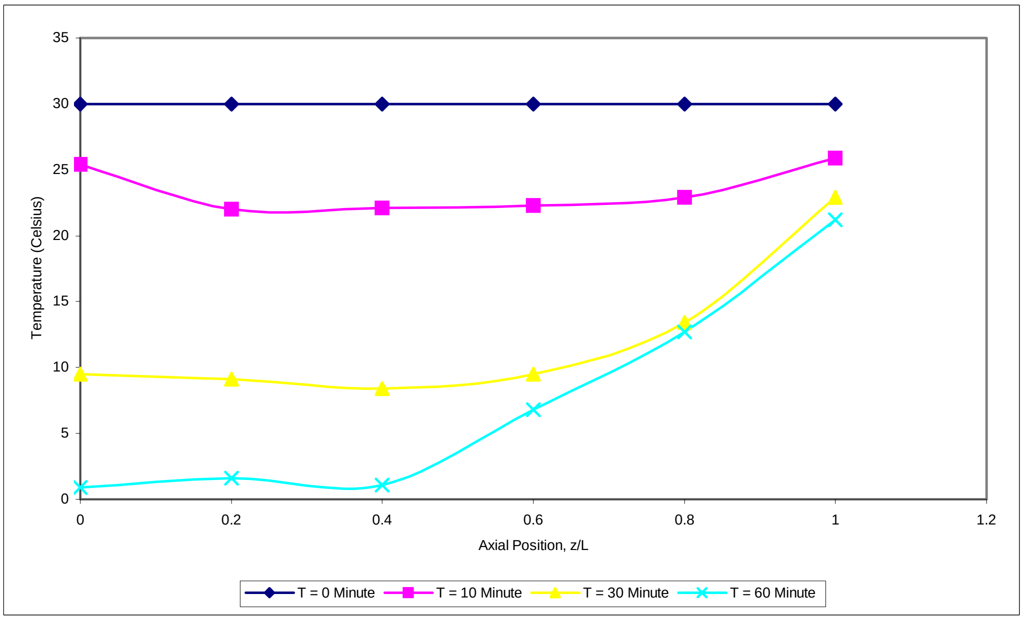
A211: Dimensionless Axial Profile of Temperature at Center of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



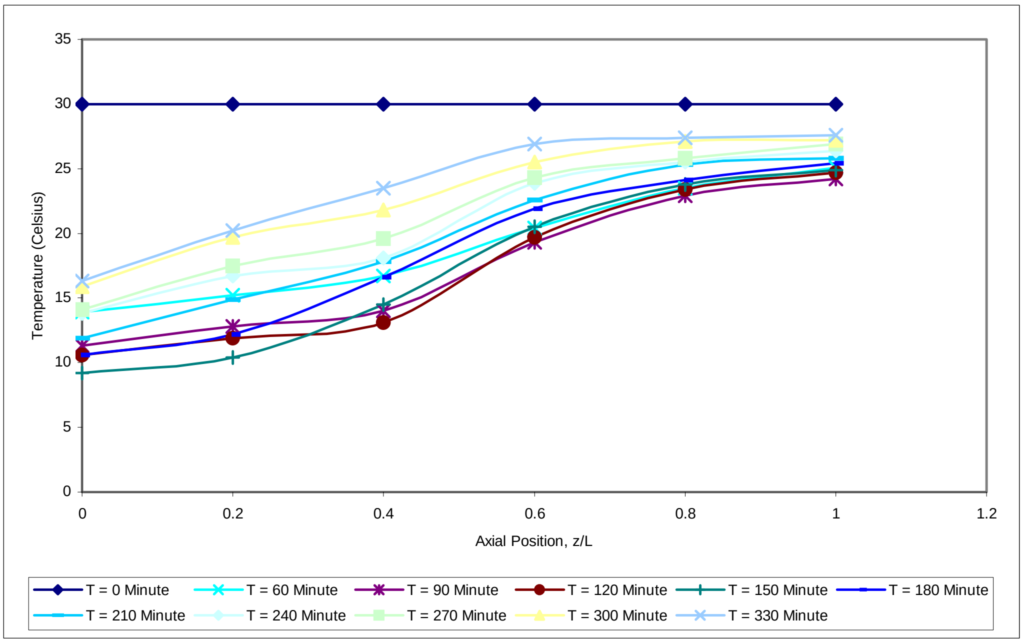
A212: Dimensionless Axial Profile of Temperature at Early Stage at Center of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



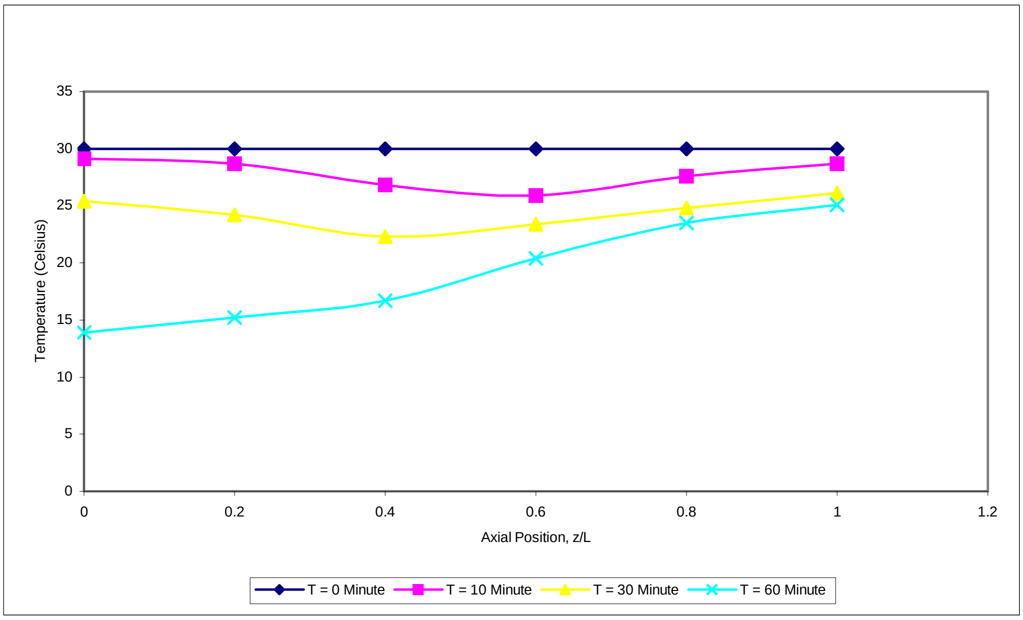
A213: Dimensionless Axial Profile of Temperature at Internal Wall of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



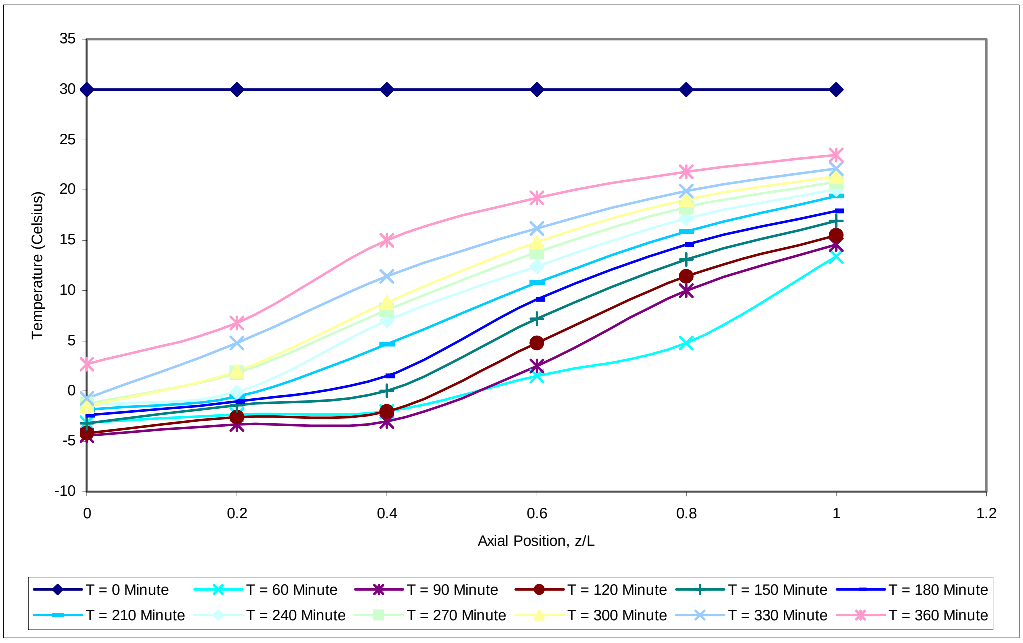
A214: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



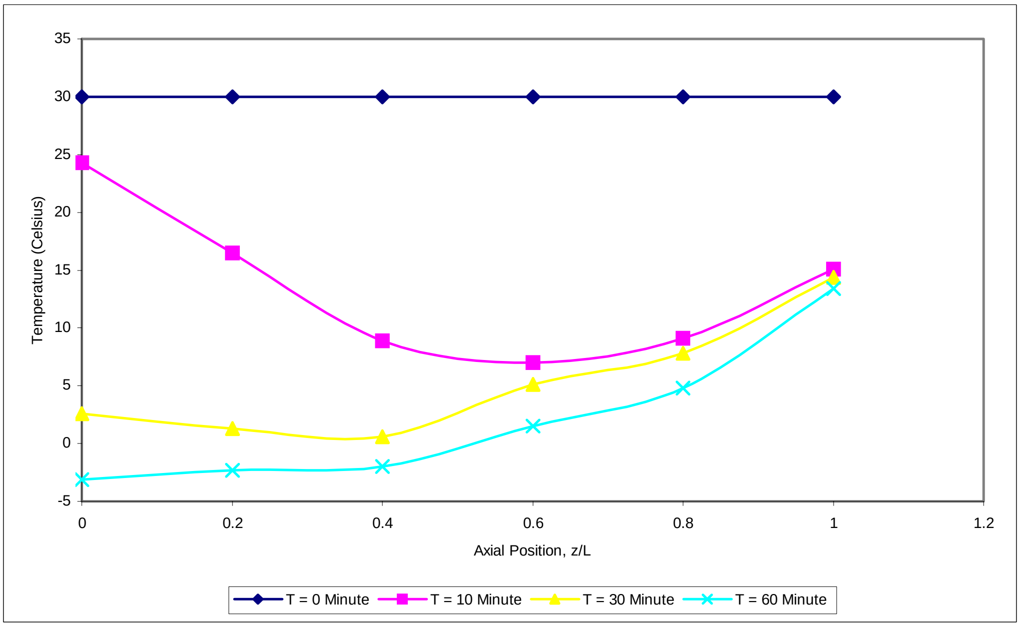
A215: Dimensionless Axial Profile of Temperature at External Wall of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



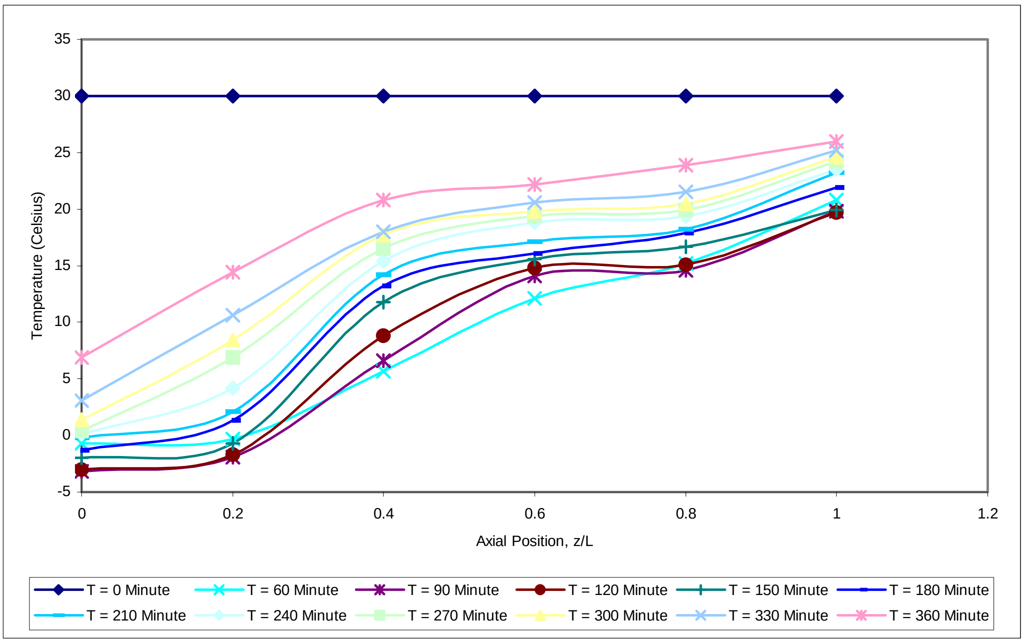
A216: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



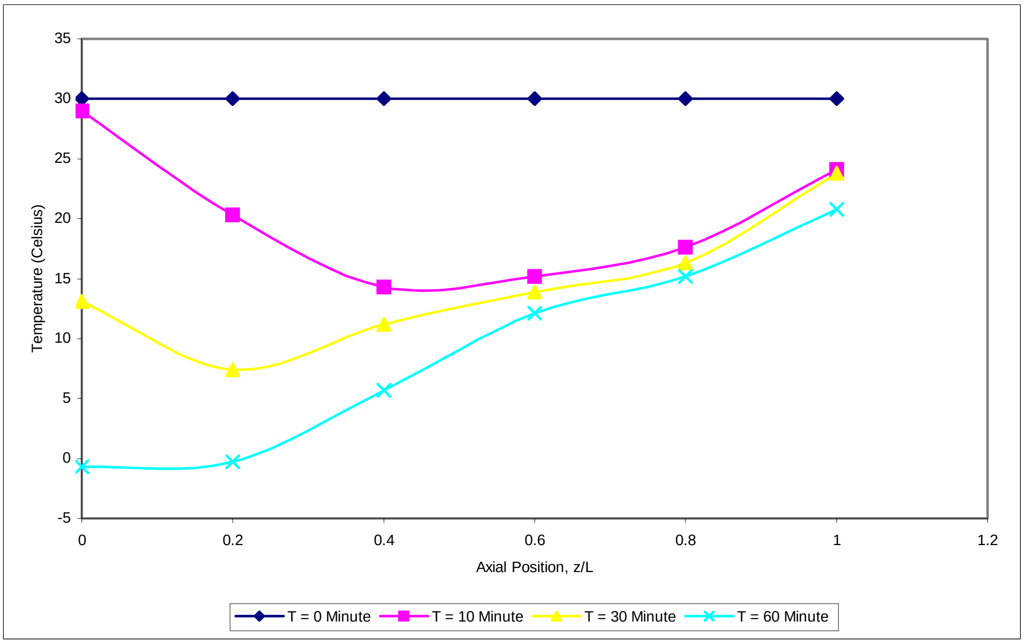
A217: Dimensionless Axial Profile of Temperature at Center of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



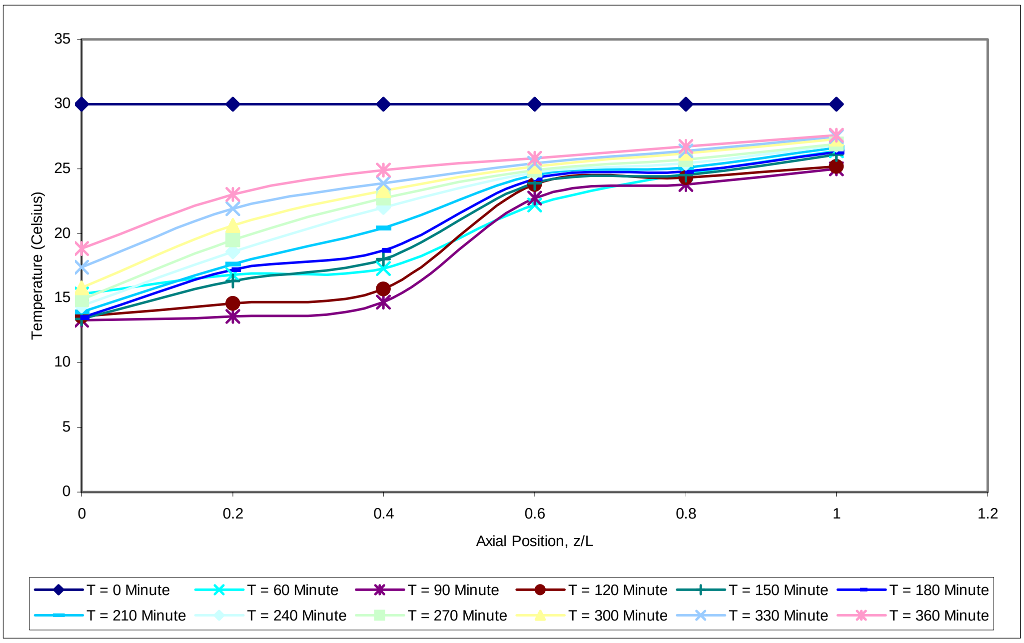
A218: Dimensionless Axial Profile of Temperature at Early Stage at Center of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



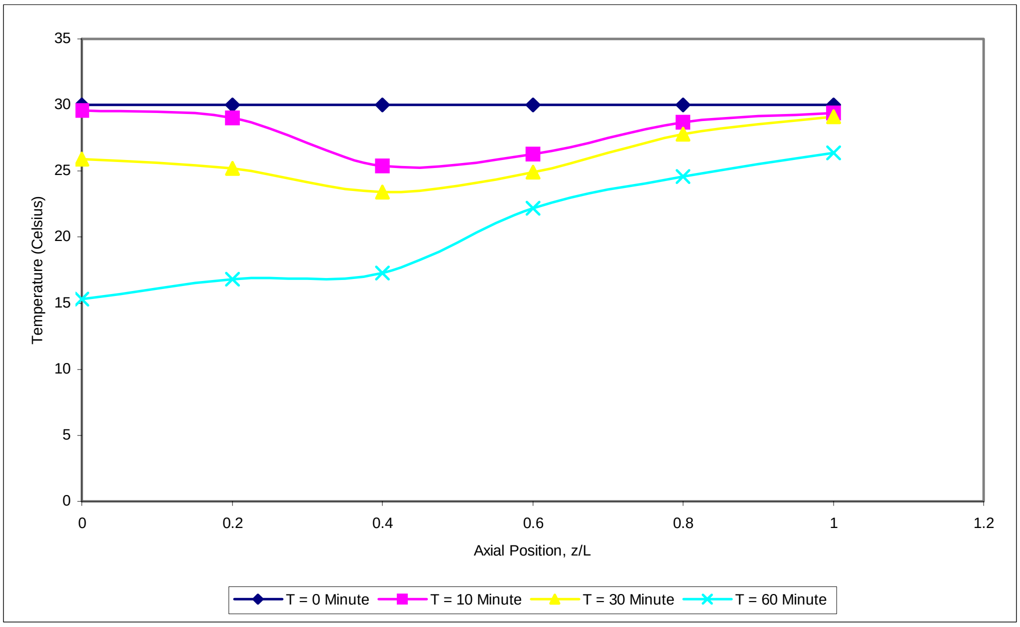
A219: Dimensionless Axial Profile of Temperature at Internal Wall of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



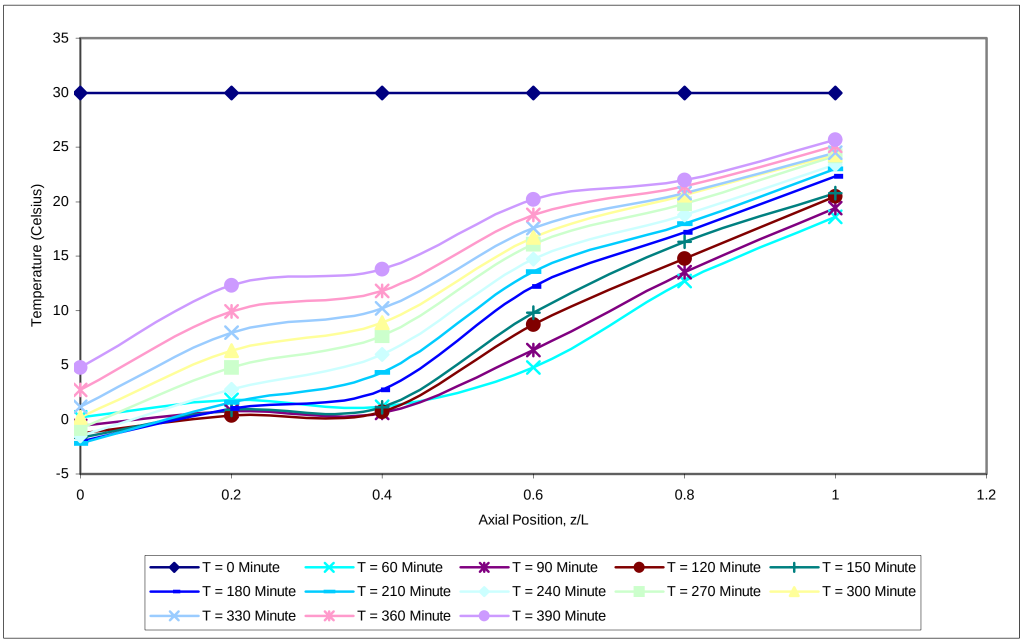
A220: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



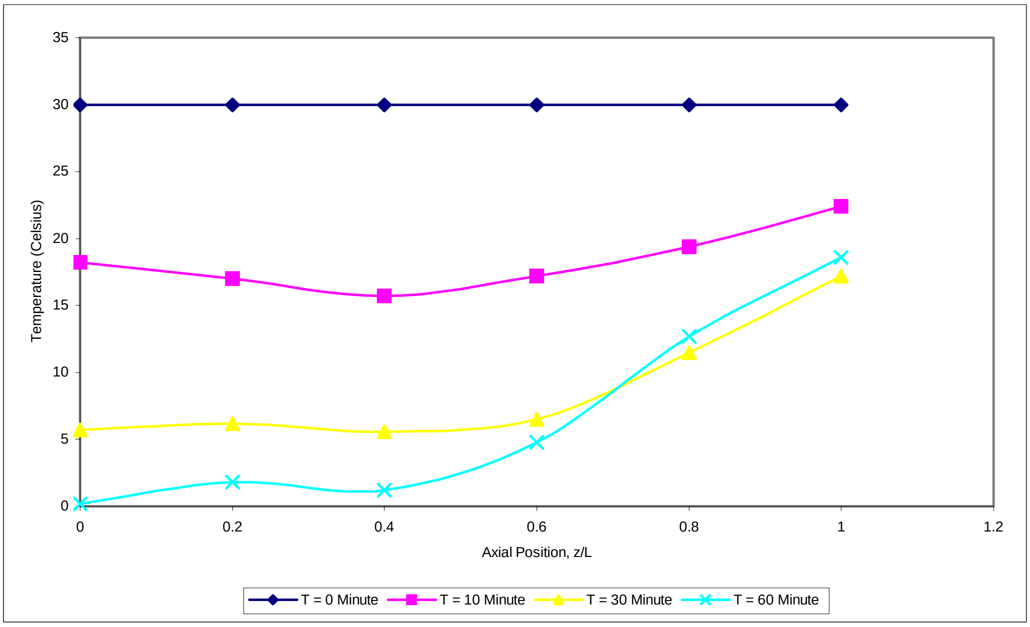
A221: Dimensionless Axial Profile of Temperature at External Wall of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



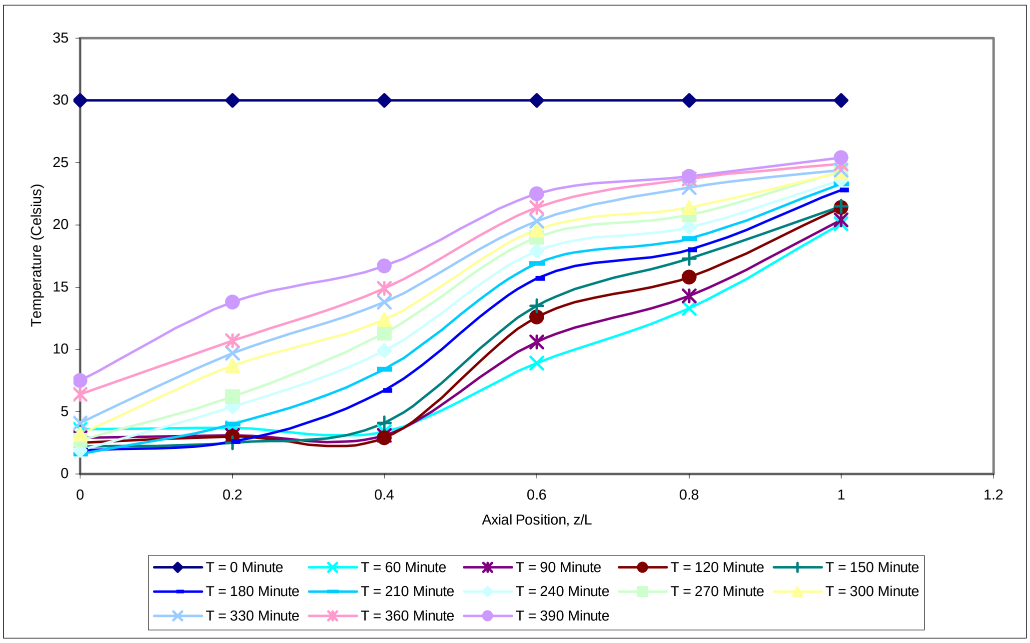
A222: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



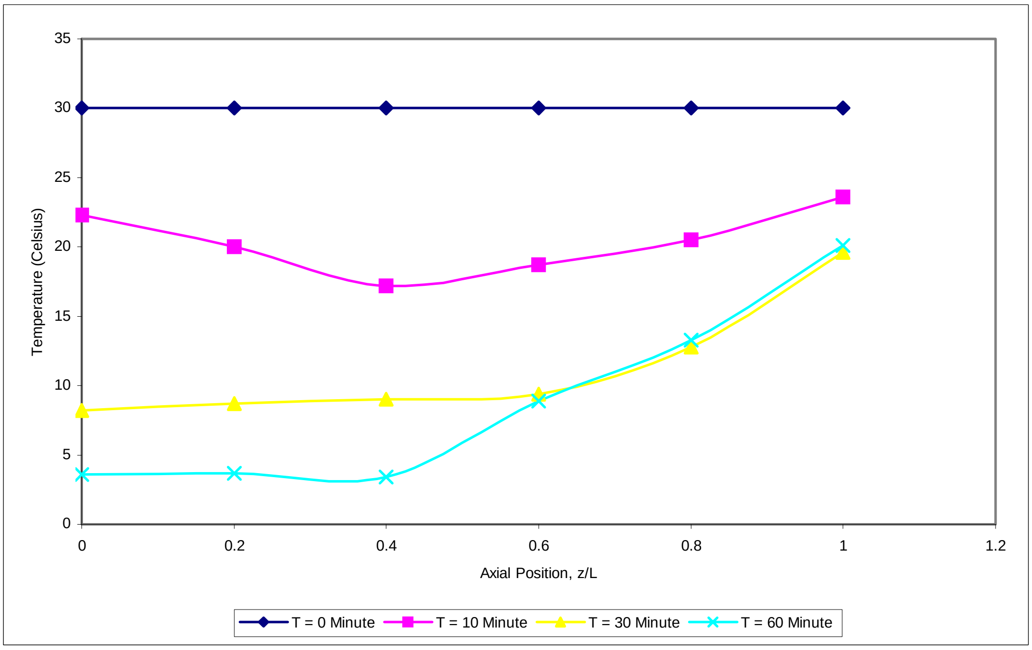
A223: Dimensionless Axial Profile of Temperature at Center of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



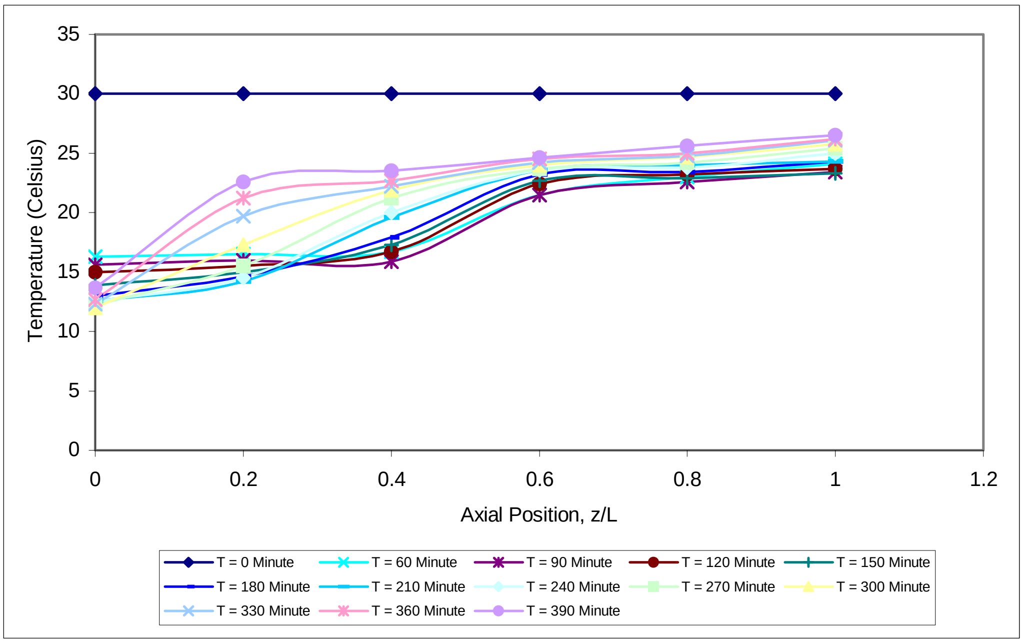
A224: Dimensionless Axial Profile of Temperature at Early Stage at Center of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



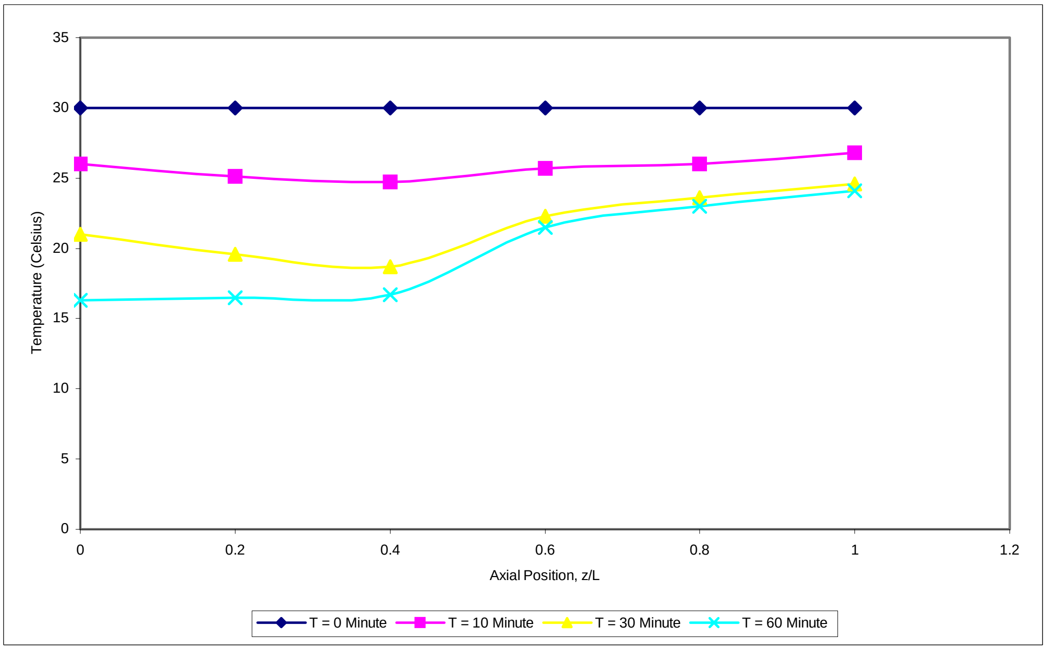
A225: Dimensionless Axial Profile of Temperature at Internal Wall of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



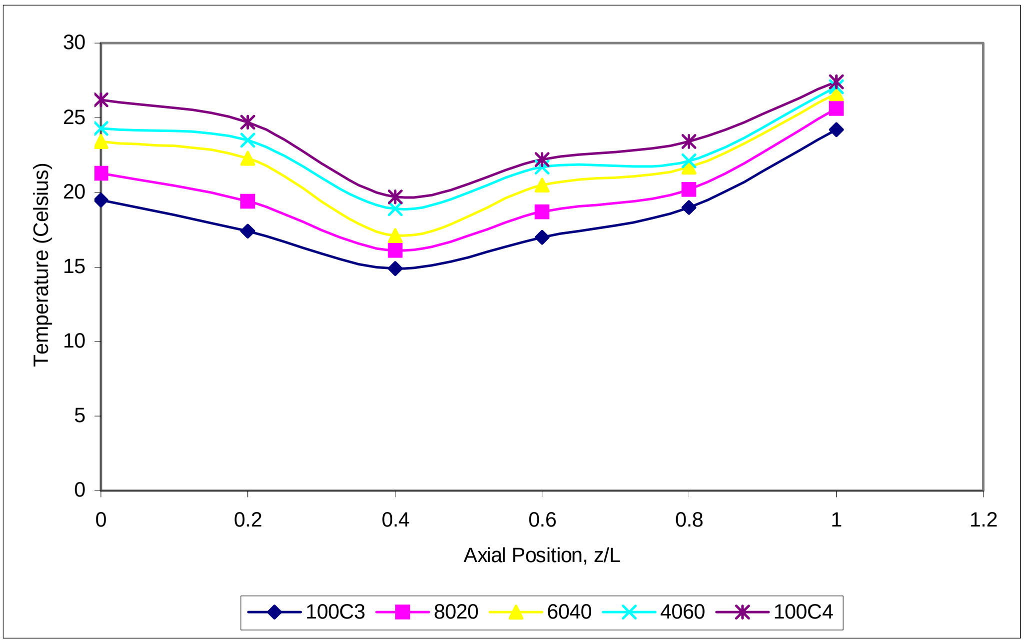
A226: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



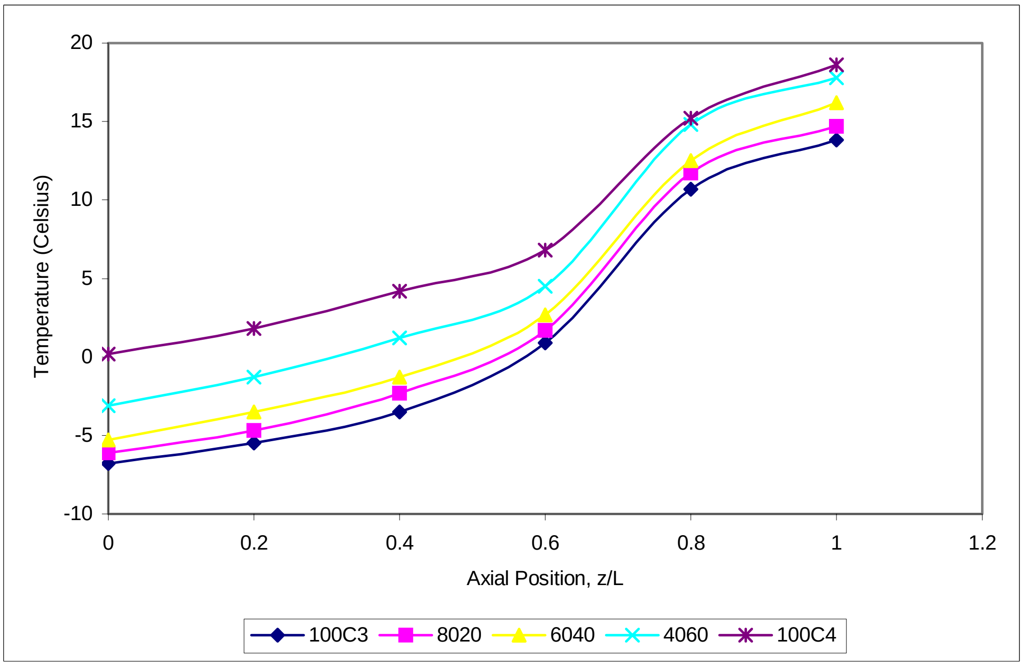
A227: Dimensionless Axial Profile of Temperature at External Wall of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



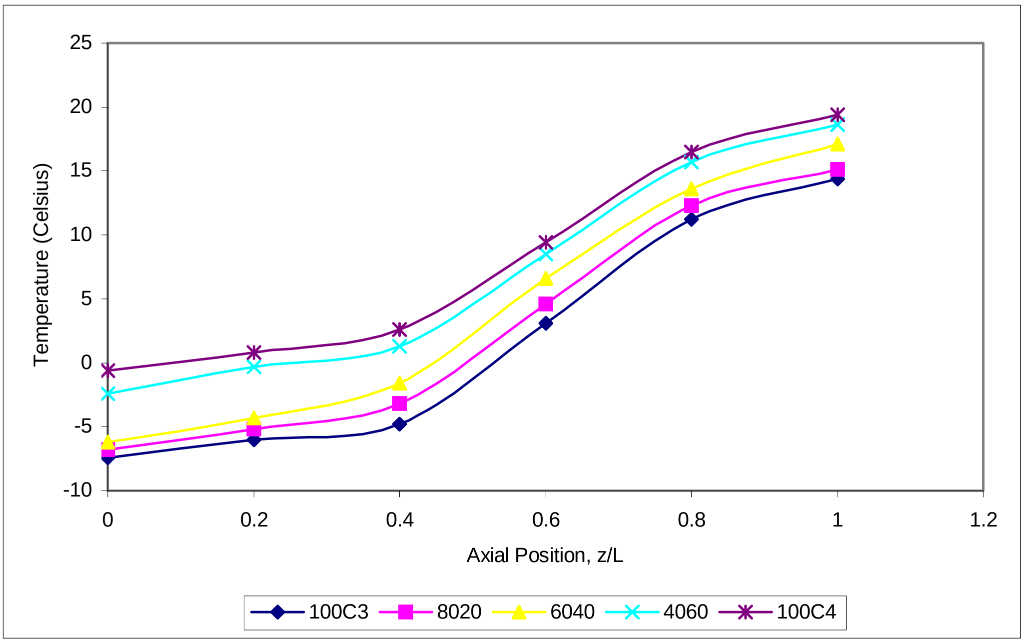
A228: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



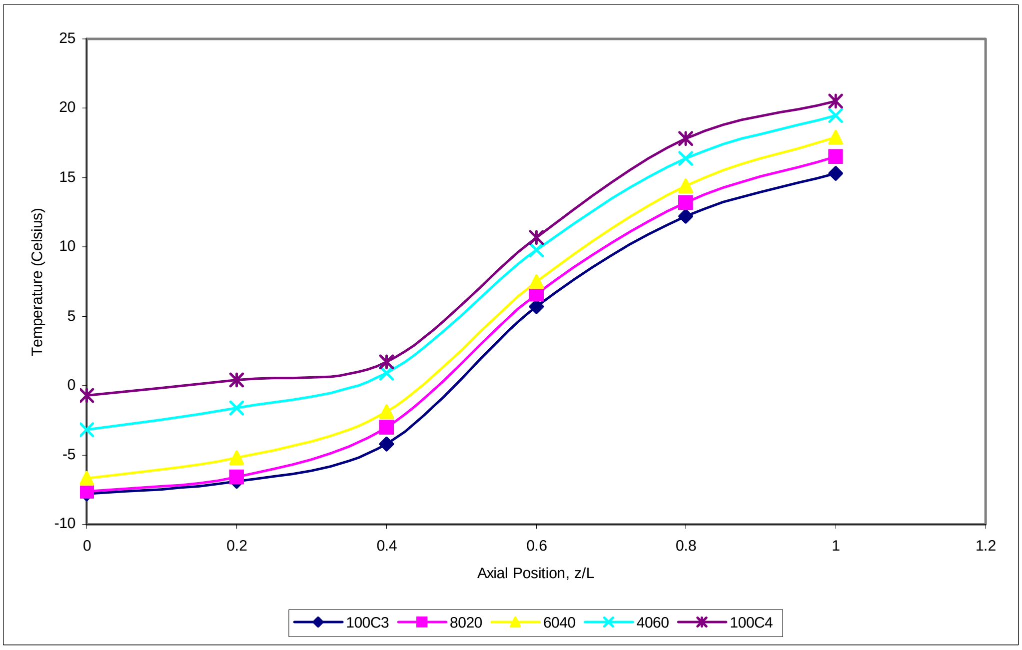
A229: Dimensionless Axial Profile of Temperature at 10 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



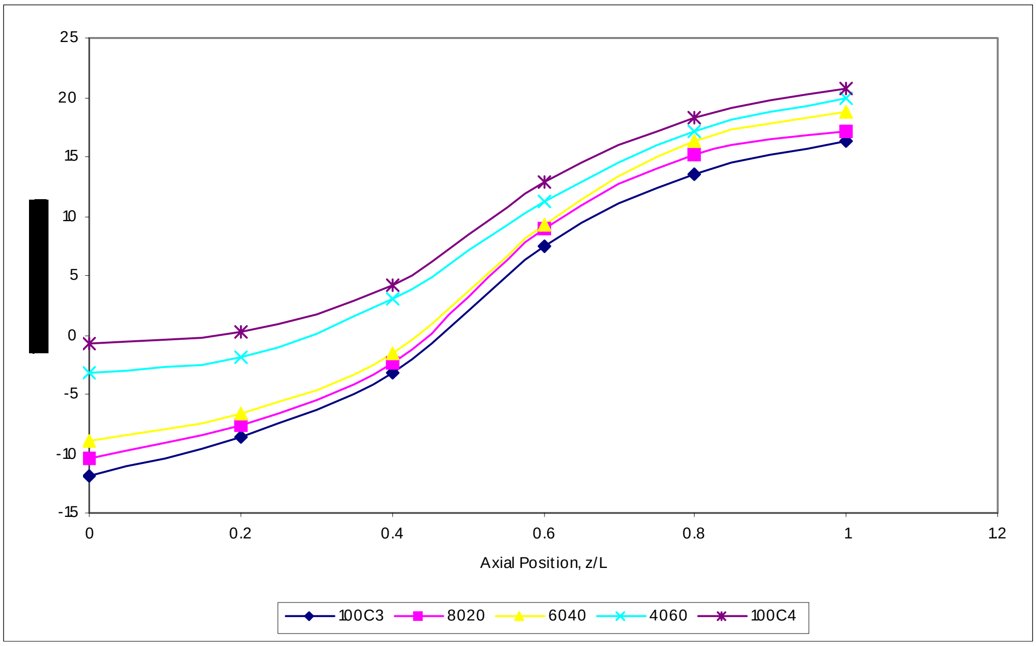
A230: Dimensionless Axial Profile of Temperature at 60 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



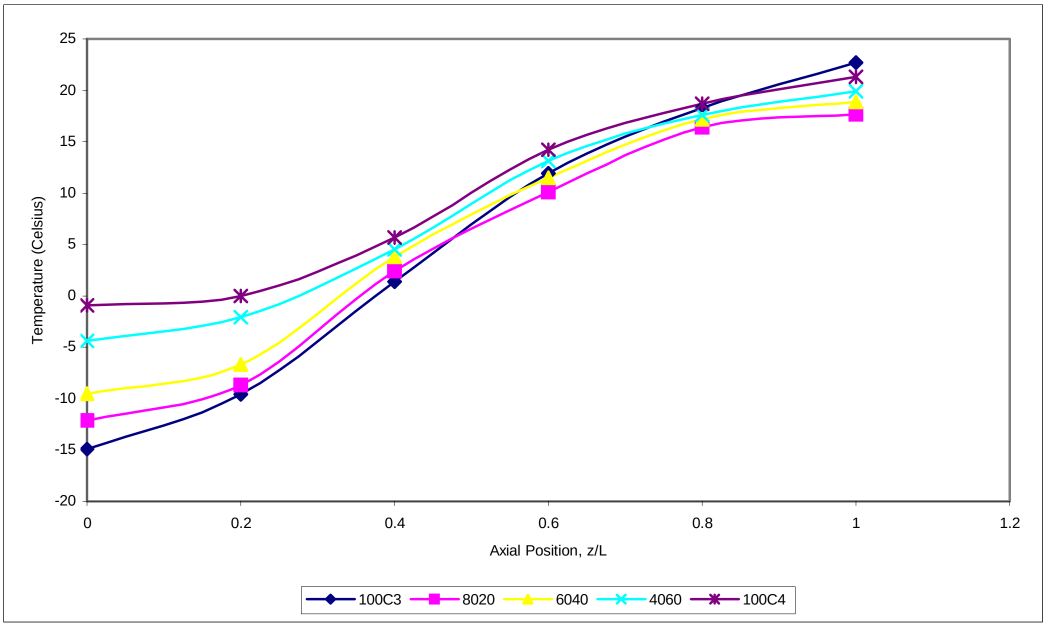
A231: Dimensionless Axial Profile of Temperature at 90 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



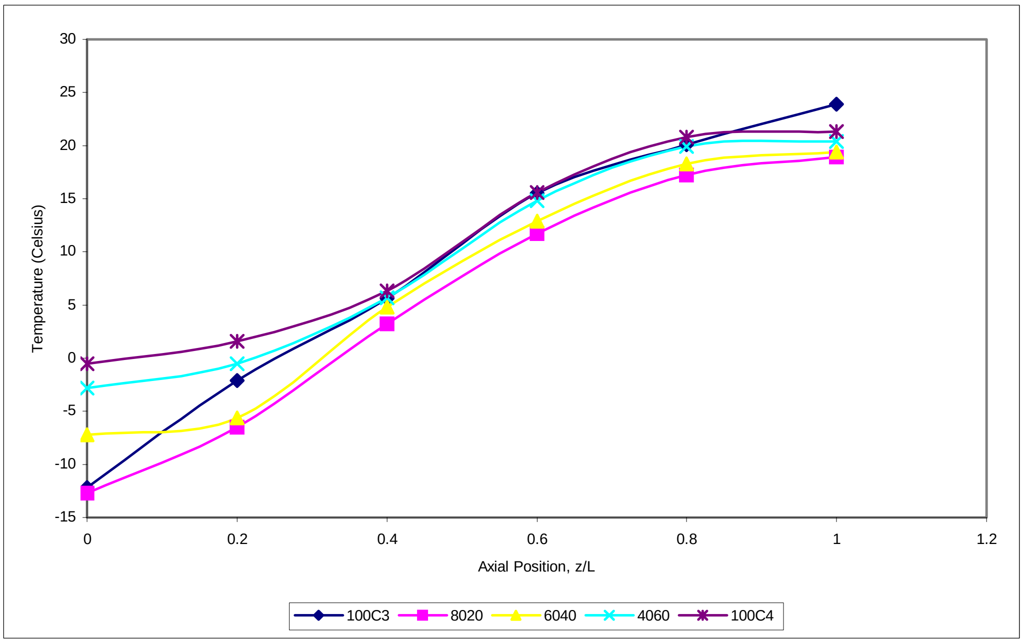
A232: Dimensionless Axial Profile of Temperature at 120 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



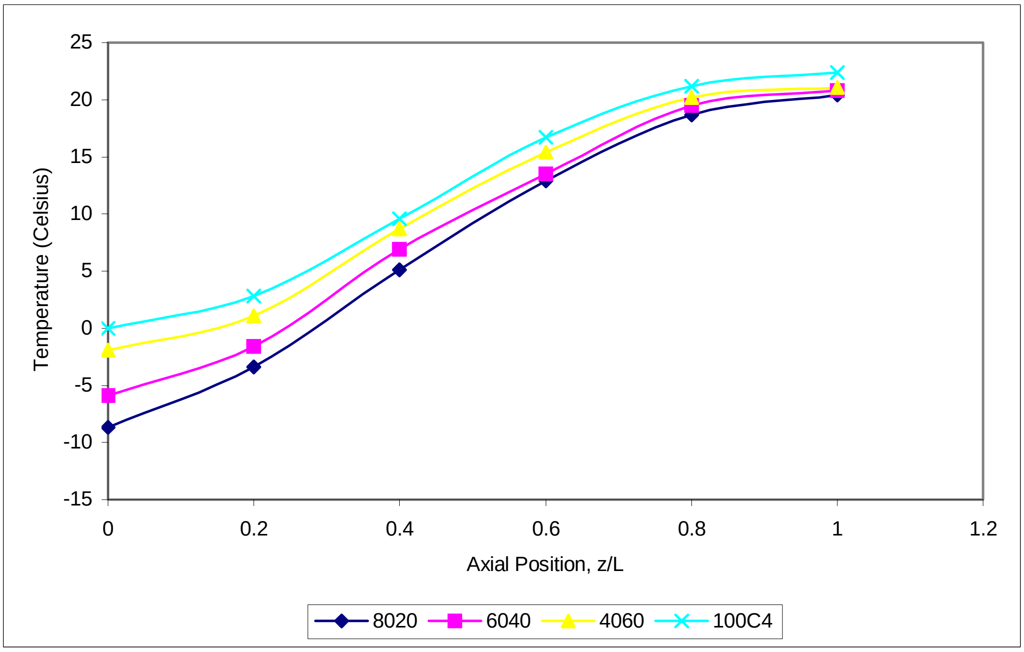
A233: Dimensionless Axial Profile of Temperature at 150 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



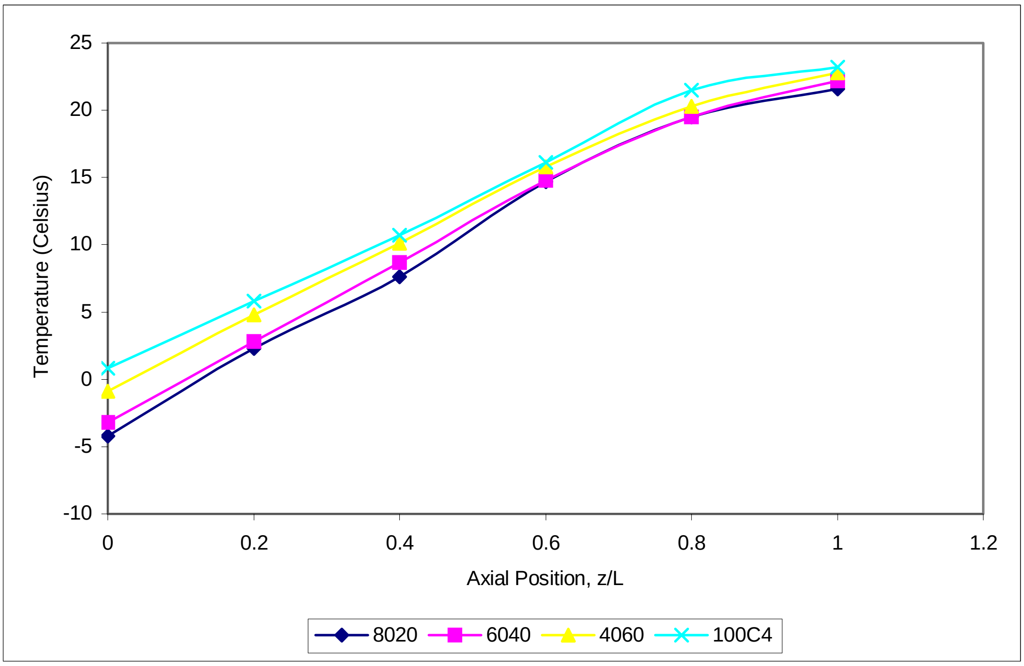
A234: Dimensionless Axial Profile of Temperature at 180 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



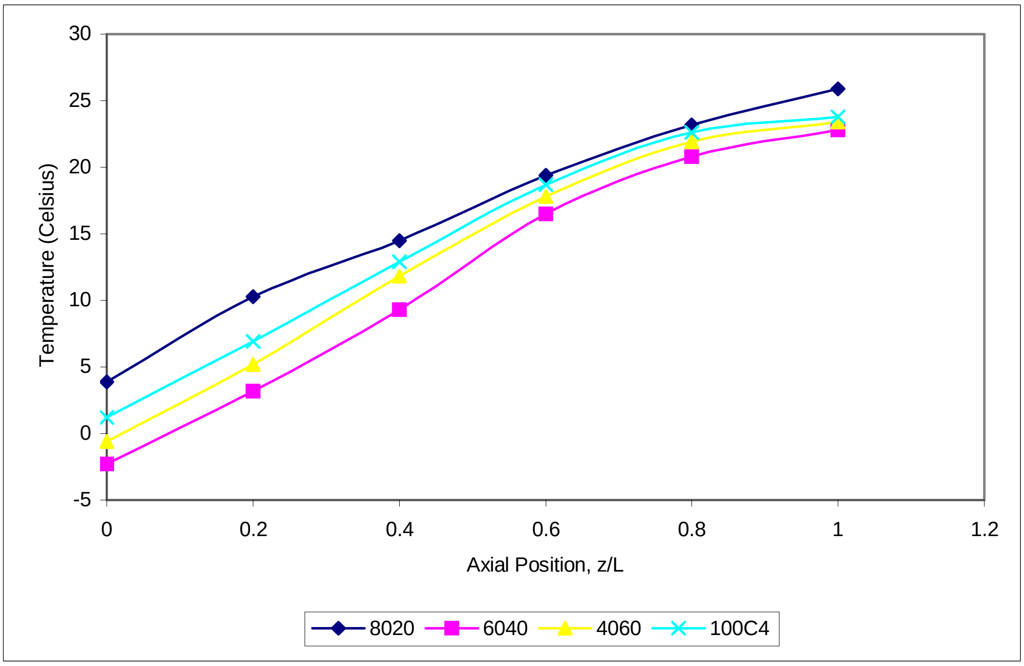
A235: Dimensionless Axial Profile of Temperature at 210 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



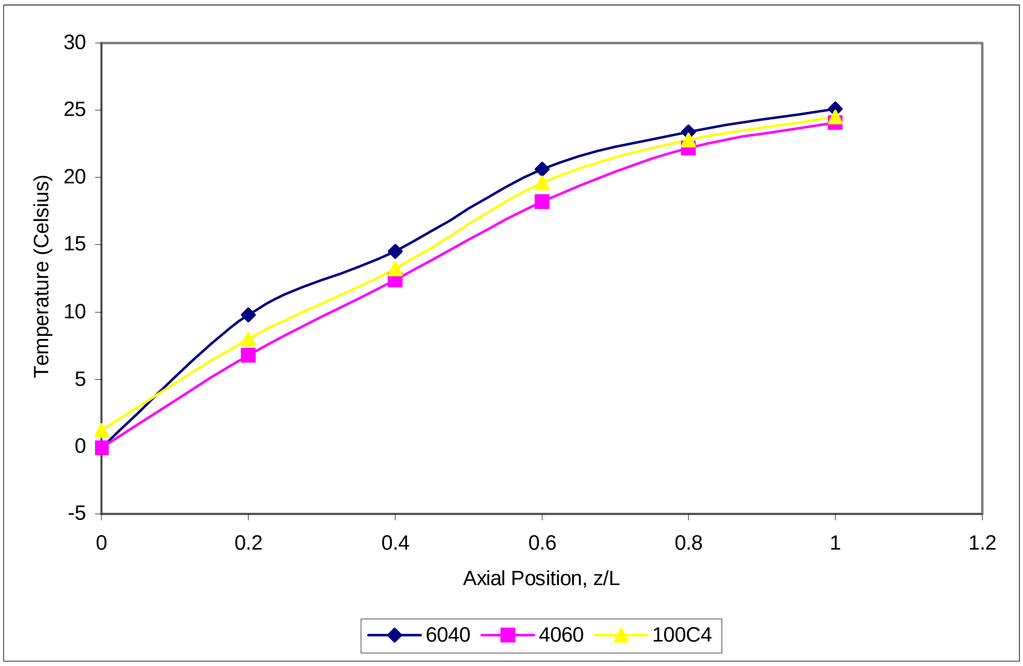
A236: Dimensionless Axial Profile of Temperature at 240 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



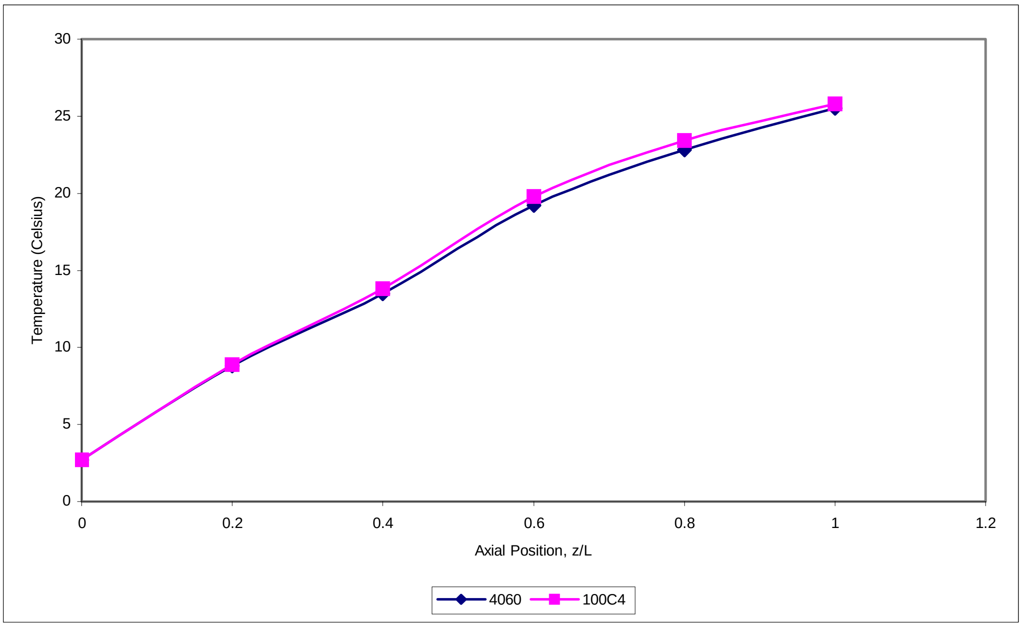
A237: Dimensionless Axial Profile of Temperature at 270 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



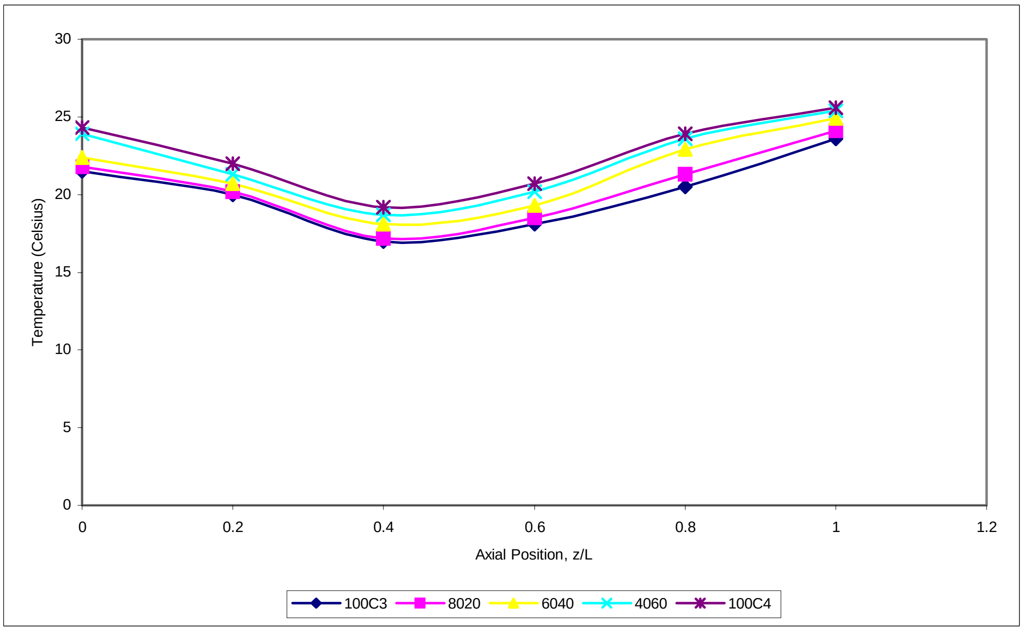
A238: Dimensionless Axial Profile of Temperature at 300 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



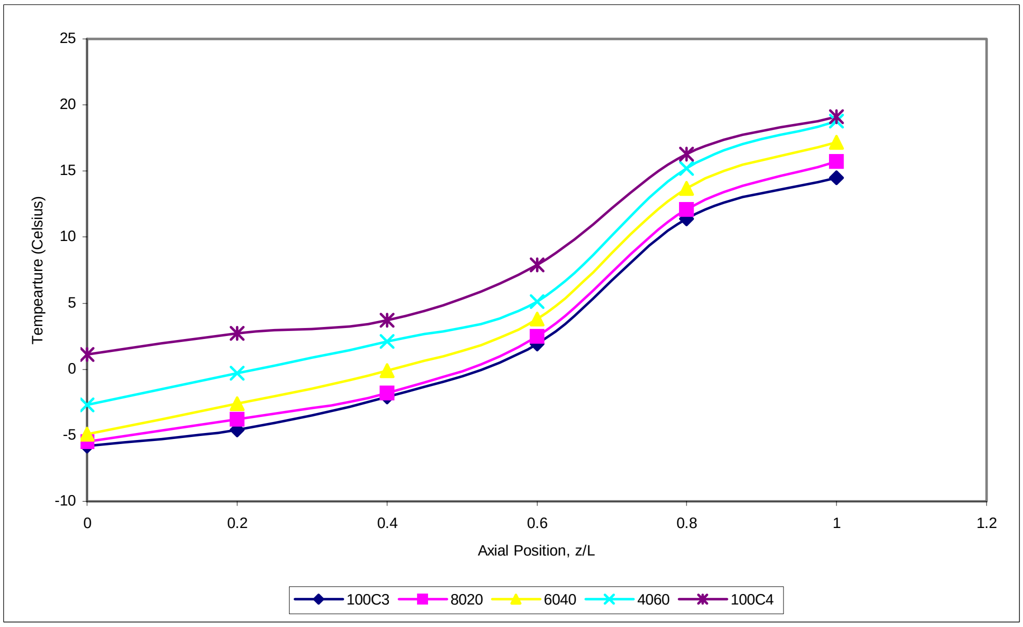
A239: Dimensionless Axial Profile of Temperature at 330 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



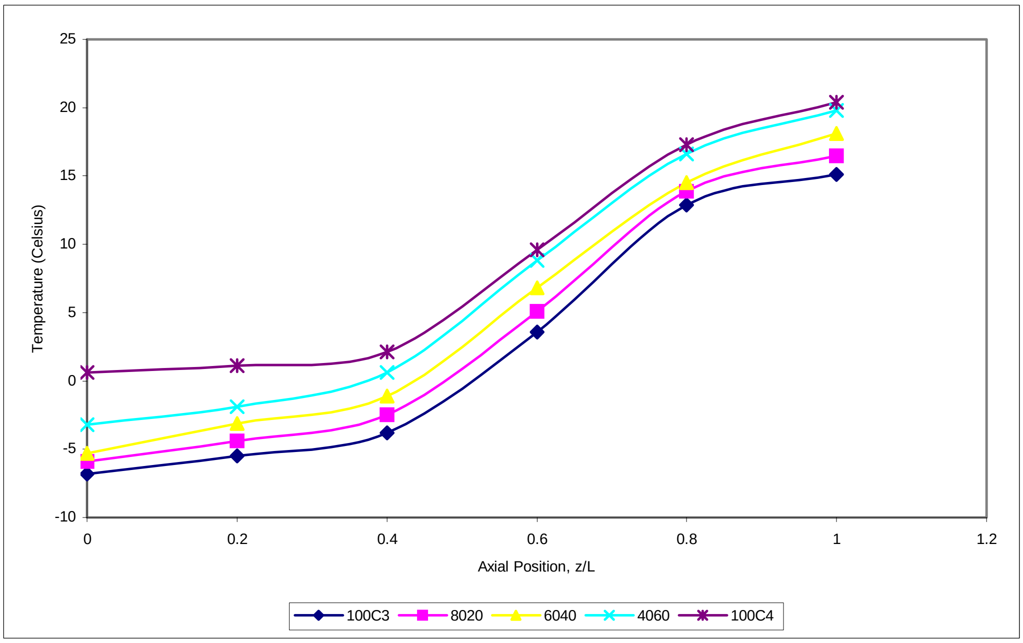
A240: Dimensionless Axial Profile of Temperature at 360 Minute at Center of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



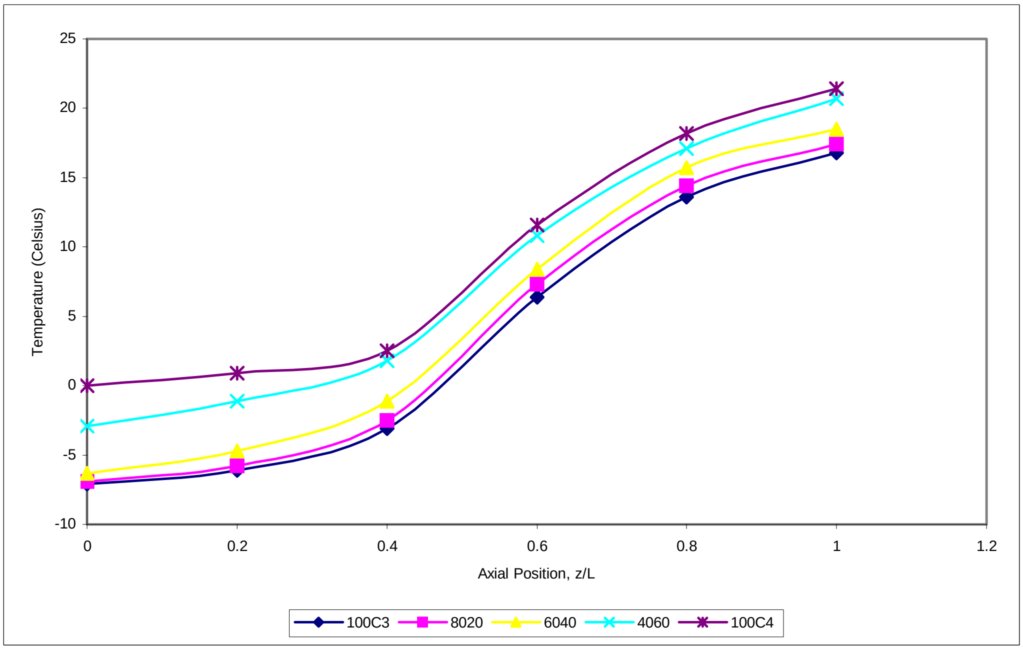
A241: Dimensionless Axial Profile of Temperature at 10 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



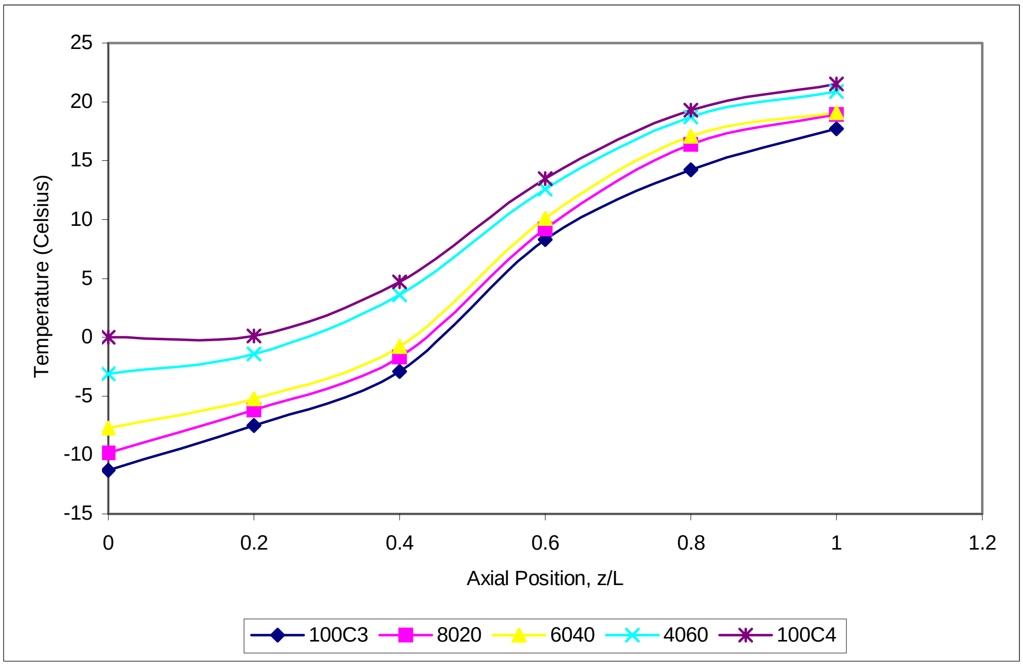
A242: Dimensionless Axial Profile of Temperature at 60 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



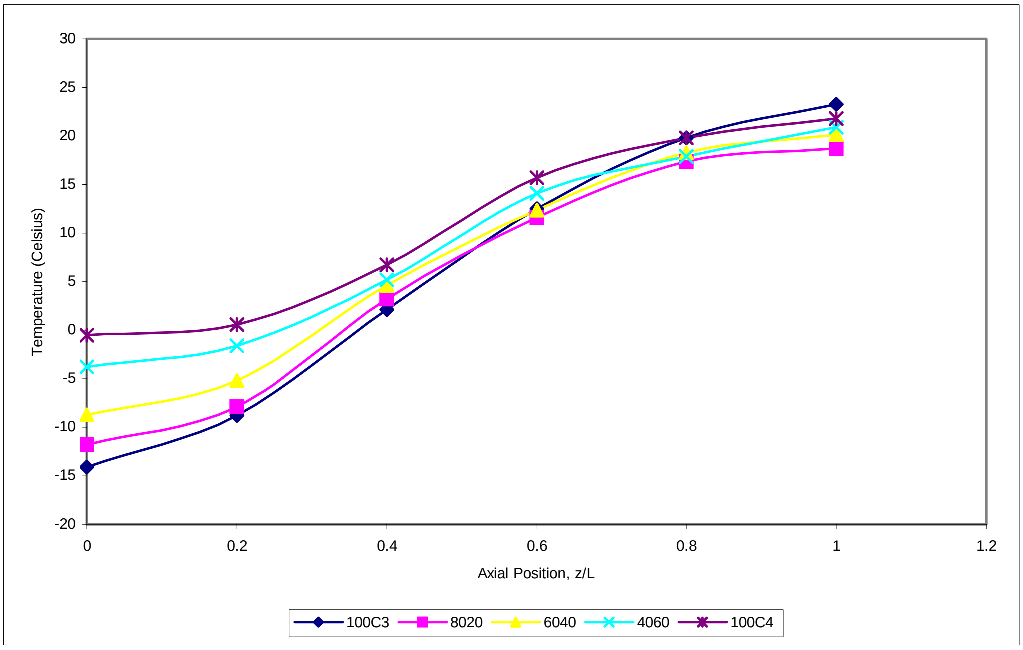
A243: Dimensionless Axial Profile of Temperature at 90 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



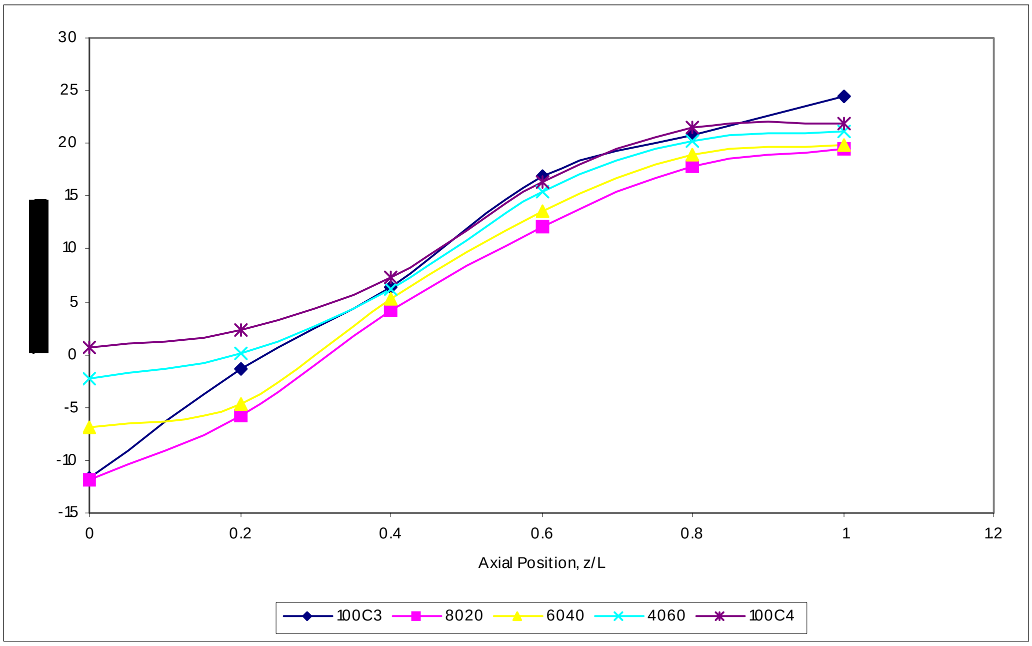
A244: Dimensionless Axial Profile of Temperature at 120 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



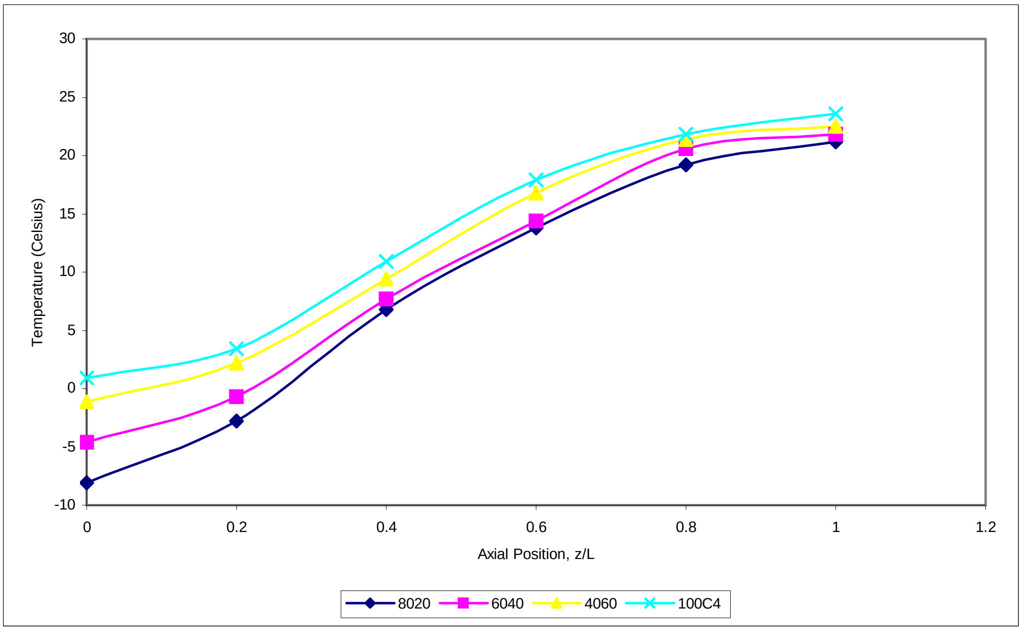
A245: Dimensionless Axial Profile of Temperature at 150 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



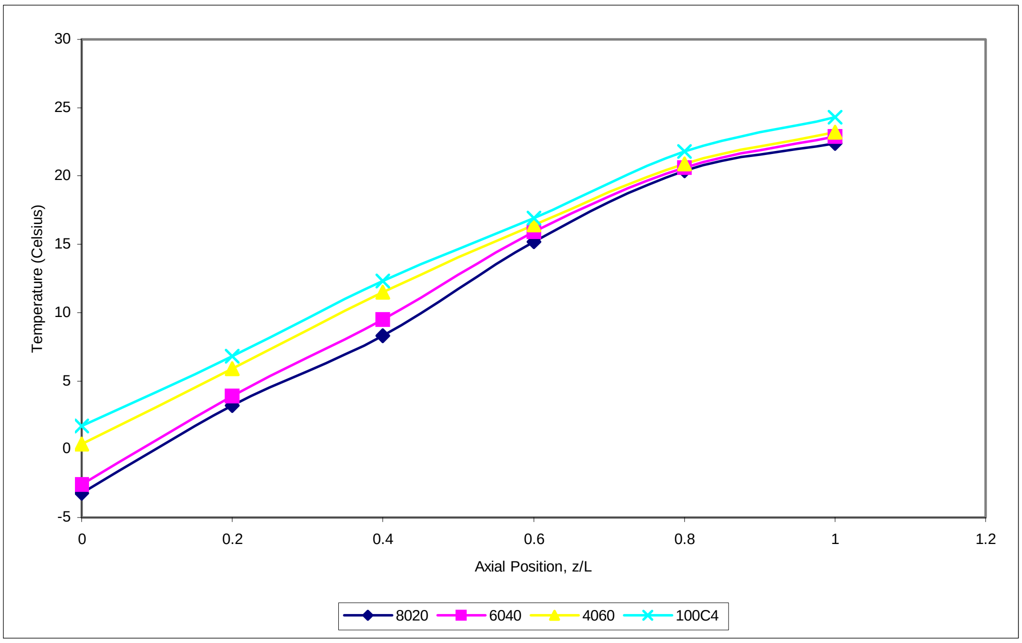
A246: Dimensionless Axial Profile of Temperature at 180 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



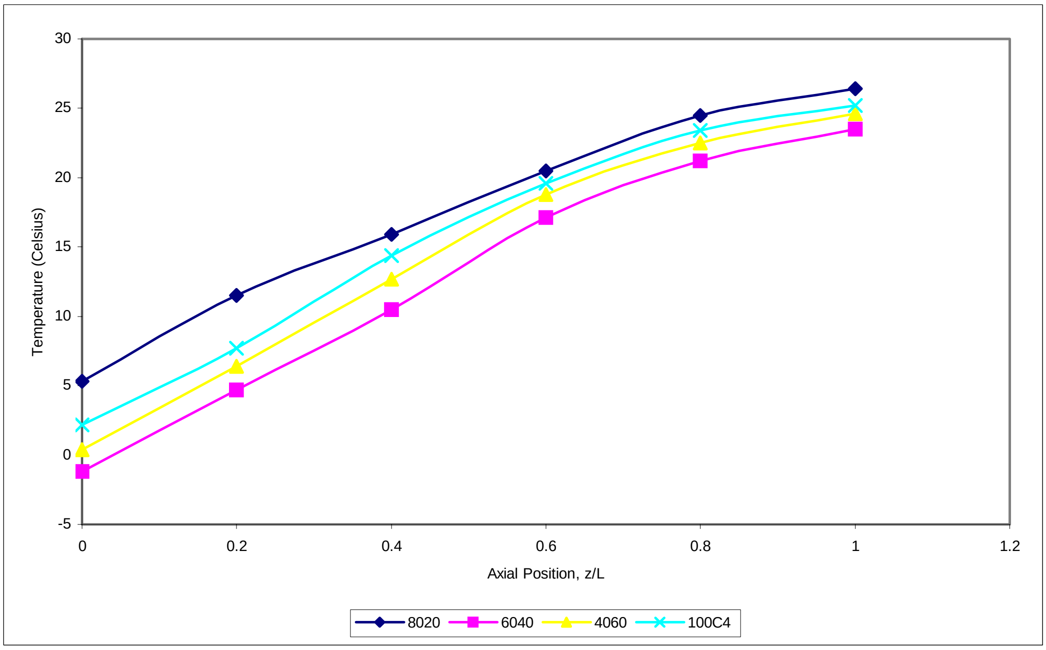
A247: Dimensionless Axial Profile of Temperature at 210 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



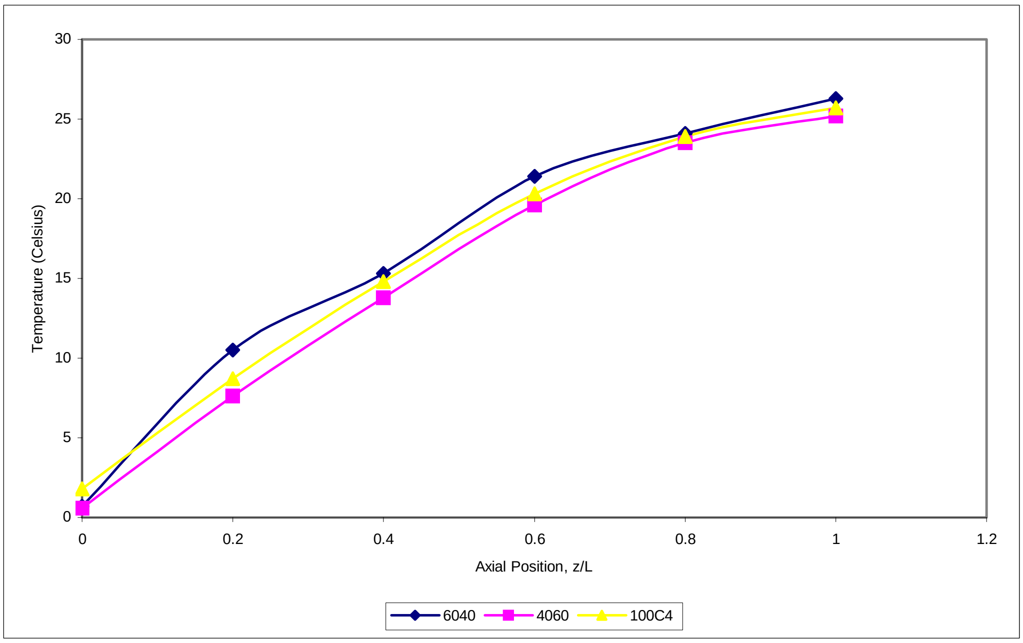
A248: Dimensionless Axial Profile of Temperature at 240 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



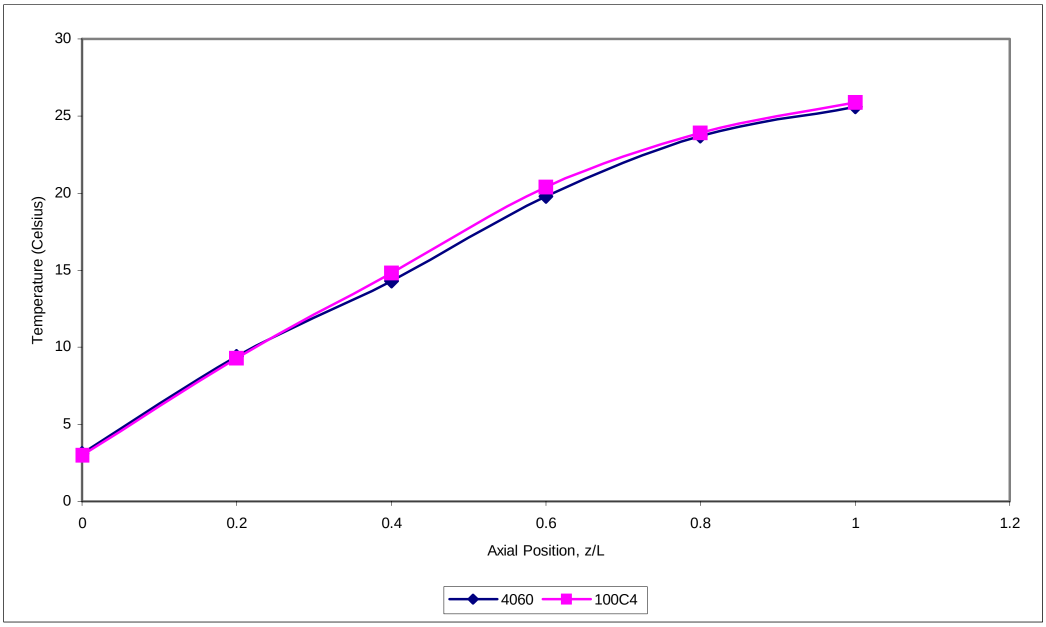
A249: Dimensionless Axial Profile of Temperature at 270 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



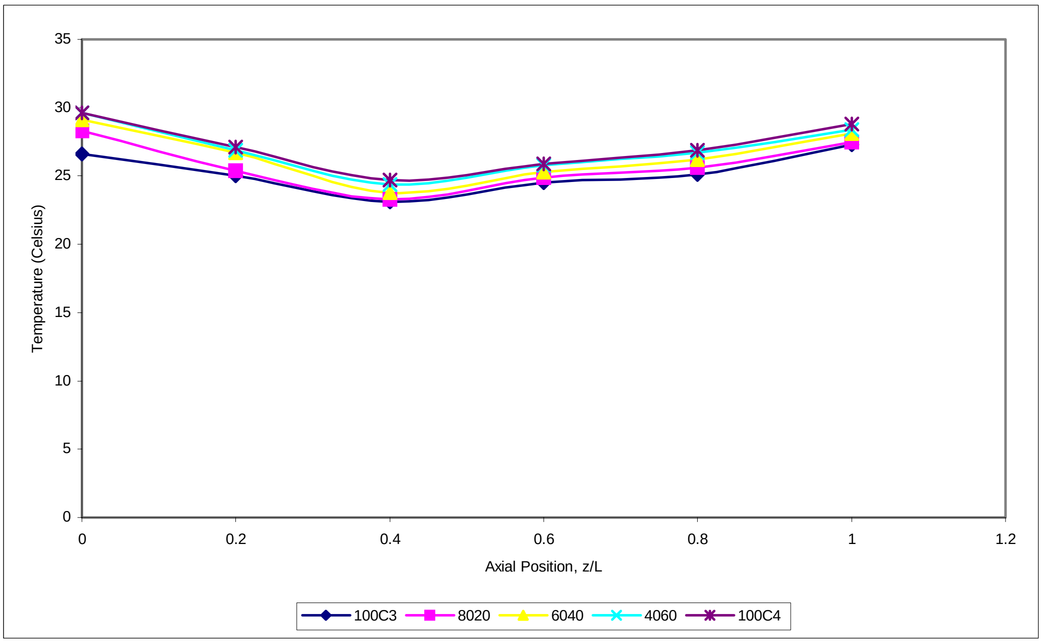
A250: Dimensionless Axial Profile of Temperature at 300 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



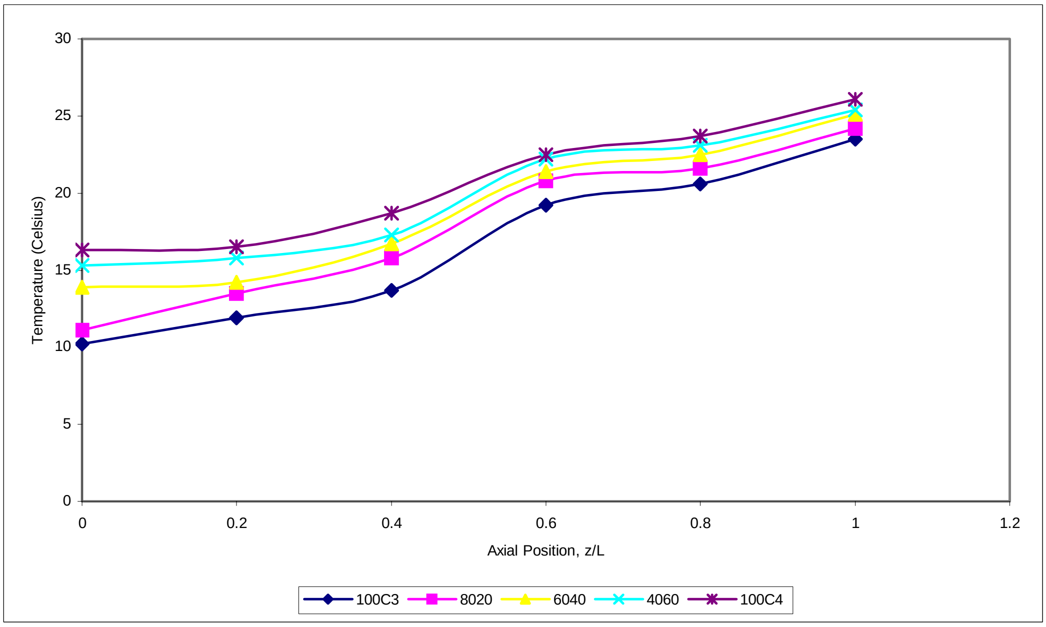
A251: Dimensionless Axial Profile of Temperature at 330 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



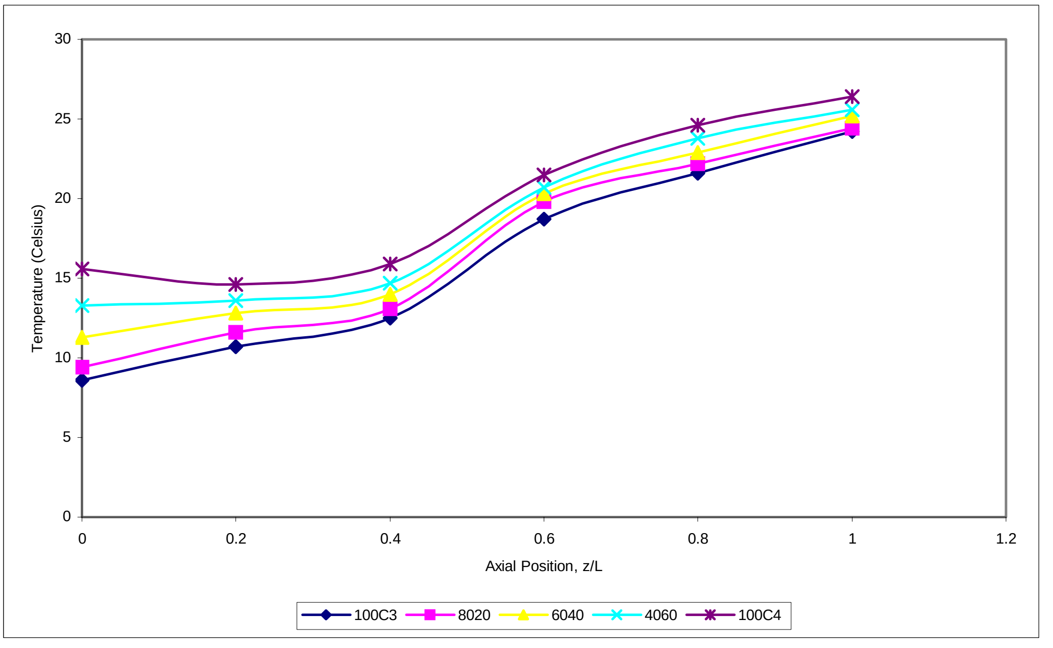
A252: Dimensionless Axial Profile of Temperature at 360 Minute at Internal Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



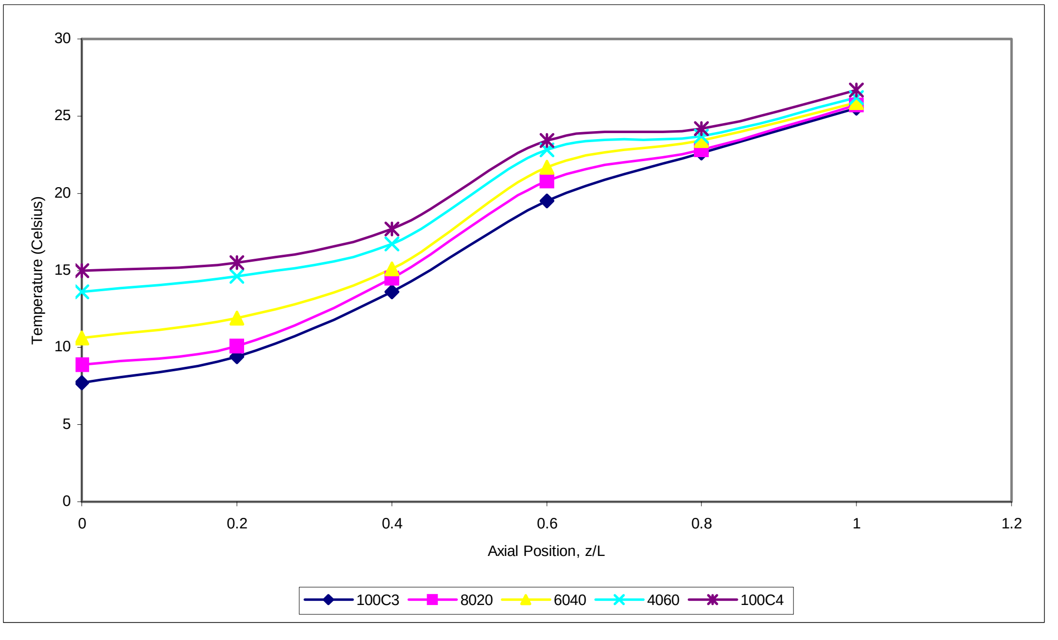
A253: Dimensionless Axial Profile of Temperature at 10 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



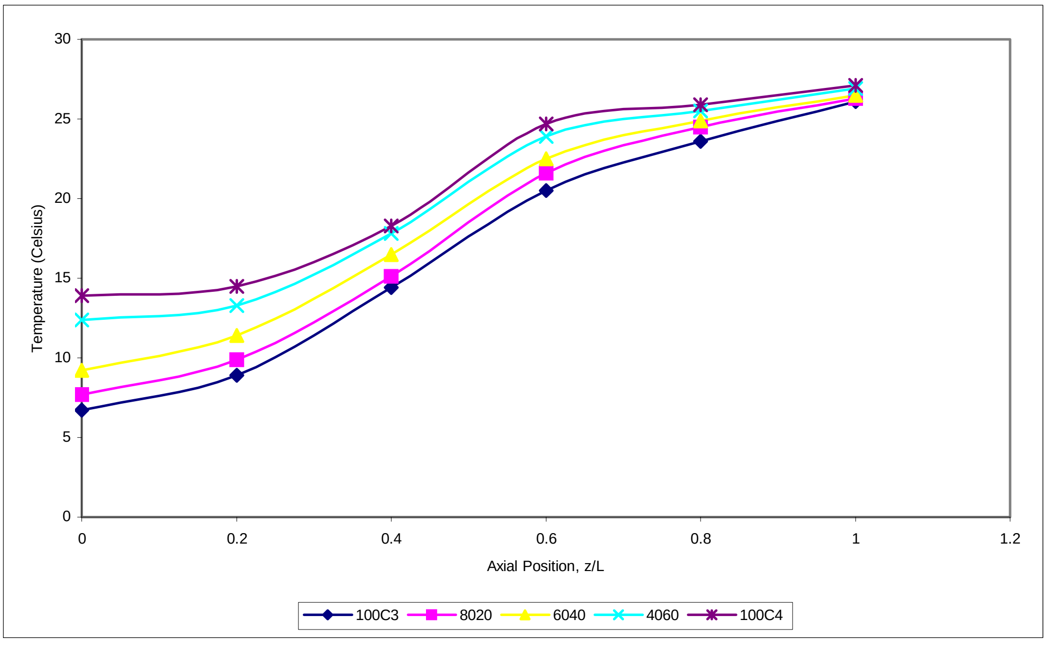
A254: Dimensionless Axial Profile of Temperature at 60 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



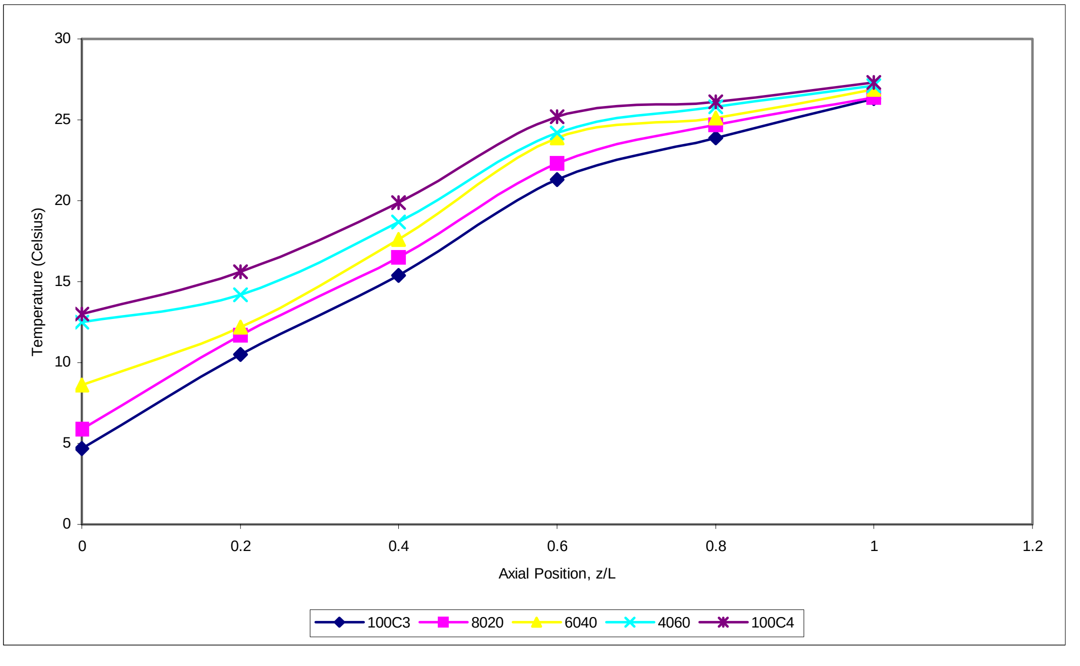
A255: Dimensionless Axial Profile of Temperature at 90 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



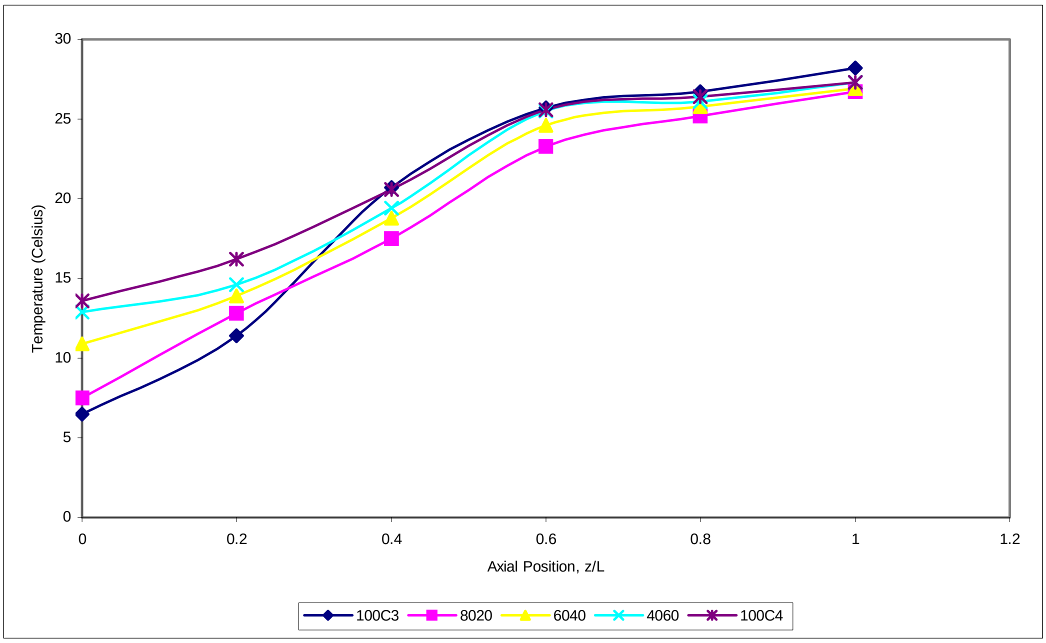
A256: Dimensionless Axial Profile of Temperature at 120 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



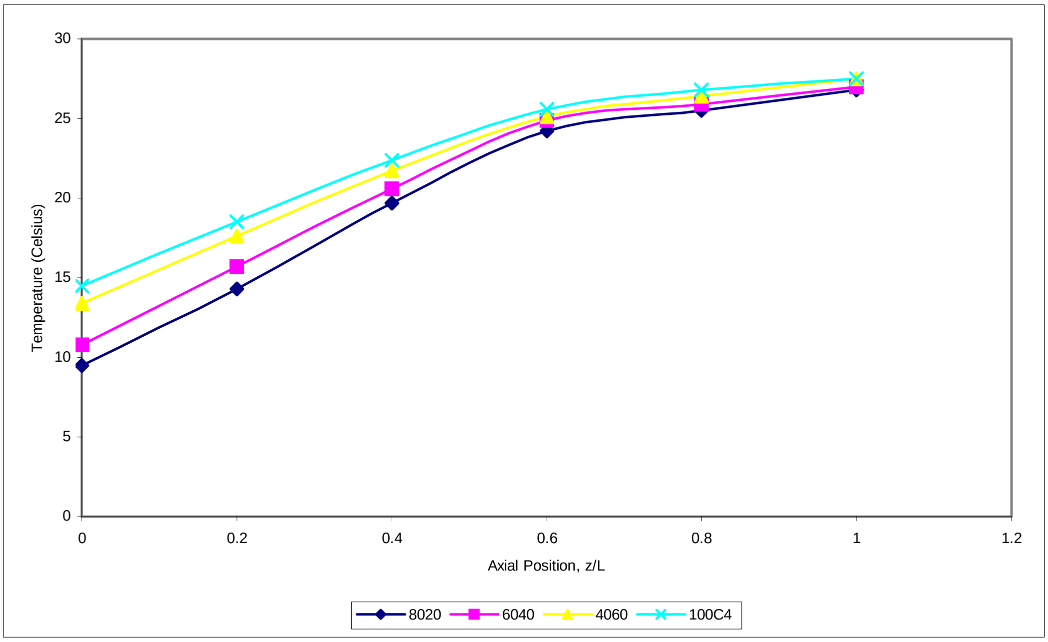
A257: Dimensionless Axial Profile of Temperature at 150 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



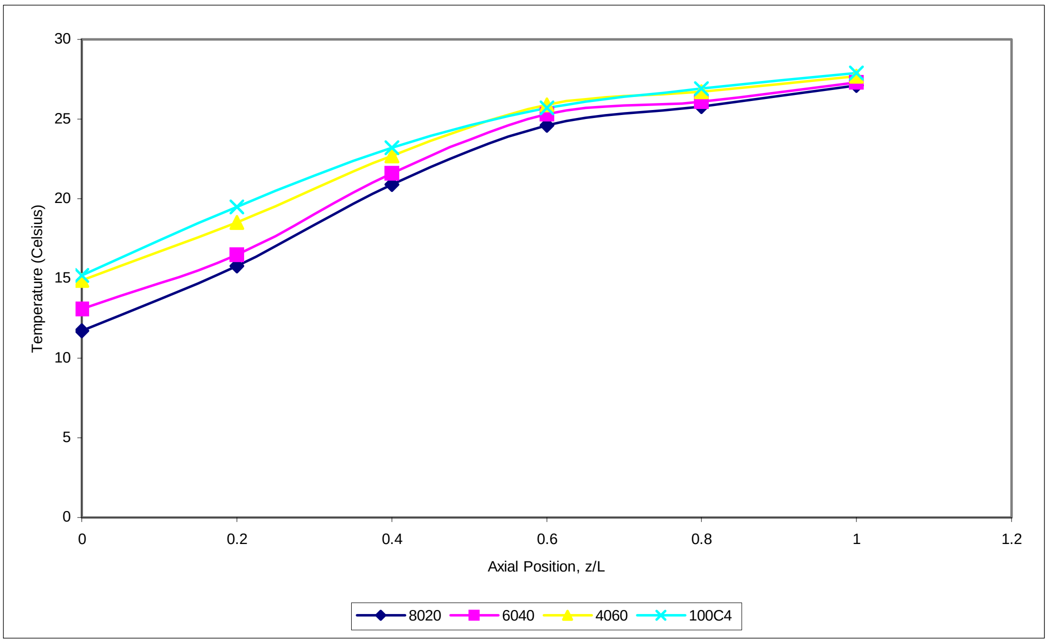
A258: Dimensionless Axial Profile of Temperature at 180 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



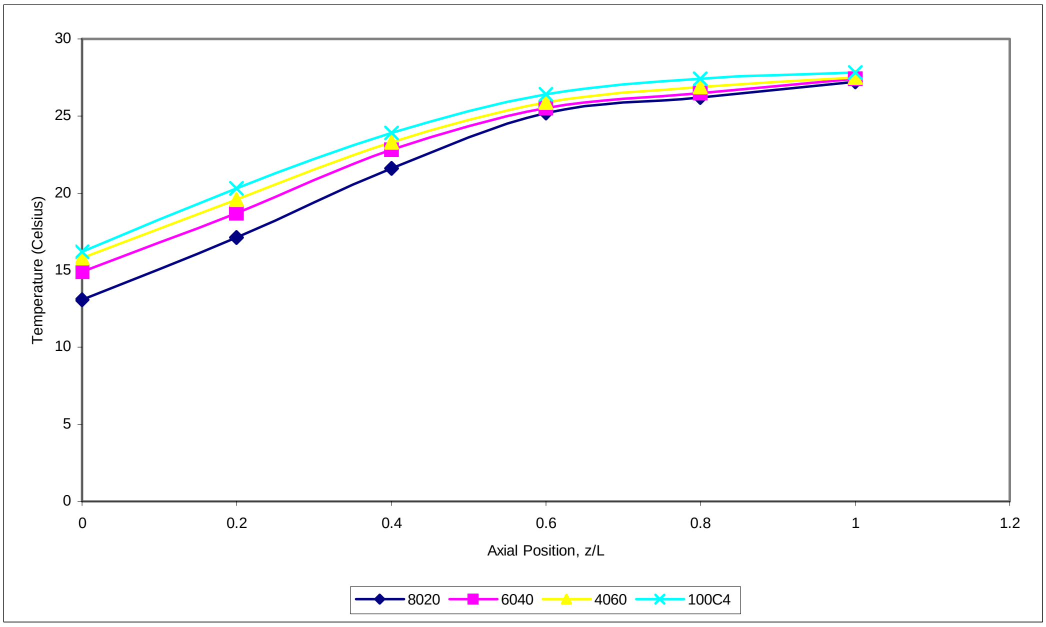
A259: Dimensionless Axial Profile of Temperature at 210 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



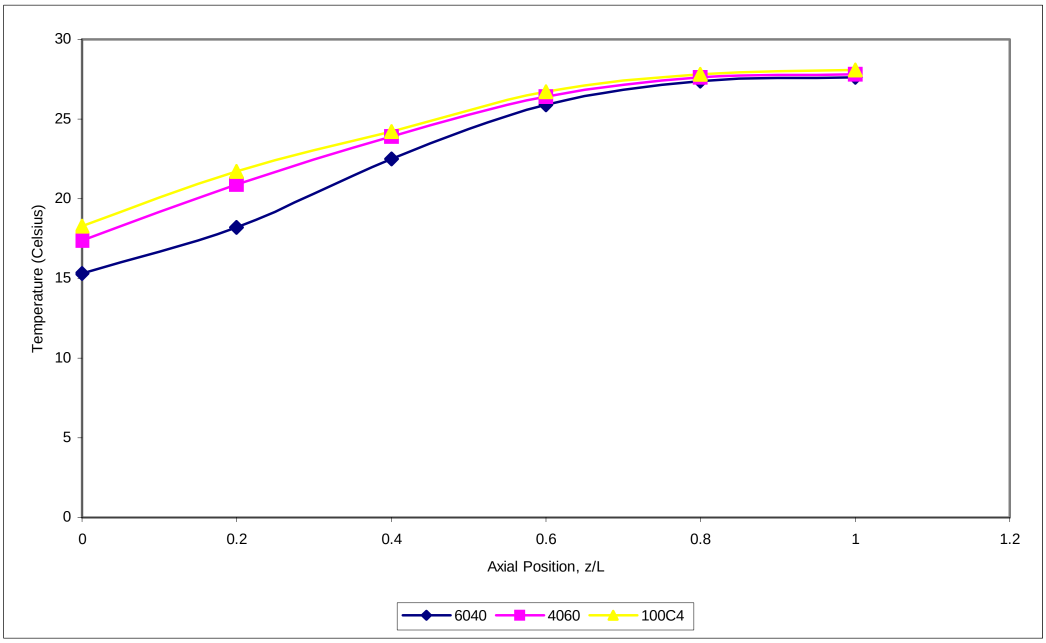
A260: Dimensionless Axial Profile of Temperature at 240 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



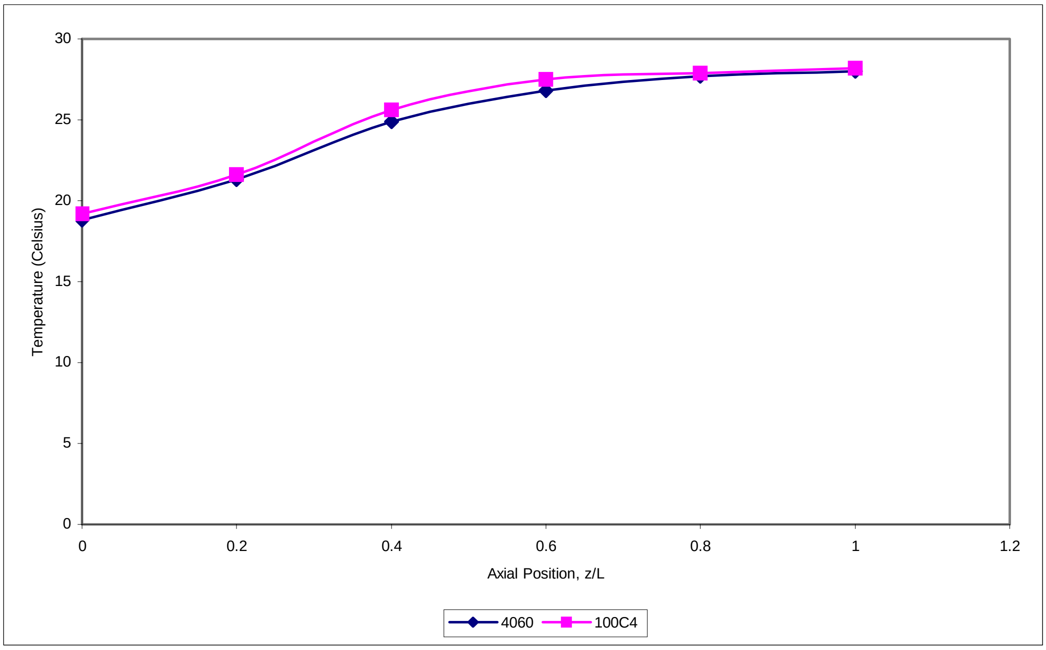
A261: Dimensionless Axial Profile of Temperature at 270 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



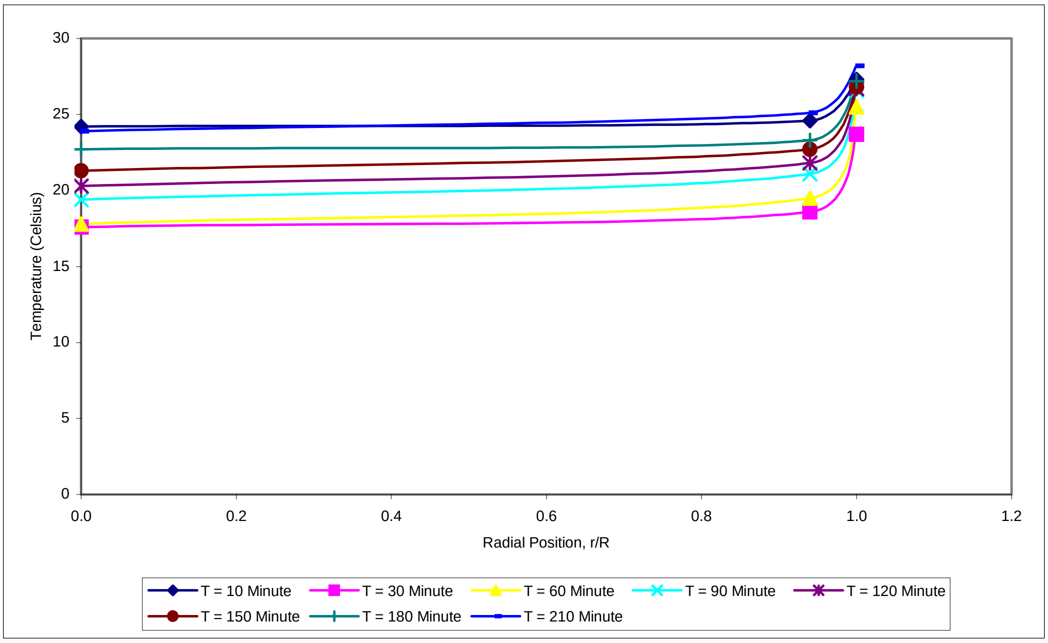
A262: Dimensionless Axial Profile of Temperature at 300 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



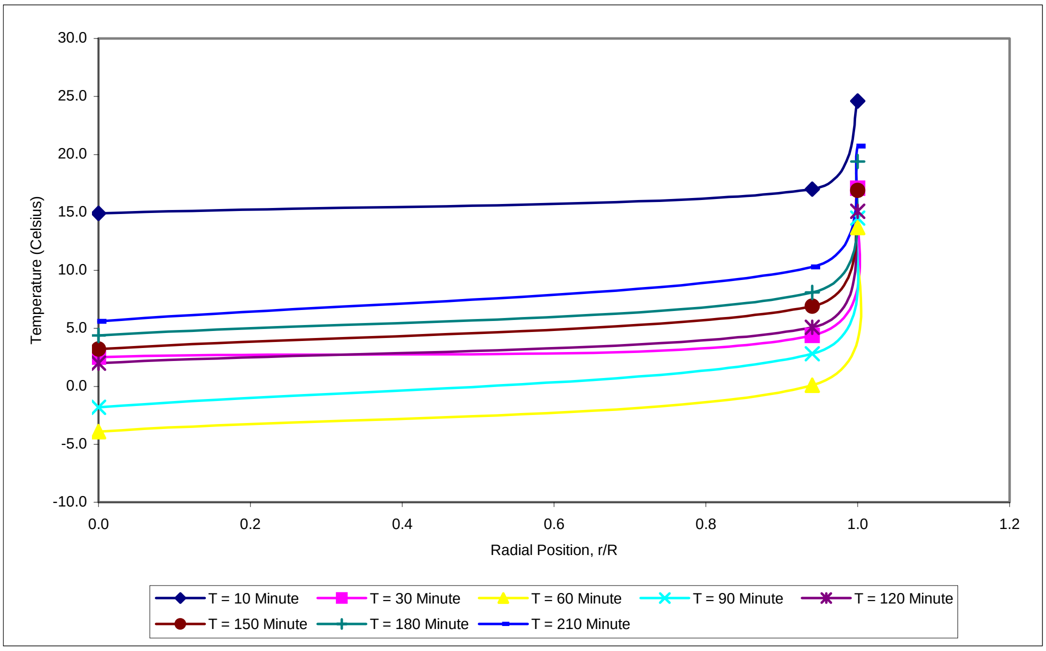
A263: Dimensionless Axial Profile of Temperature at 330 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



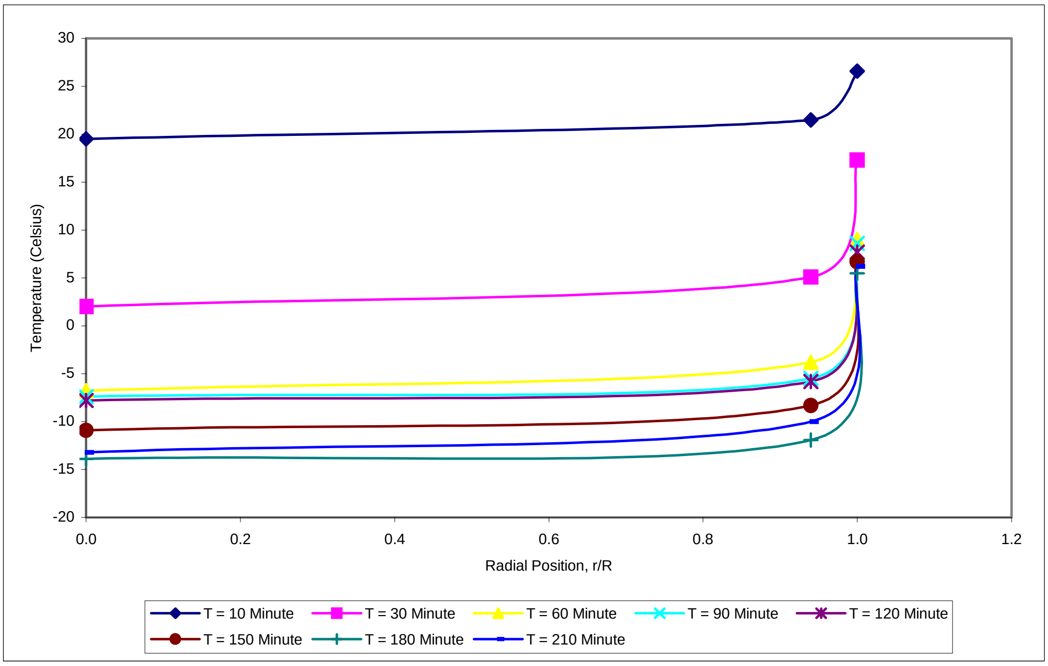
A264: Dimensionless Axial Profile of Temperature at 360 Minute at External Wall of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



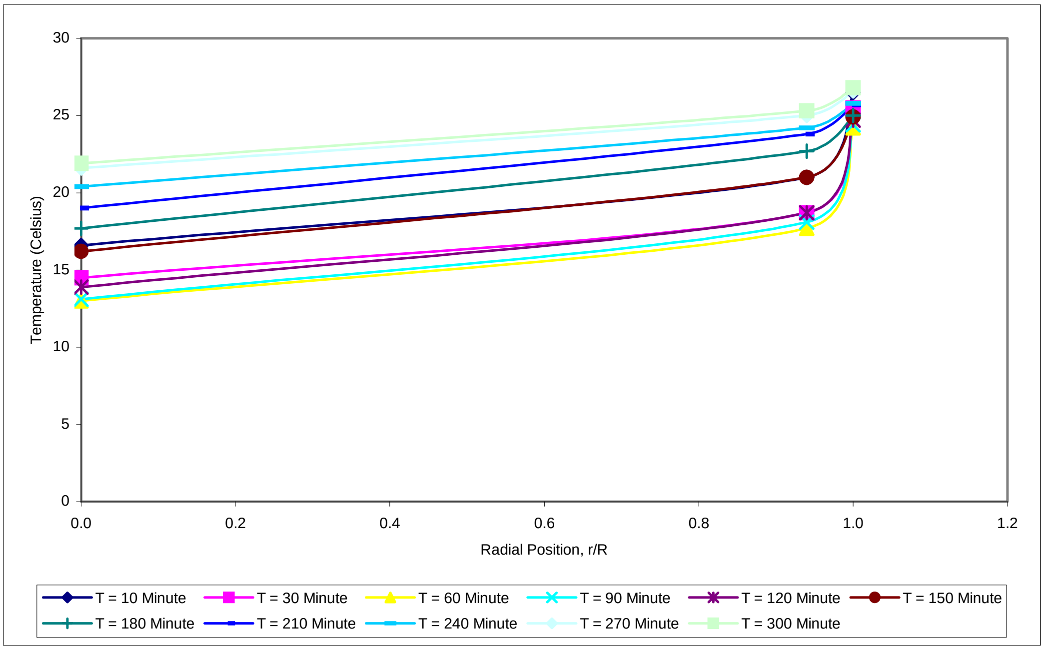
A265: Dimensionless Radial Profile of Temperature at Level 1 of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



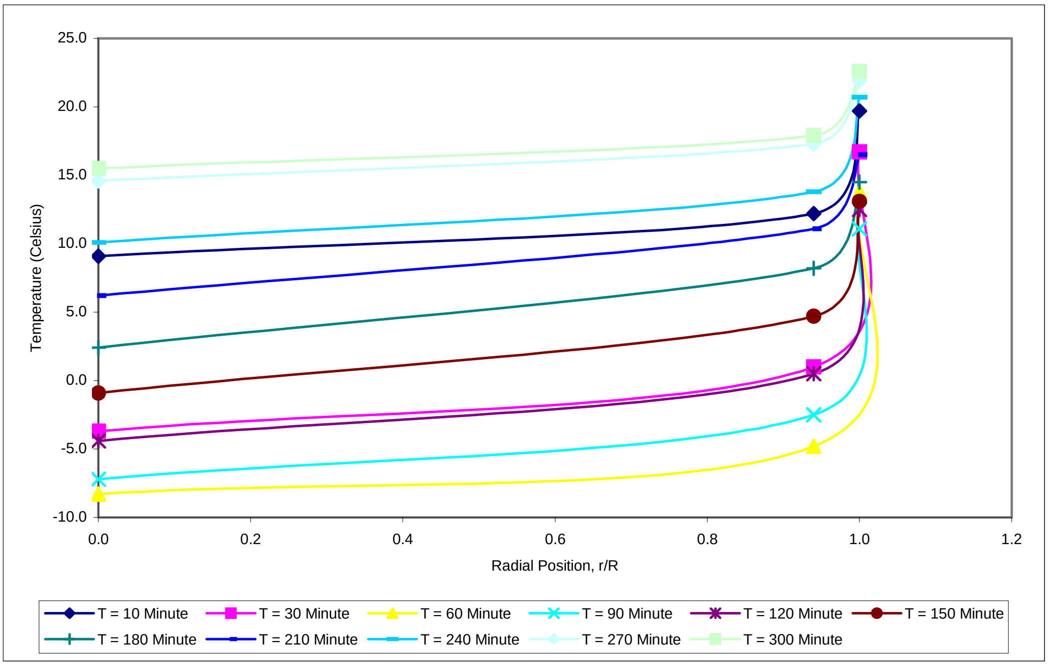
A266: Dimensionless Radial Profile of Temperature at Level 4 of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



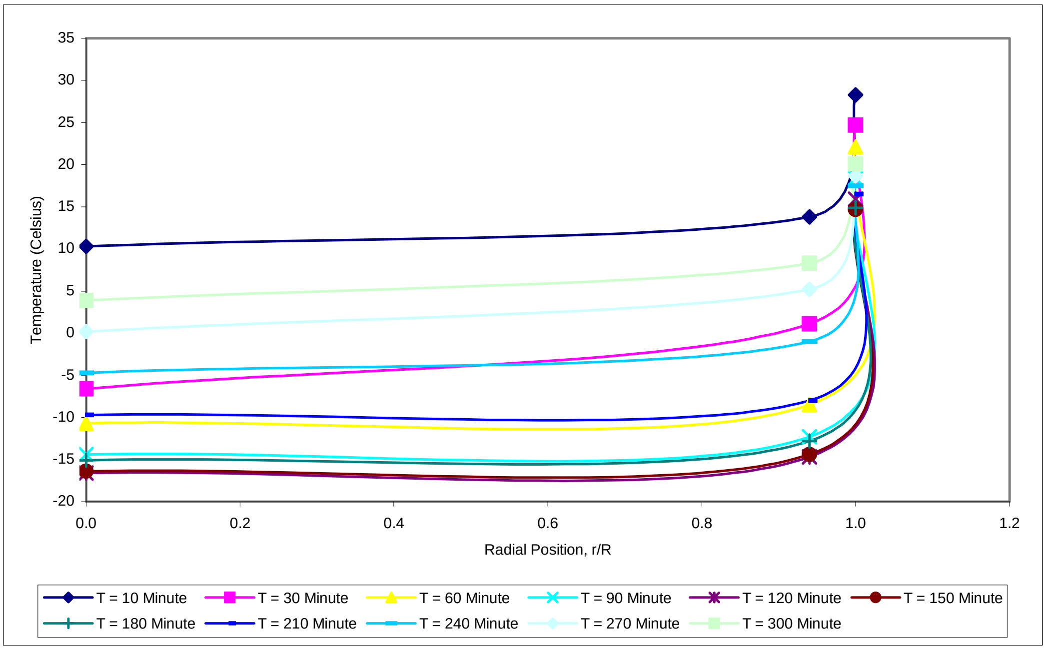
A267: Dimensionless Radial Profile of Temperature at Level 6 of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



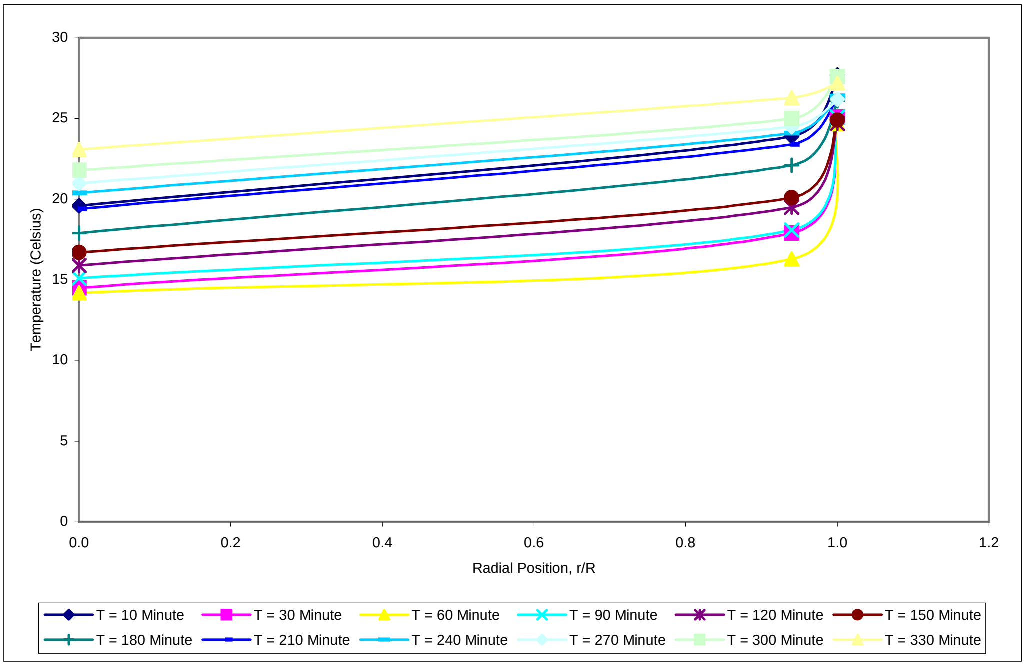
A268: Dimensionless Radial Profile of Temperature at Level 1 of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



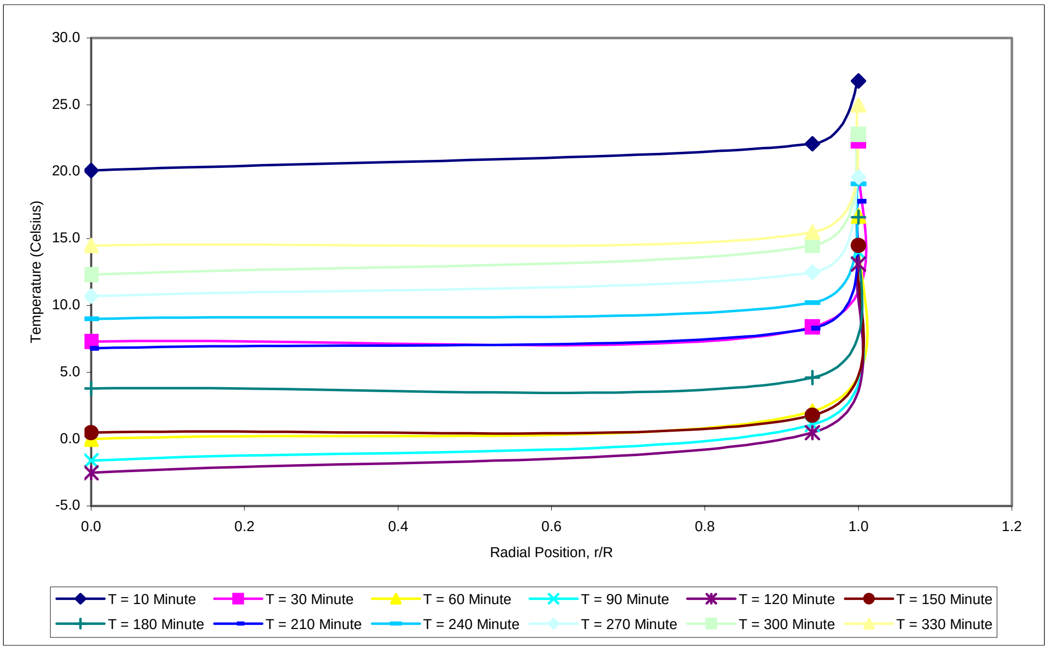
A269: Dimensionless Radial Profile of Temperature at Level 4 of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



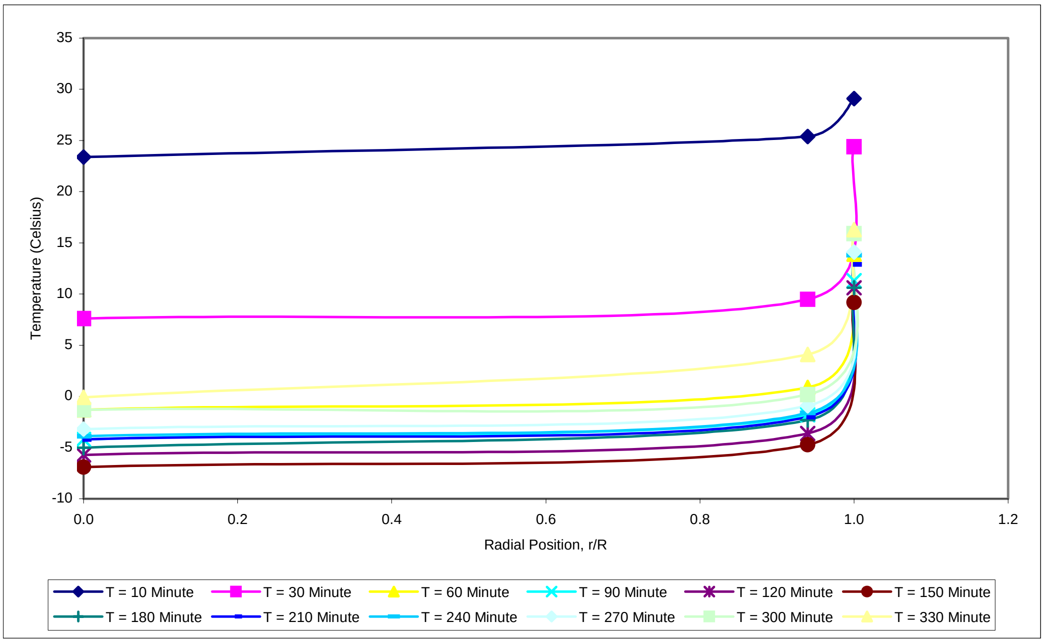
A270: Dimensionless Radial Profile of Temperature at Level 6 of Composition of 8020 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



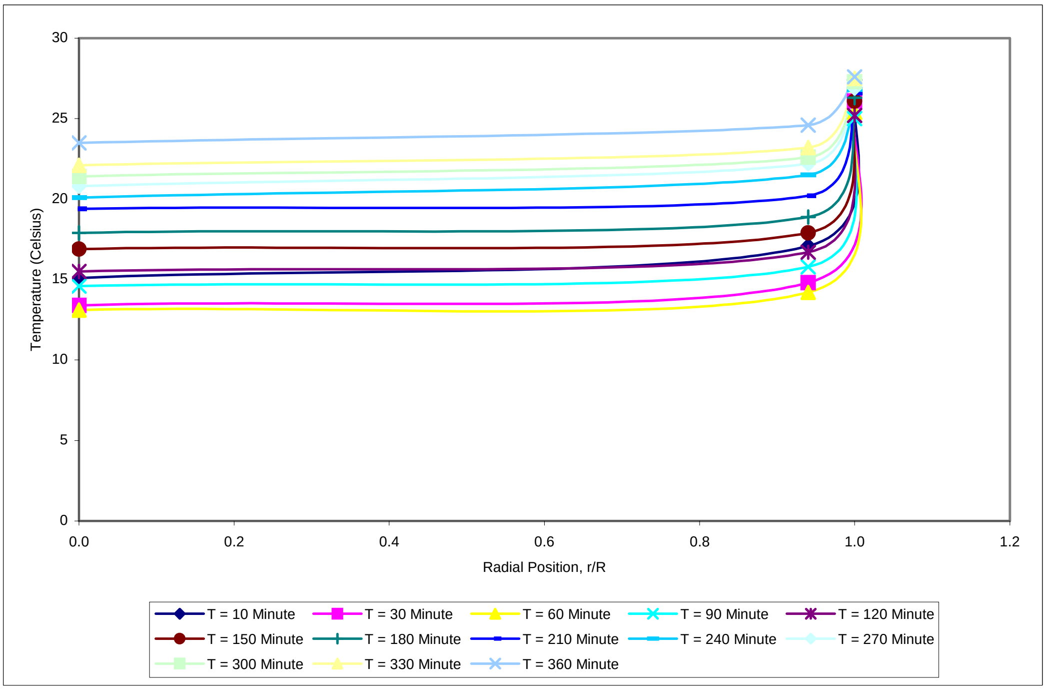
A271: Dimensionless Radial Profile of Temperature at Center Level 1 of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



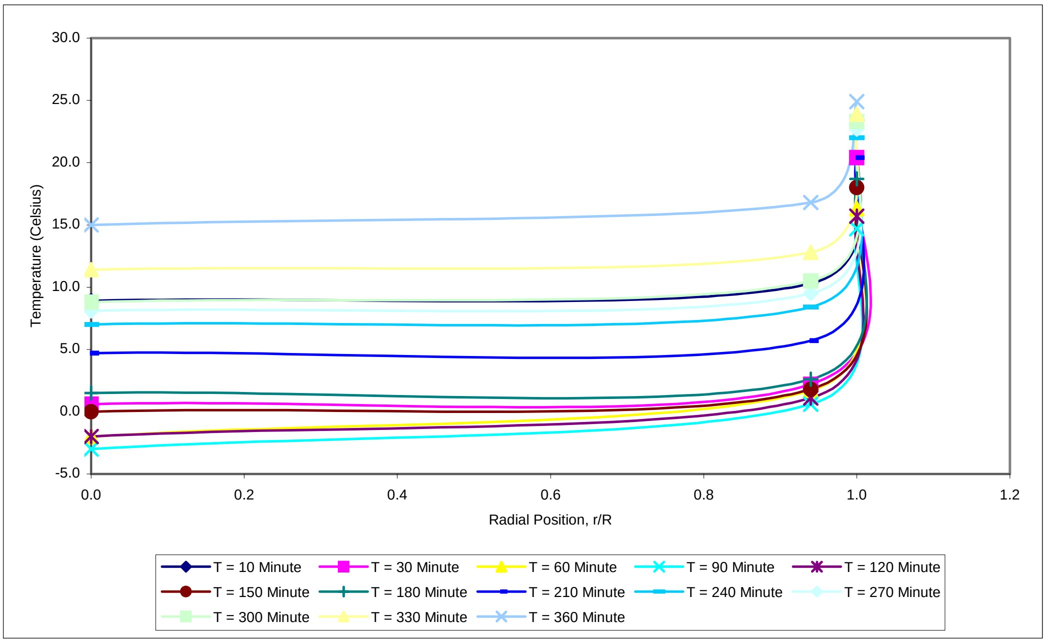
A272: Dimensionless Radial Profile of Temperature at Level 4 of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



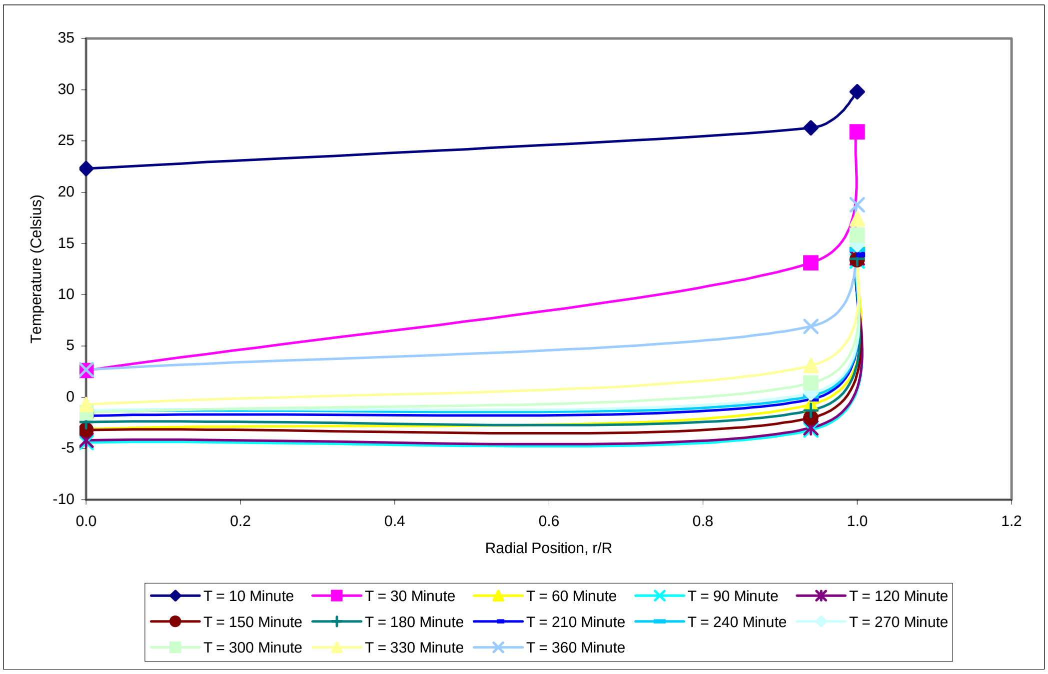
A273: Dimensionless Radial Profile of Temperature at Level 6 of Composition of 6040 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



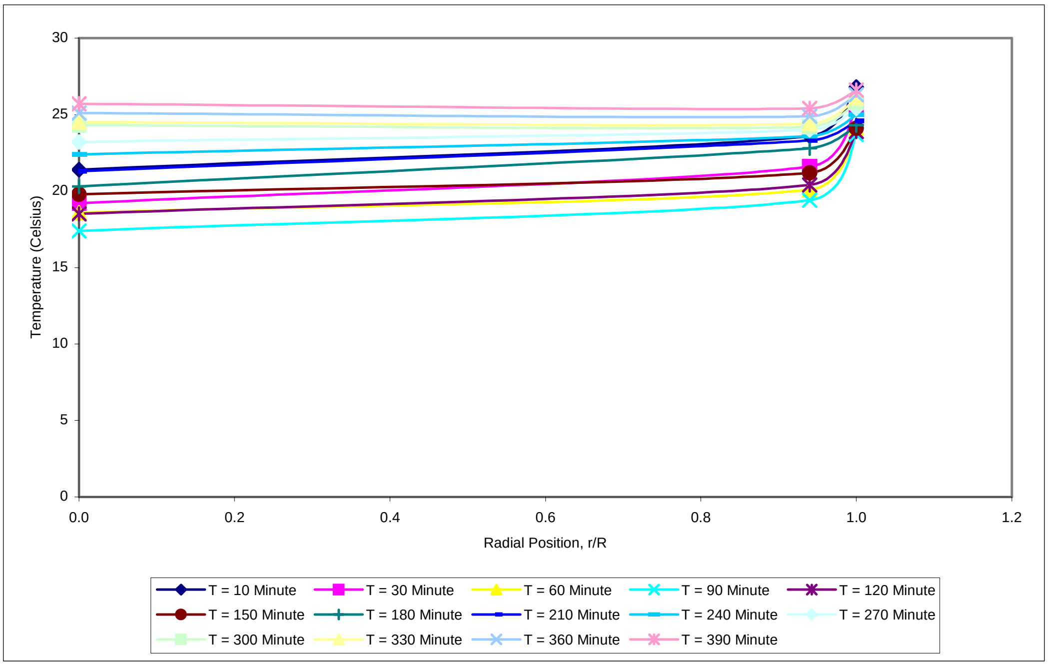
A274: Dimensionless Radial Profile of Temperature at Level 1 of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



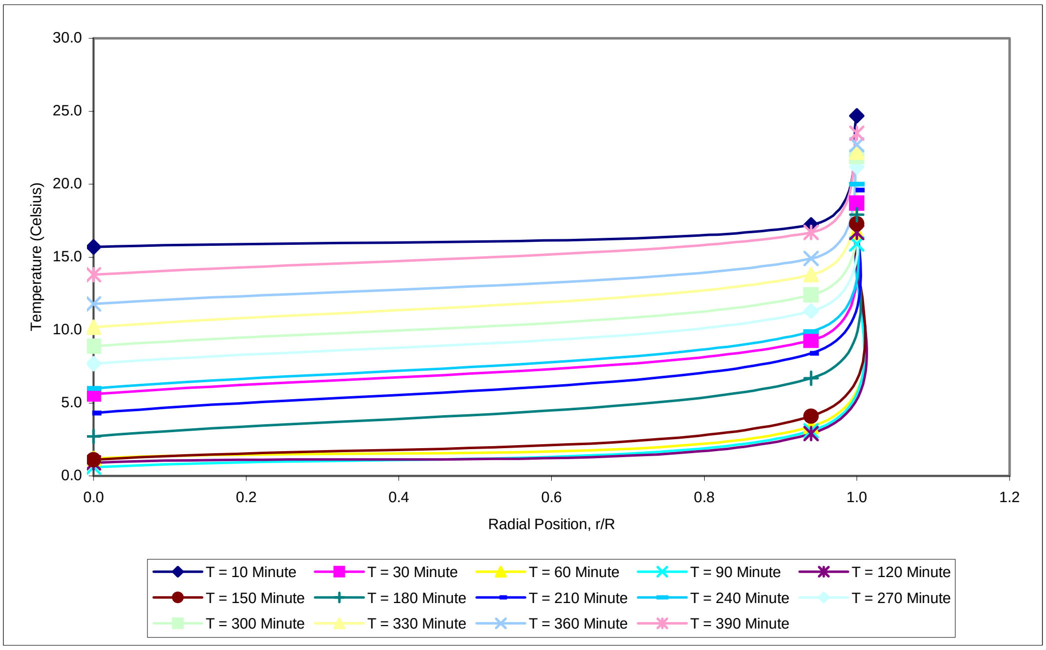
A275: Dimensionless Radial Profile of Temperature at Level 4 of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



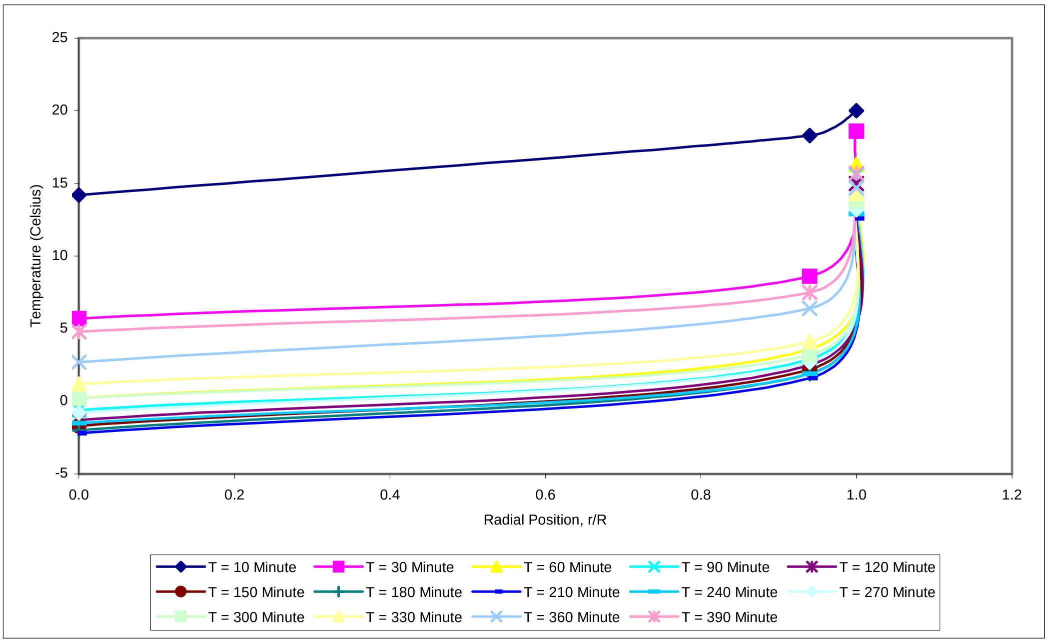
A276: Dimensionless Radial Profile of Temperature at Level 6 of Composition of 4060 at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



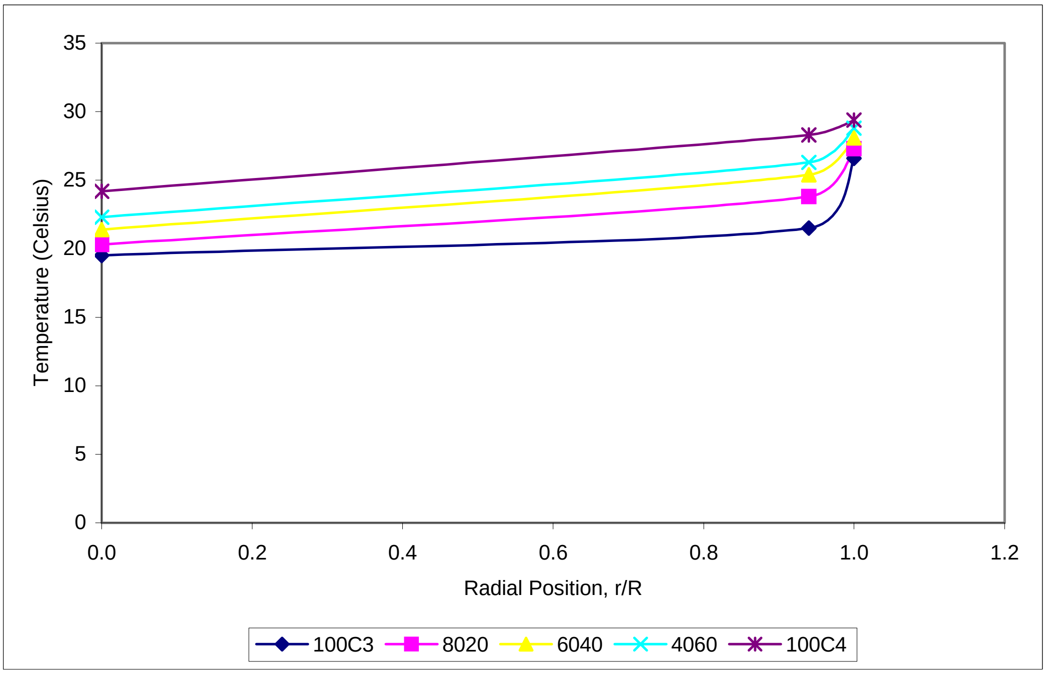
A277: Dimensionless Radial Profile of Temperature at Level 1 of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



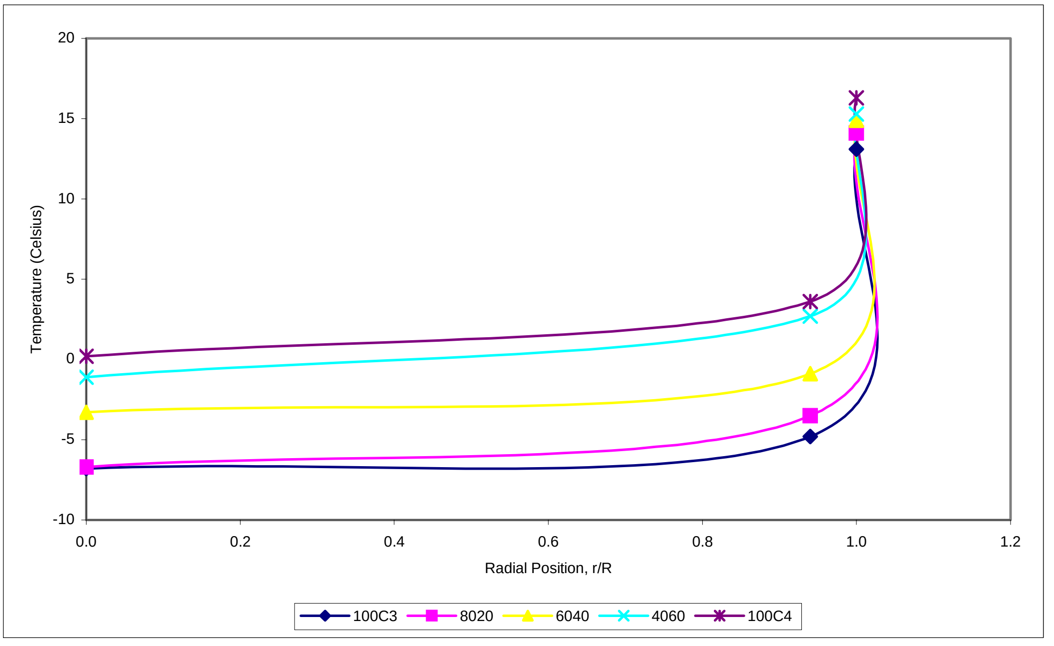
A278: Dimensionless Radial Profile of Temperature at Level 4 of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



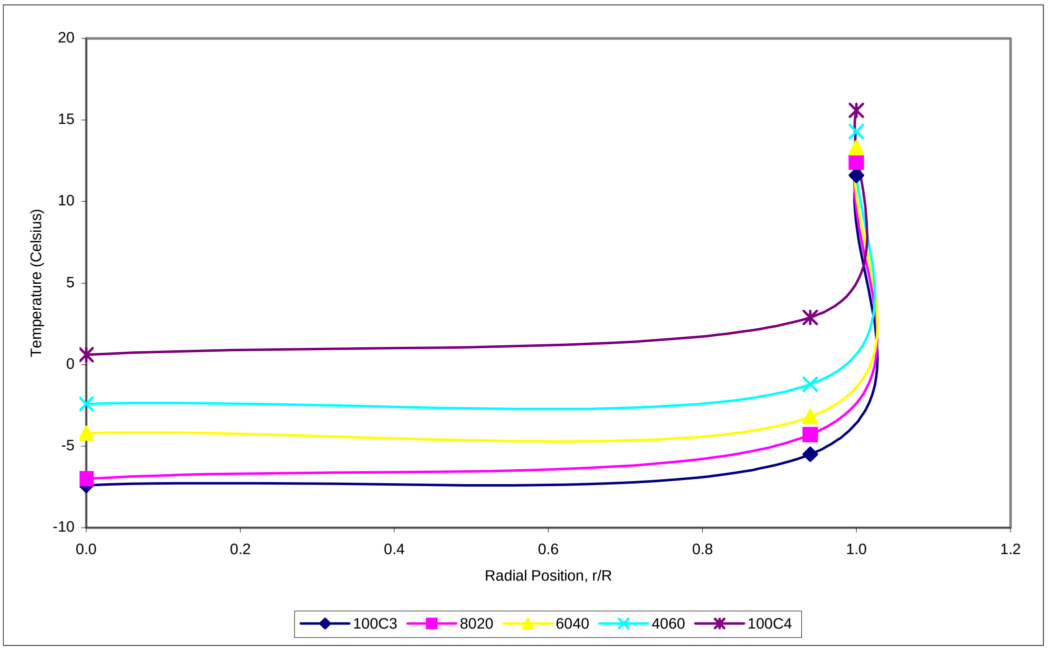
A279: Dimensionless Radial Profile of Temperature at Level 6 of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



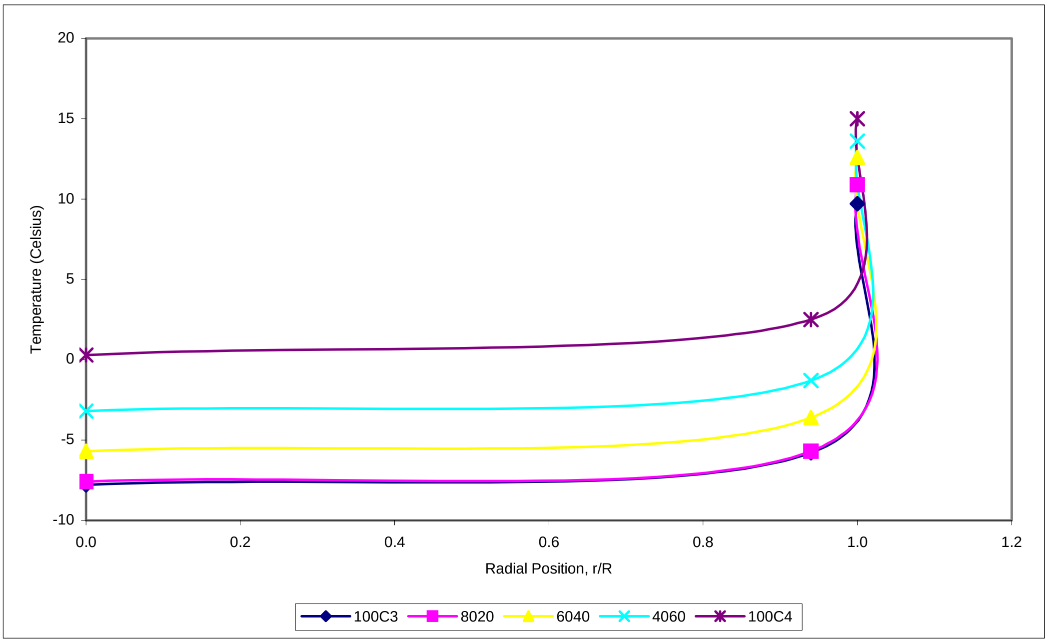
A280: Dimensionless Radial Profile of Temperature at Level 6 at 10 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



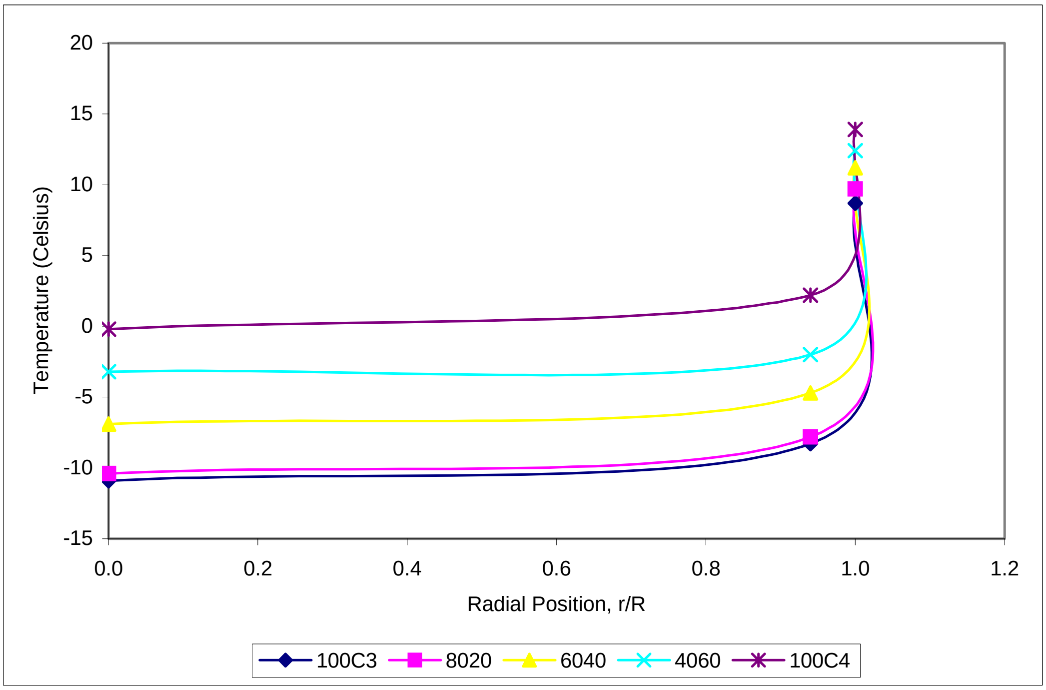
A281: Dimensionless Radial Profile of Temperature at Level 6 at 60 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



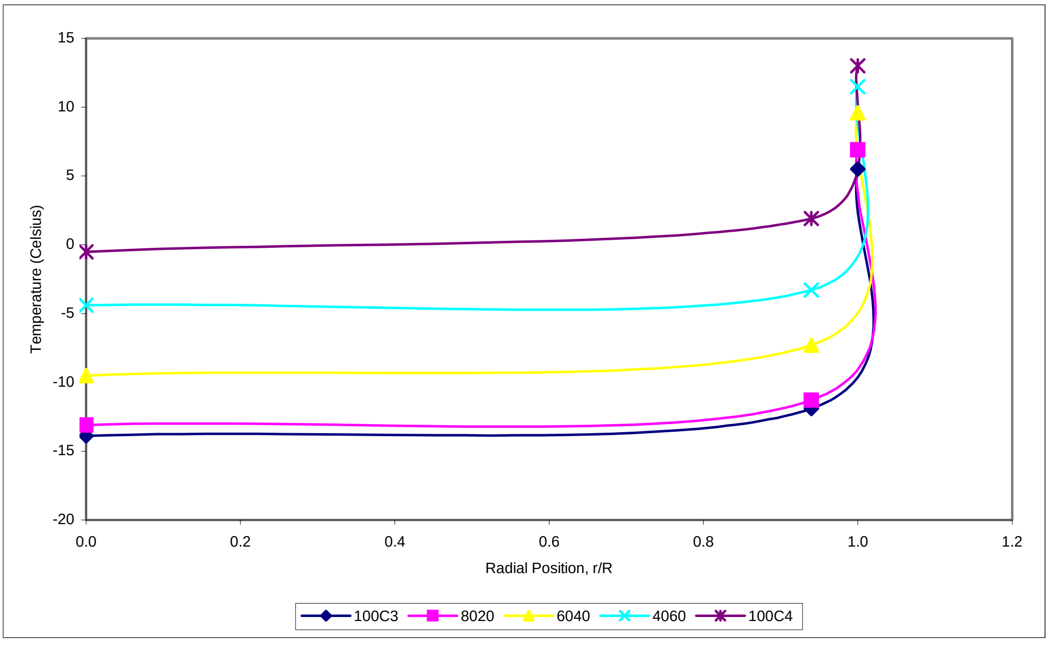
A282: Dimensionless Radial Profile of Temperature at Level 6 at 90 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



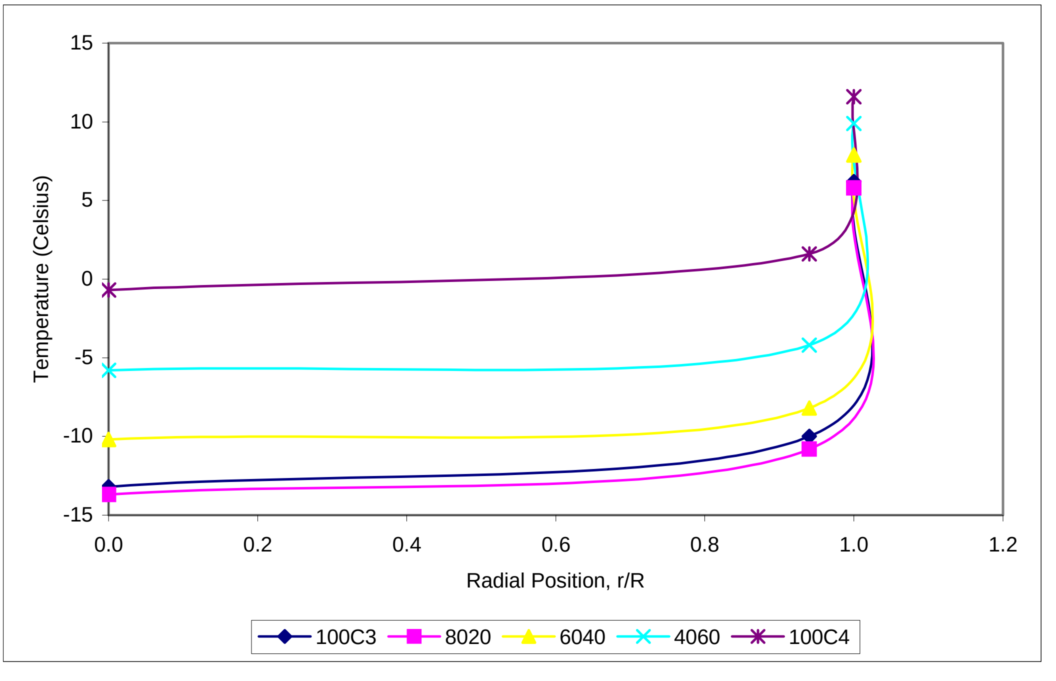
A283: Dimensionless Radial Profile of Temperature at Level 6 at 120 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



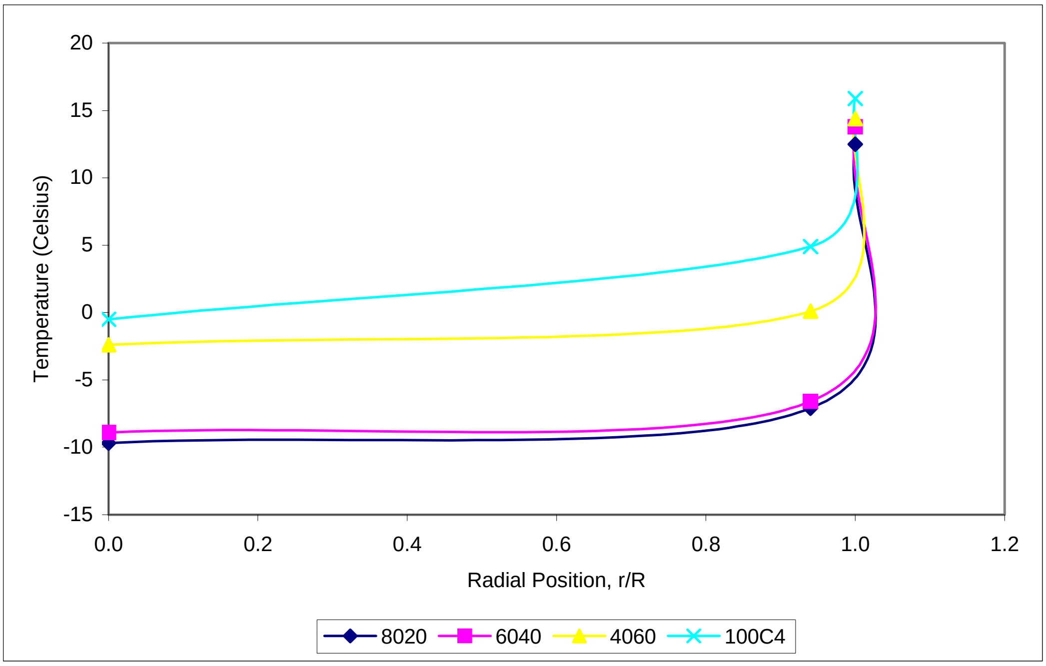
A284: Dimensionless Radial Profile of Temperature at Level 6 at 150 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



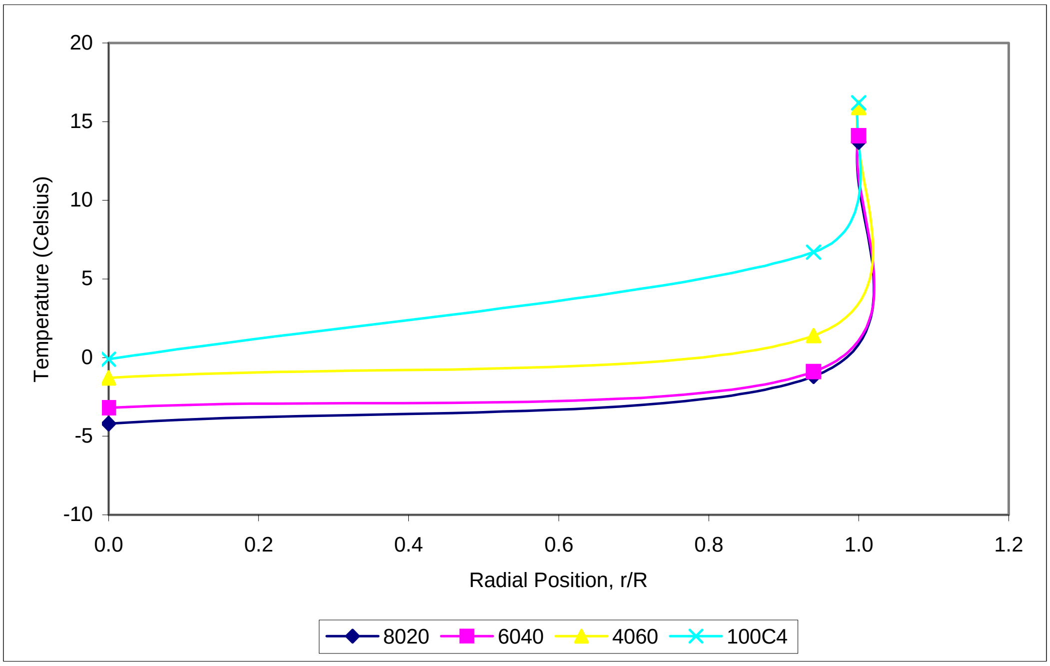
A285: Dimensionless Radial Profile of Temperature at Level 6 at 180 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



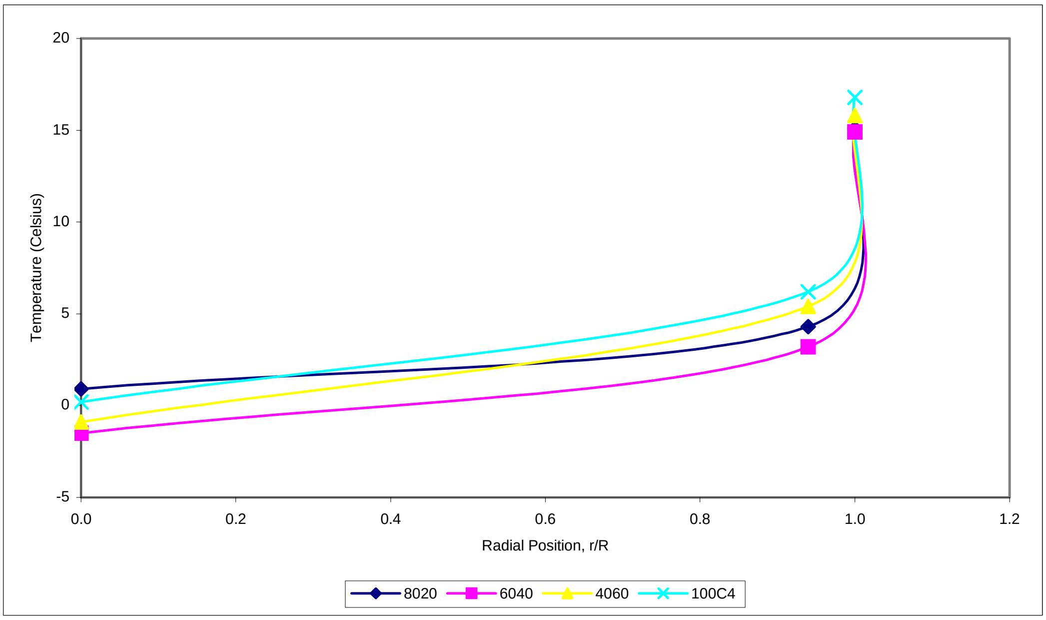
A286: Dimensionless Radial Profile of Temperature at Level 6 at 210 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



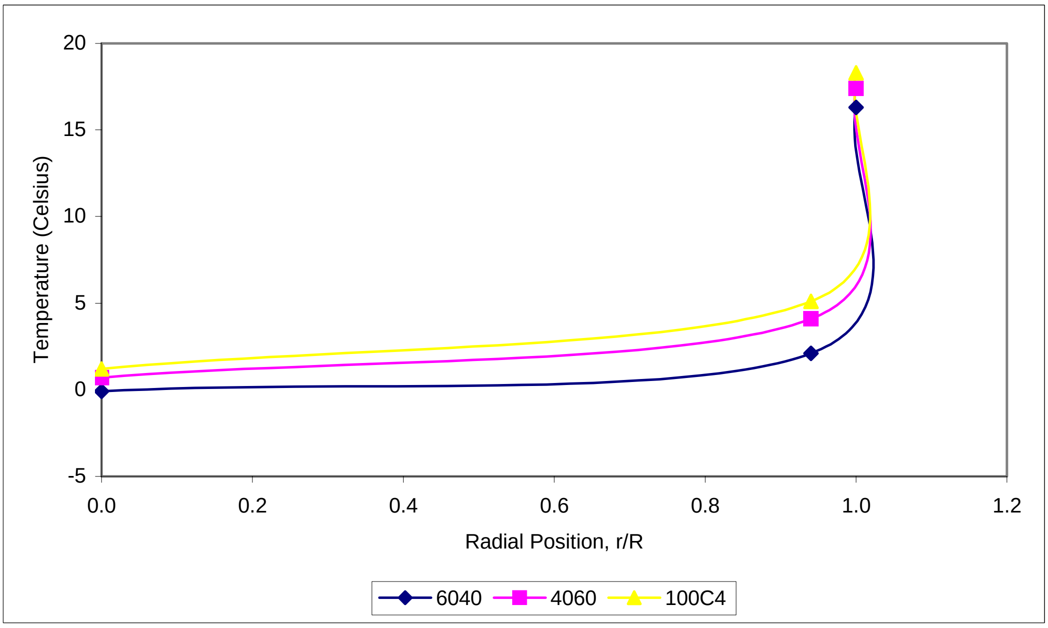
A287: Dimensionless Radial Profile of Temperature at Level 6 at 240 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



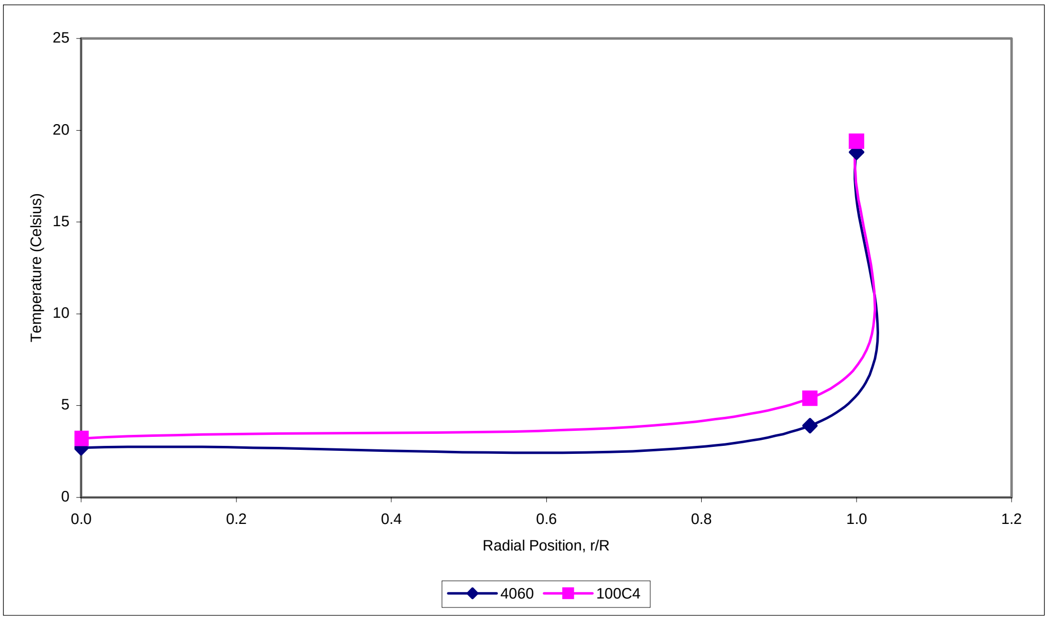
A288: Dimensionless Radial Profile of Temperature at Level 6 at 270 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



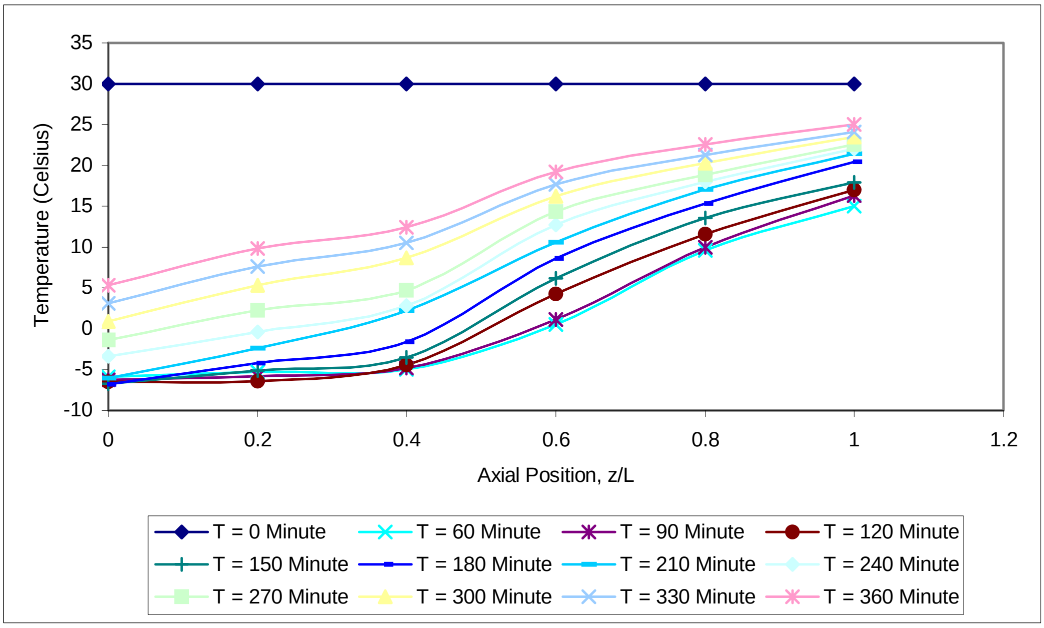
A289: Dimensionless Radial Profile of Temperature at Level 6 at 300 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



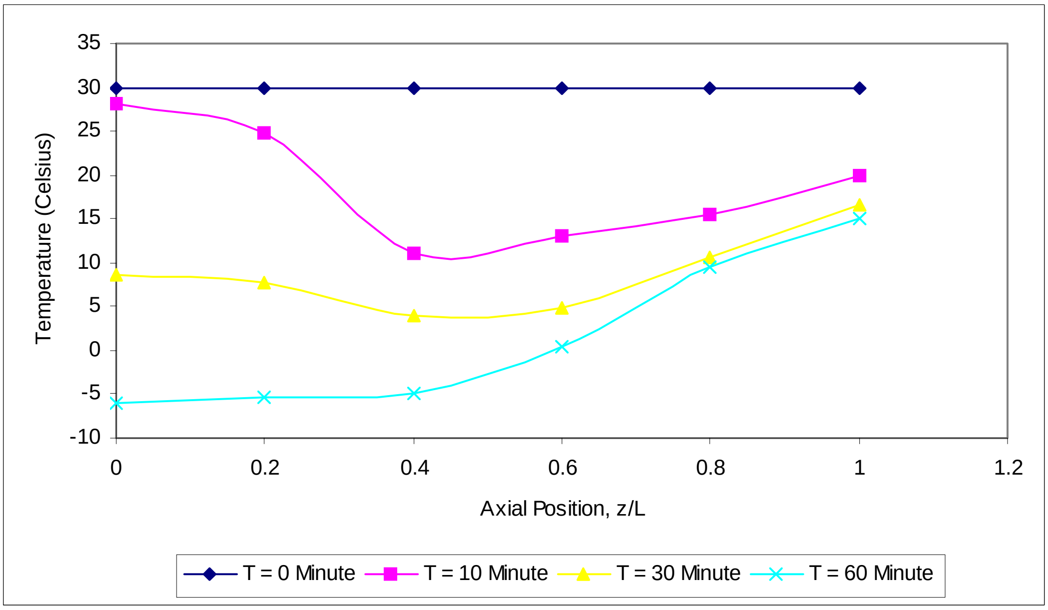
A290: Dimensionless Radial Profile of Temperature at Level 6 at 330 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg



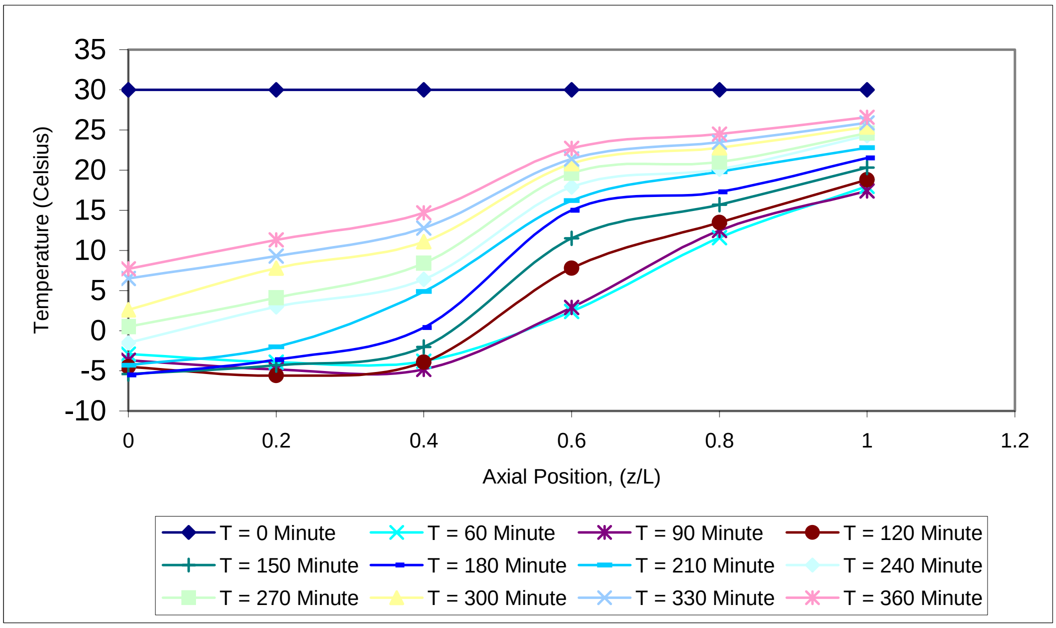
A291: Dimensionless Radial Profile of Temperature at Level 6 at 360 Minute of Various Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg



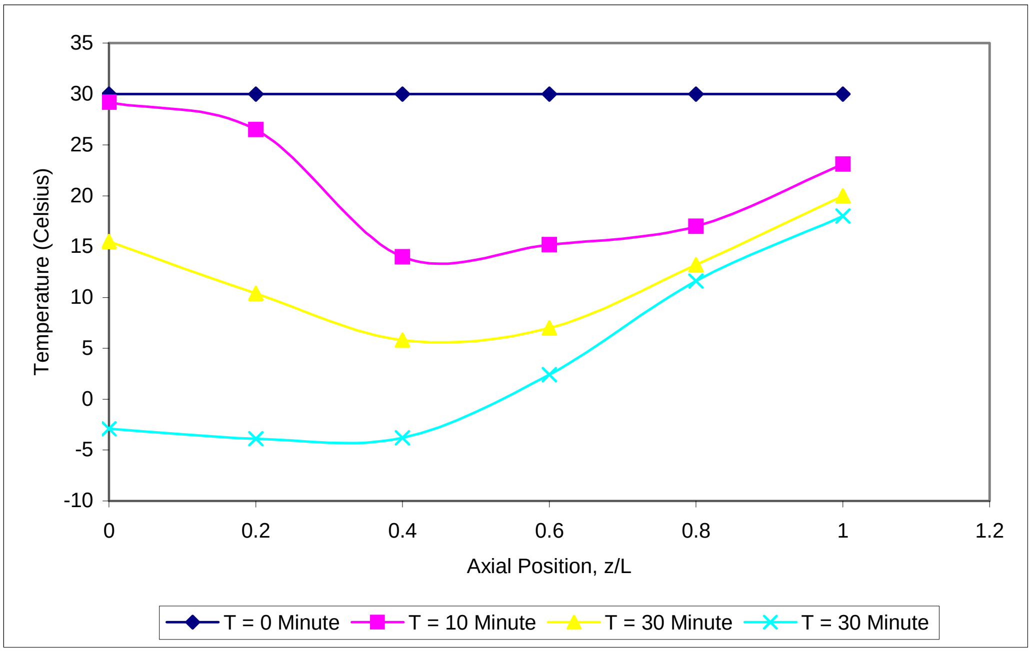
A292: Dimensionless Axial Profile of Temperature at Center of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



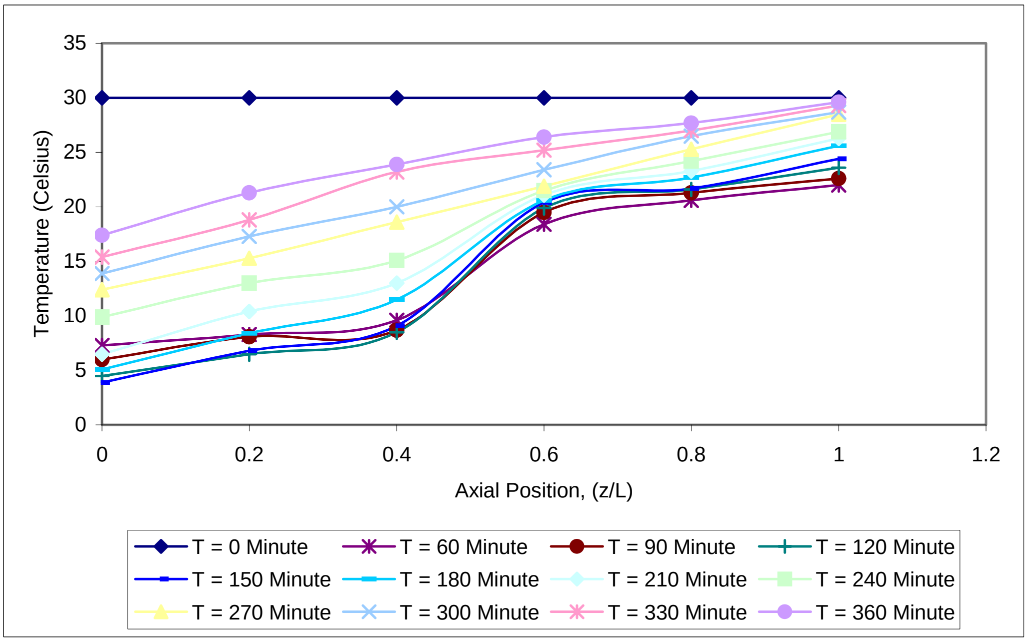
A293: Dimensionless Axial Profile of Temperature at Early Stage at Center of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



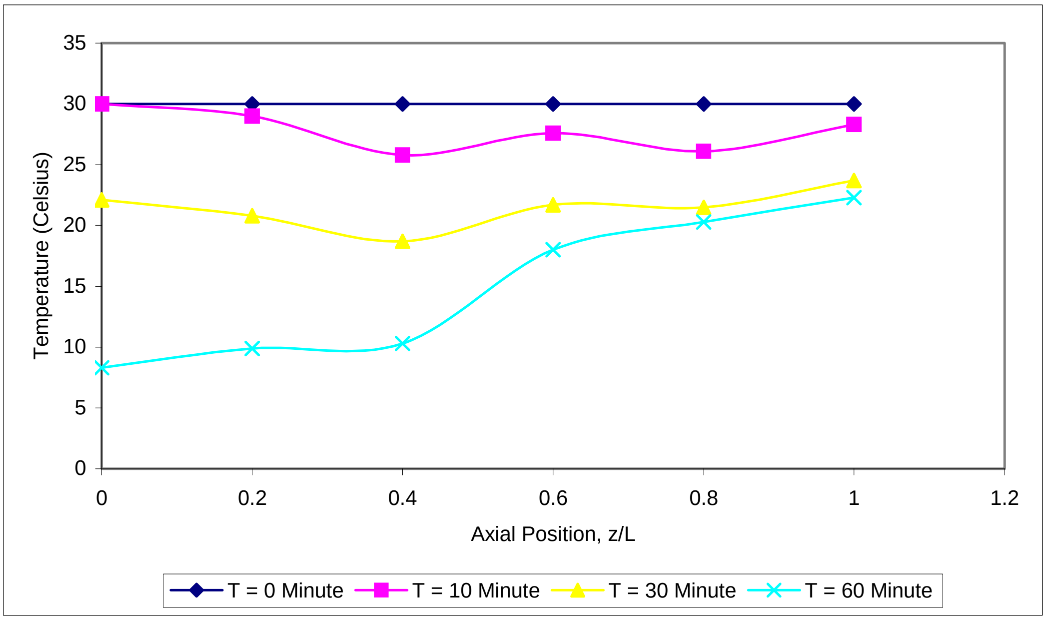
A294: Dimensionless Axial Profile of Temperature at Internal Wall of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



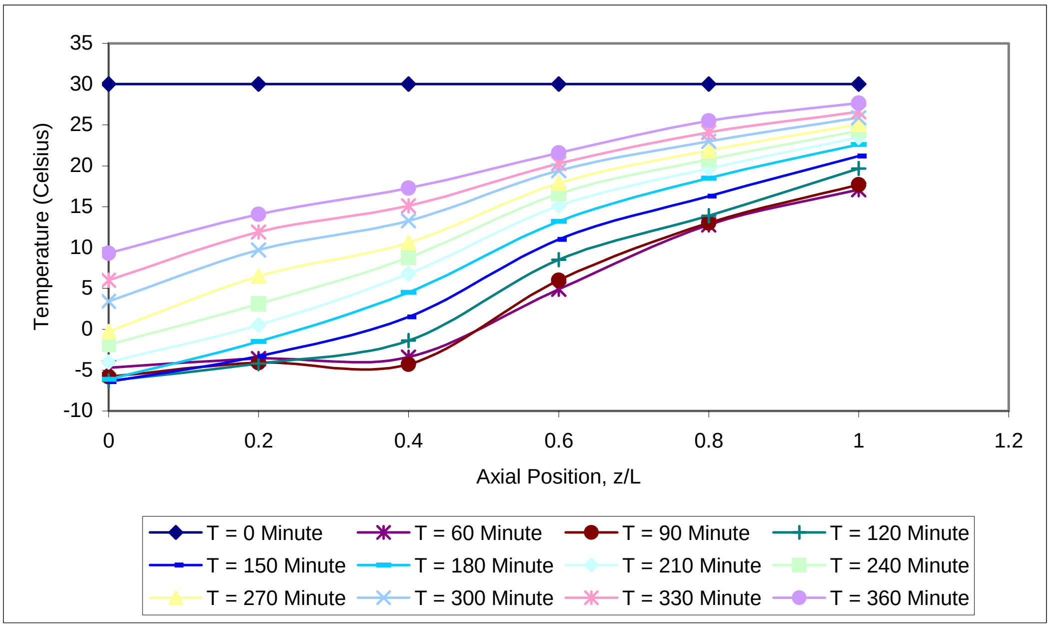
A295: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



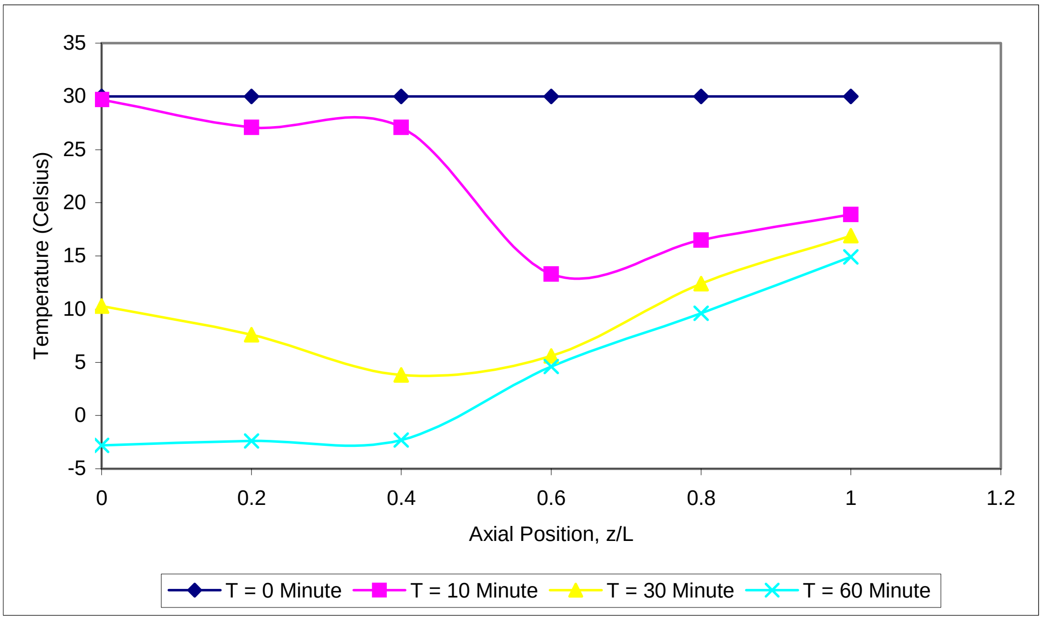
A296: Dimensionless Axial Profile of Temperature at External Wall of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



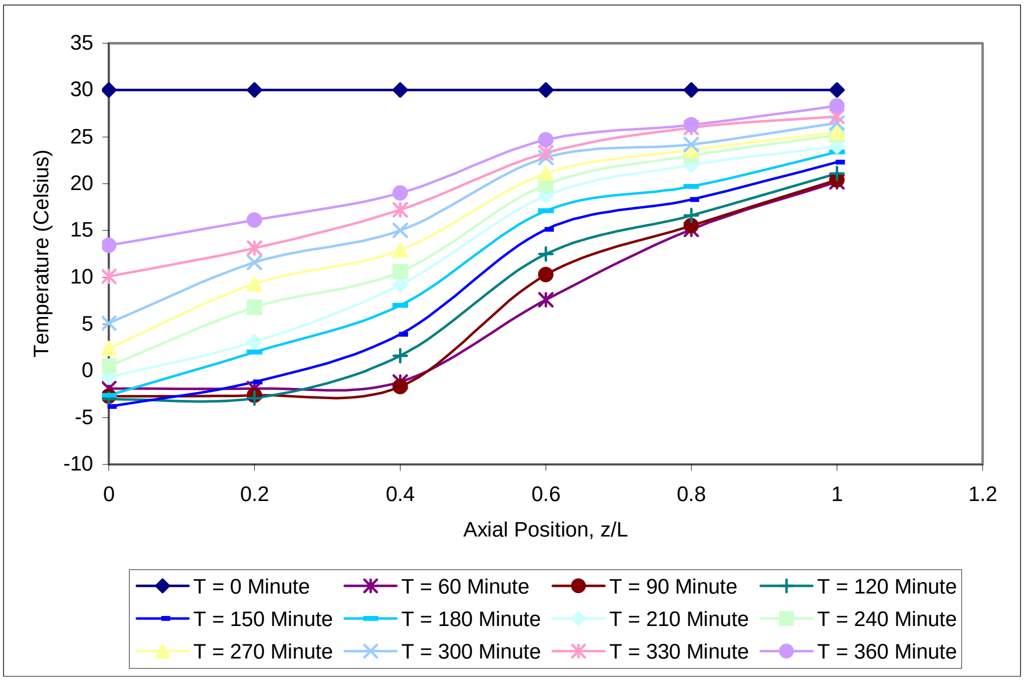
A297: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



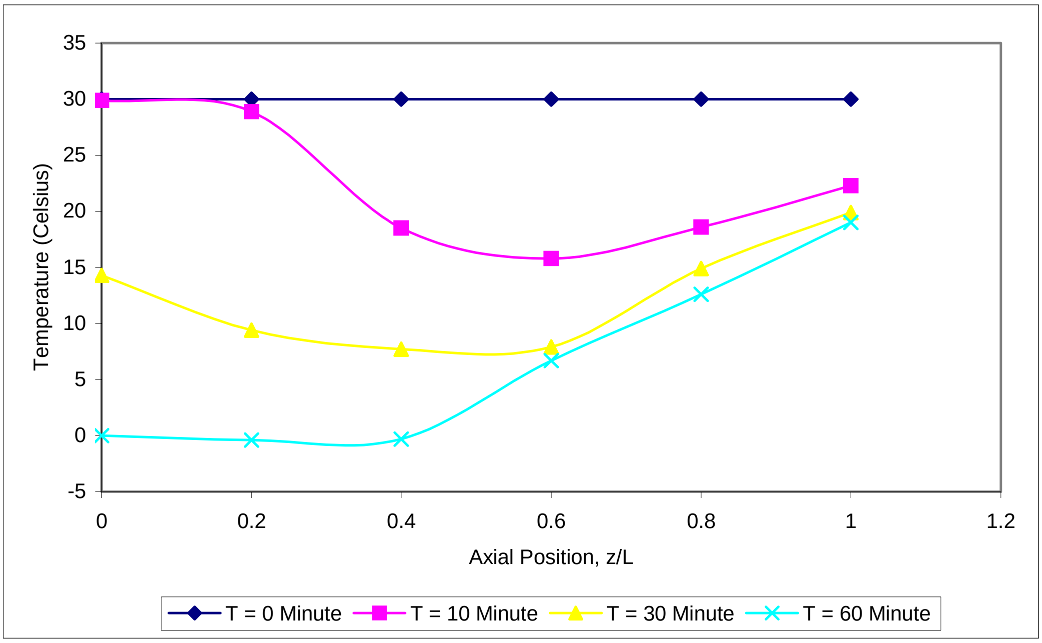
A298: Dimensionless Axial Profile of Temperature at Center of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



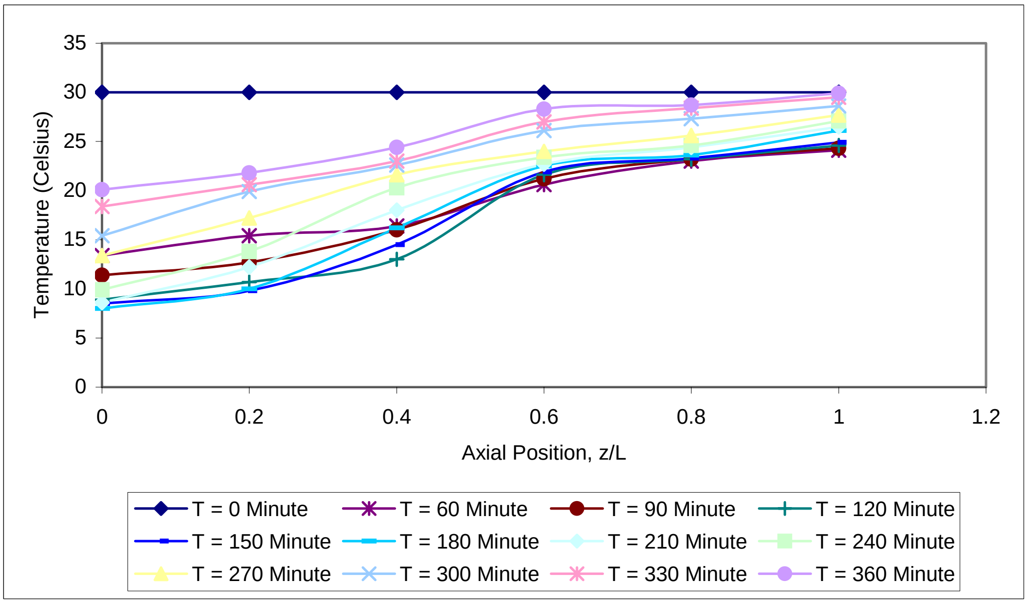
A299: Dimensionless Axial Profile of Temperature at Early Stage at Center of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



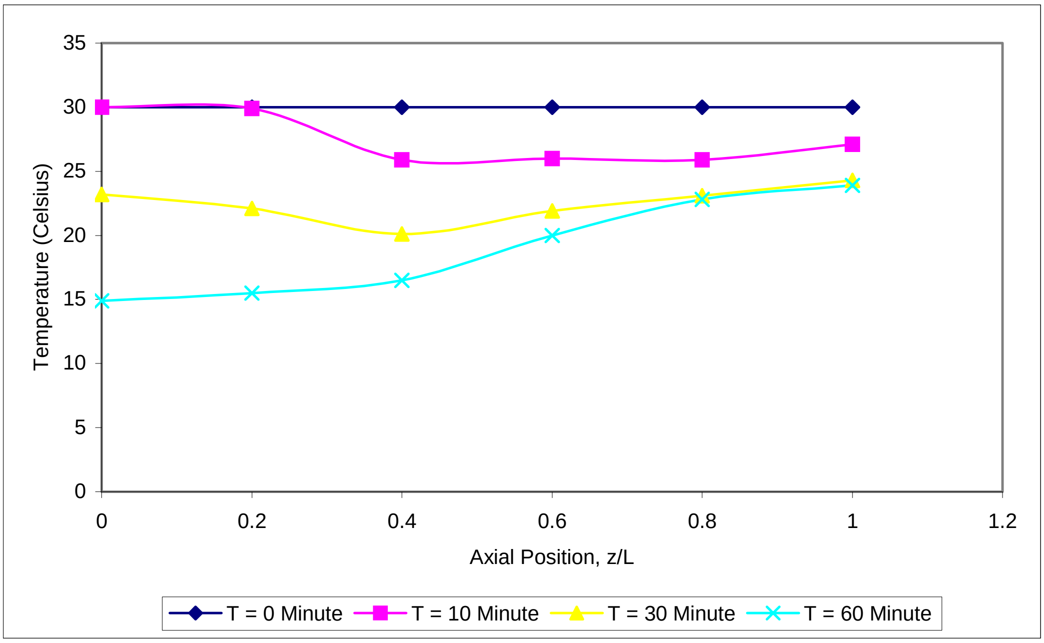
A300: Dimensionless Axial Profile of Temperature at Internal Wall of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



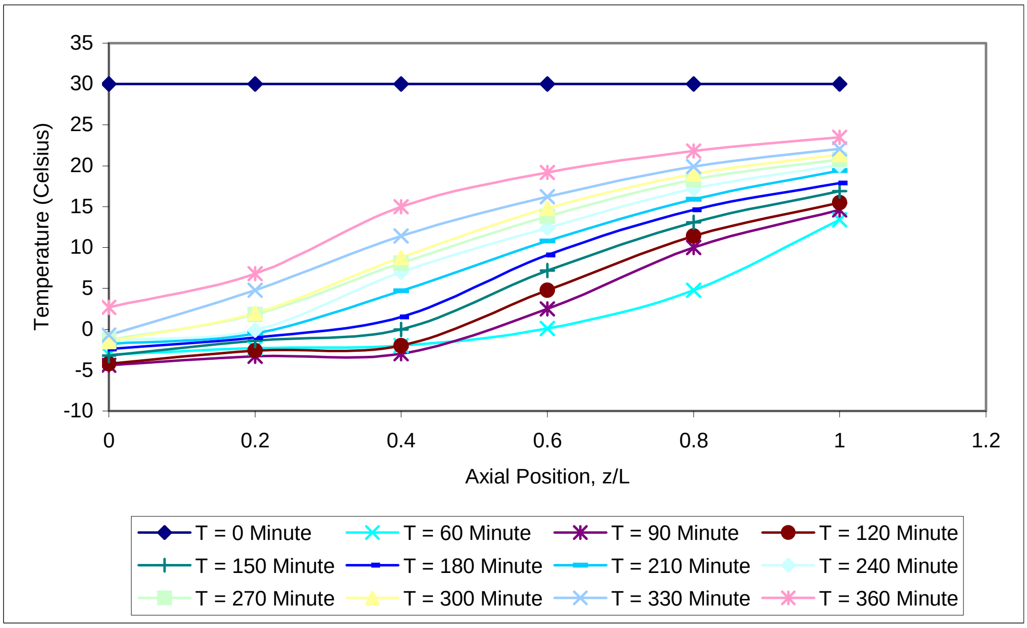
A301: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



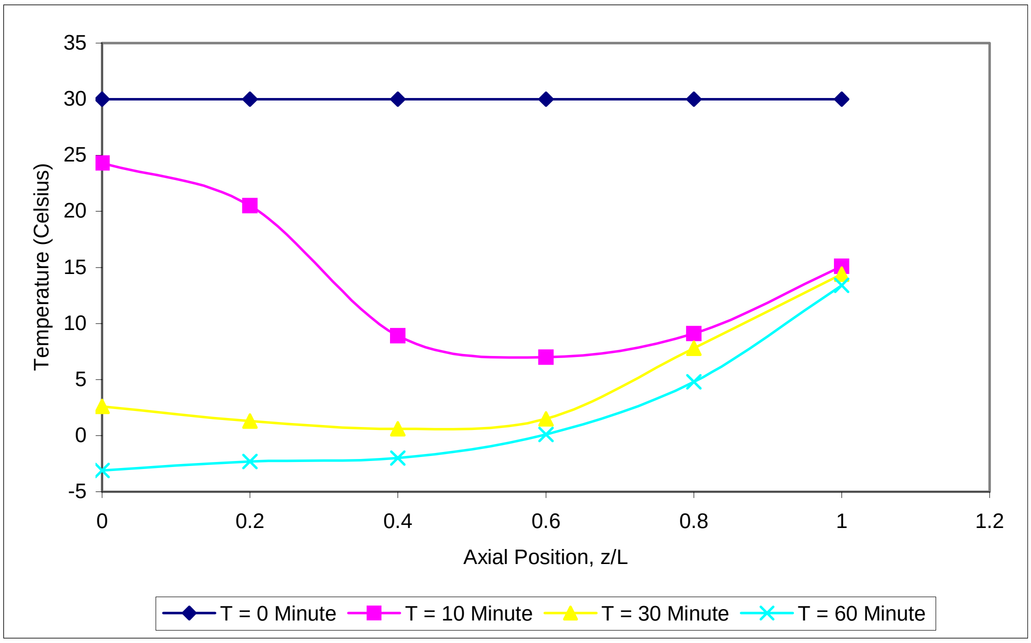
A302: Dimensionless Axial Profile of Temperature at External Wall of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



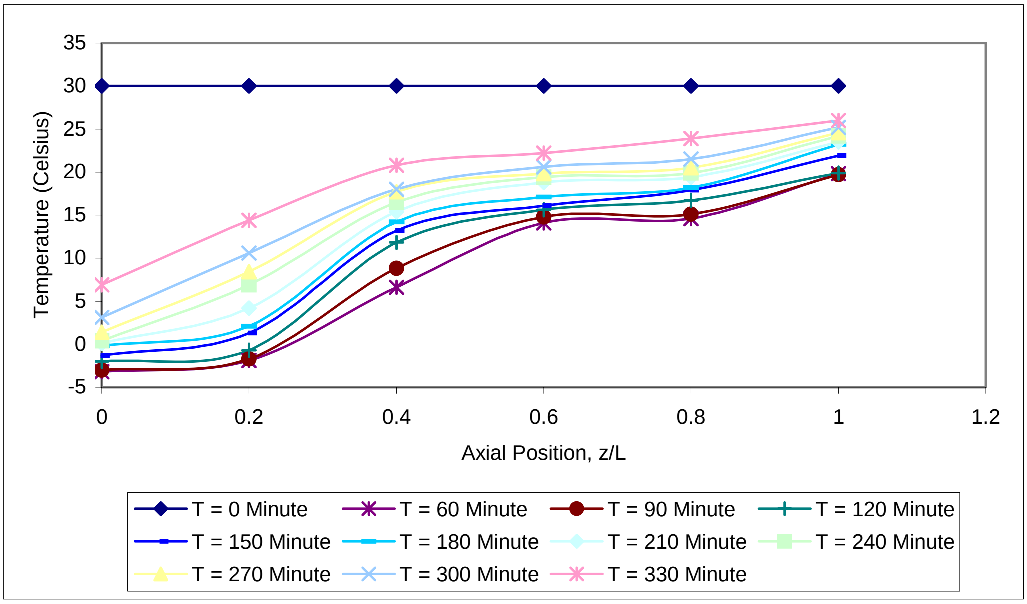
A303: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



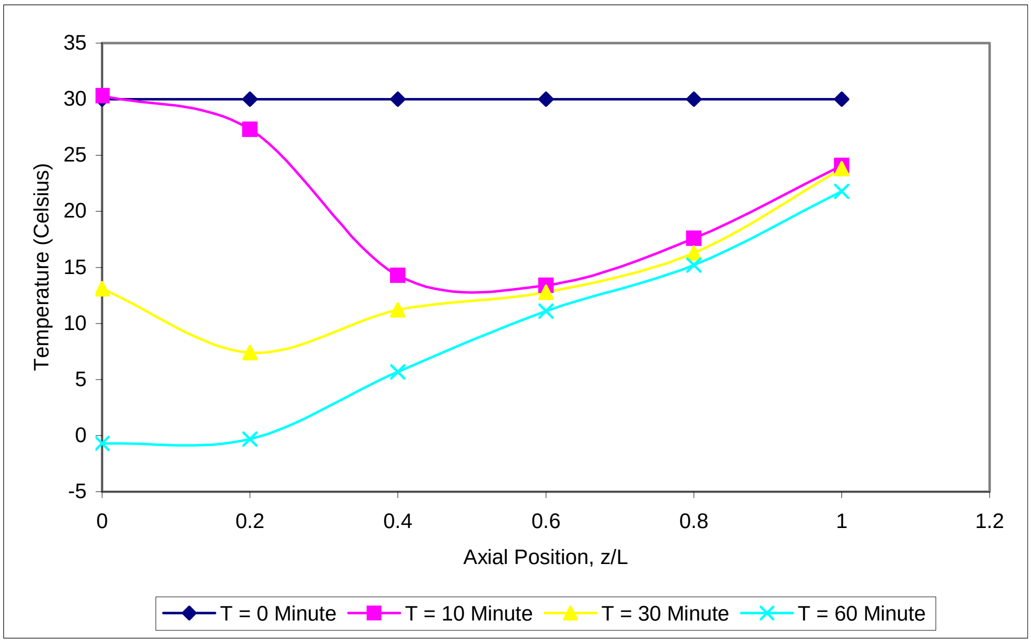
A304: Dimensionless Axial Profile of Temperature at Center of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



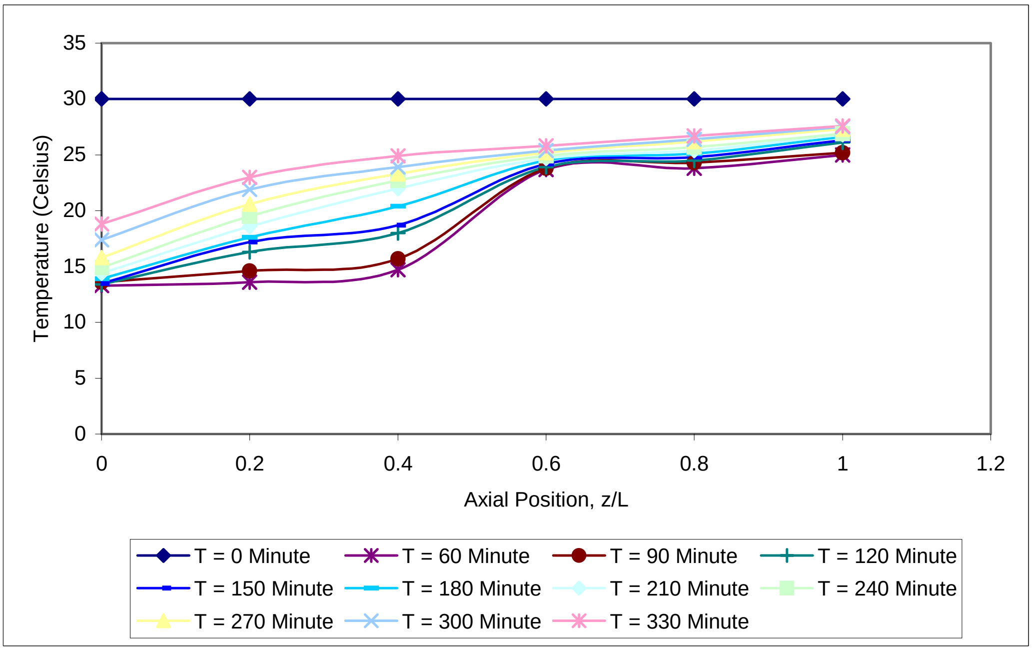
A305: Dimensionless Axial Profile of Temperature at Early Stage at Center of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



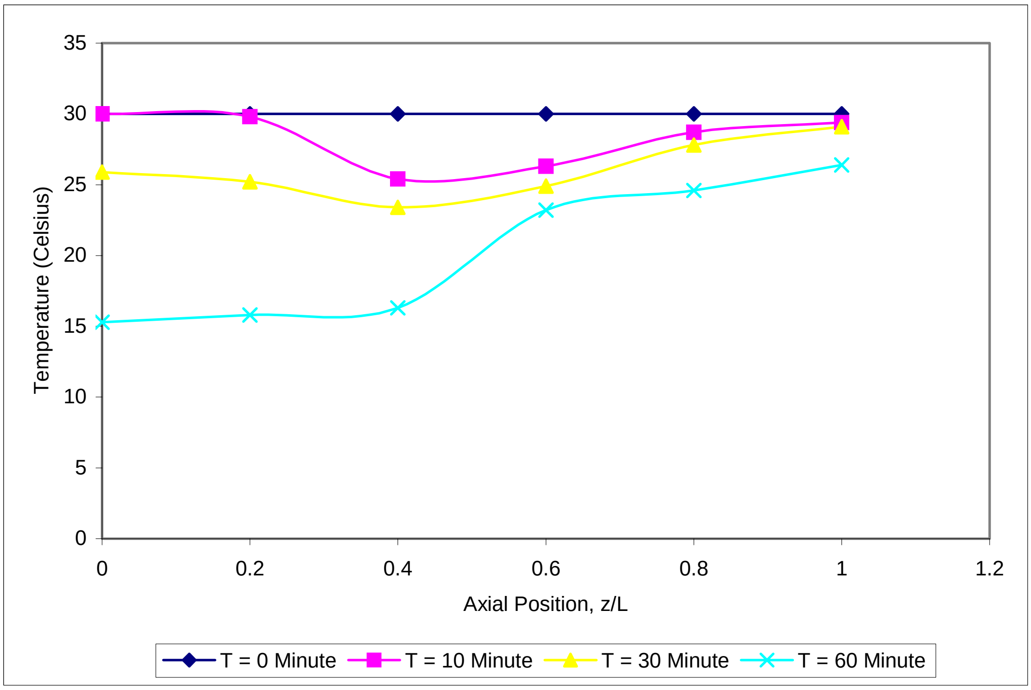
A306: Dimensionless Axial Profile of Temperature at Internal Wall of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



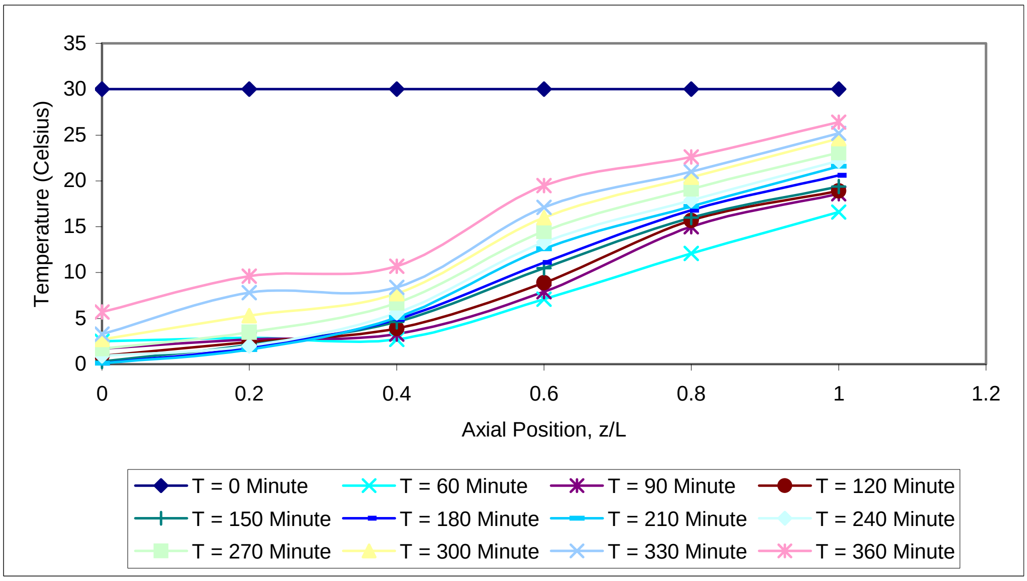
A307: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



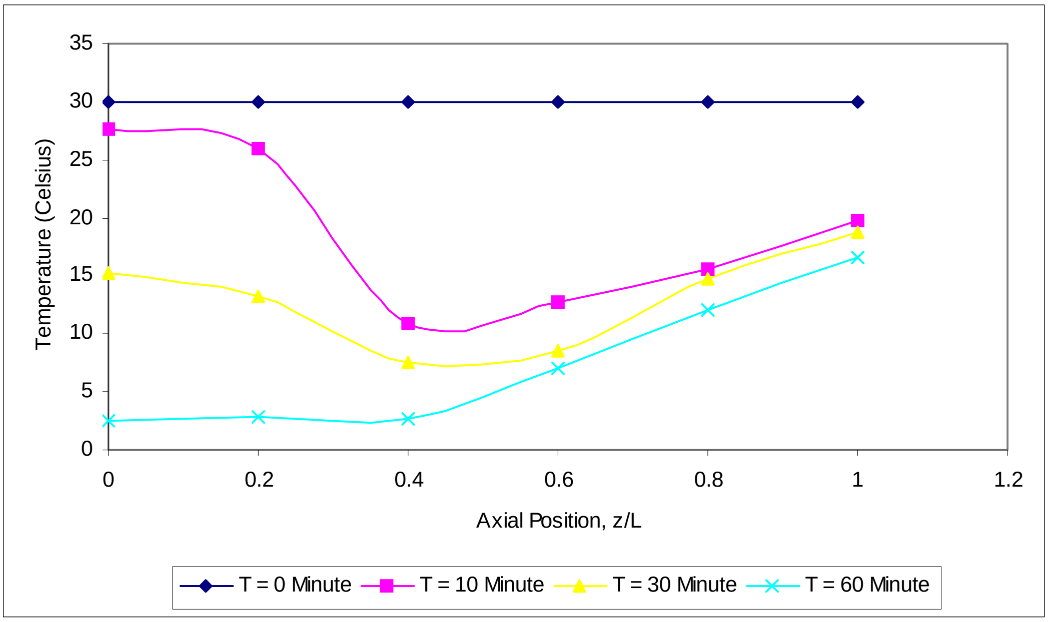
A308: Dimensionless Axial Profile of Temperature at External Wall of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



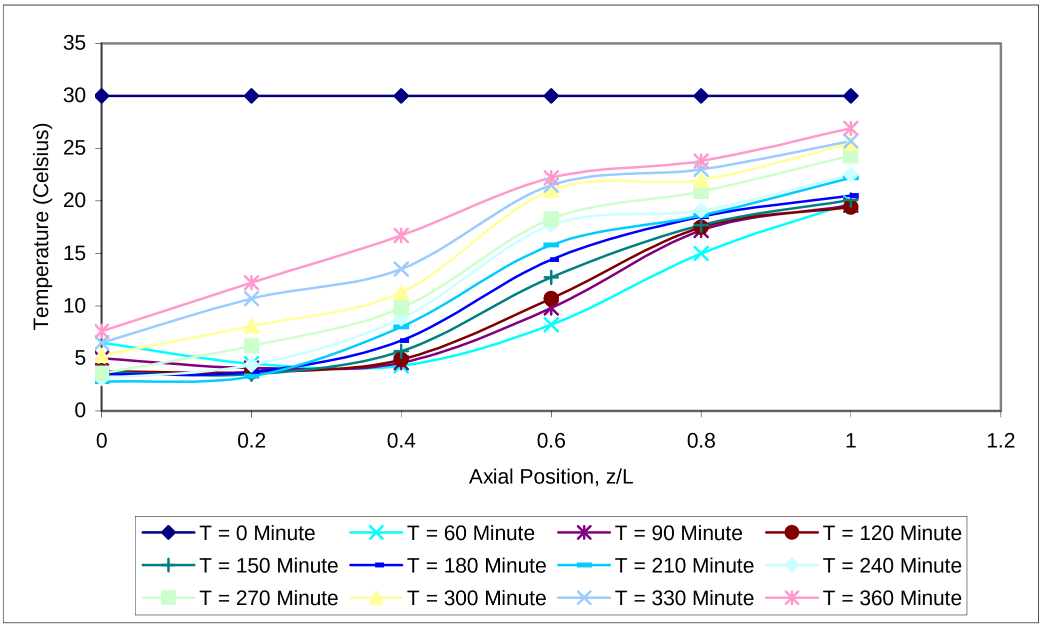
A309: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



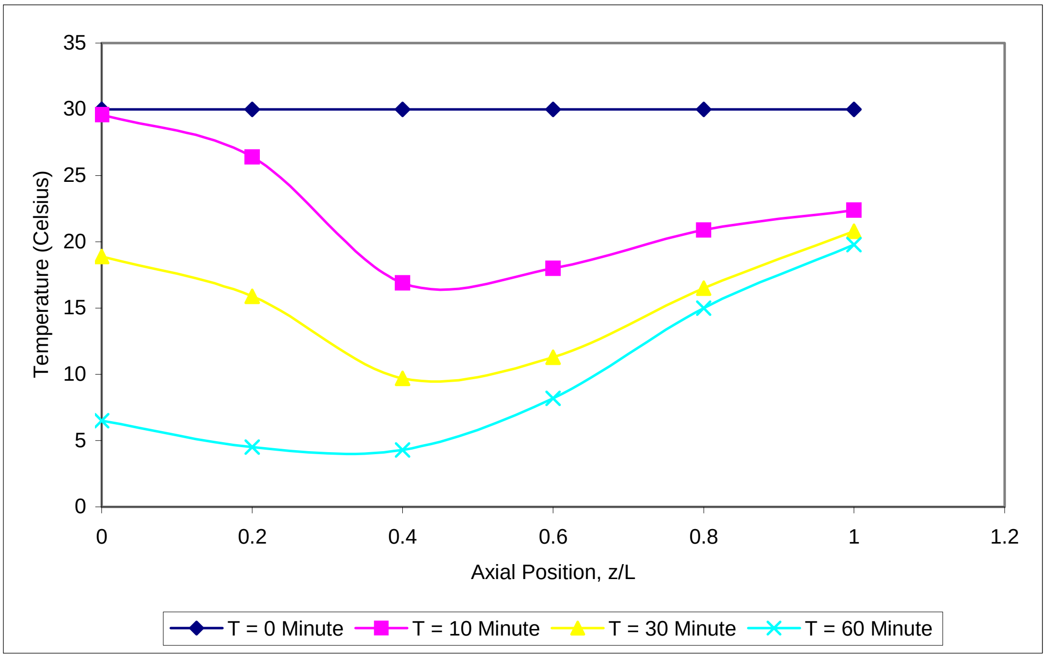
A310: Dimensionless Axial Profile of Temperature at Center of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



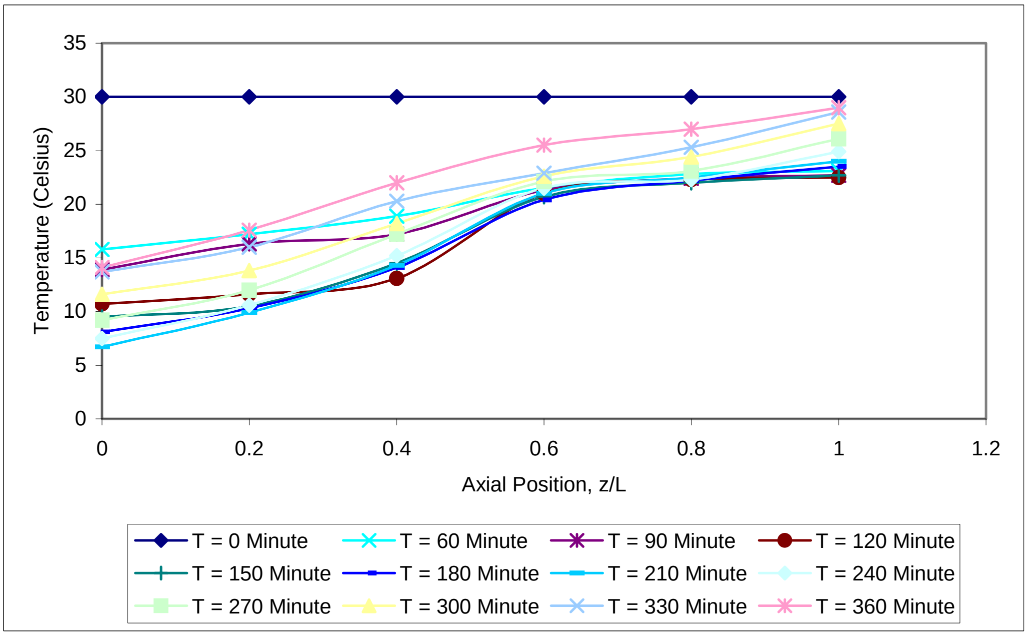
A311: Dimensionless Axial Profile of Temperature at Early Stage at Center of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



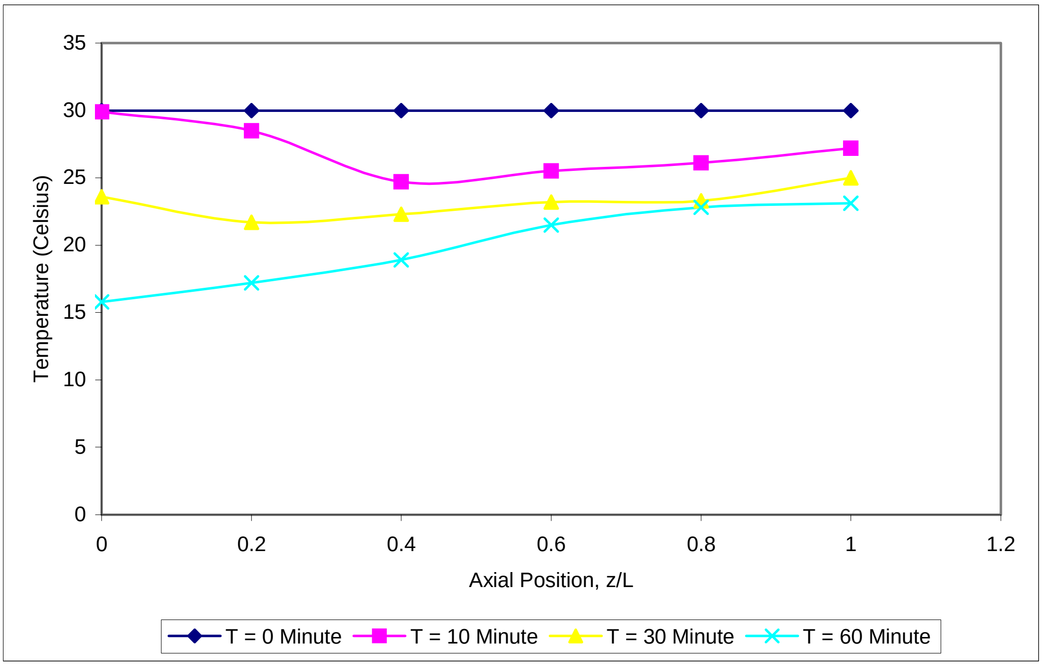
A312: Dimensionless Axial Profile of Temperature at Internal Wall of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



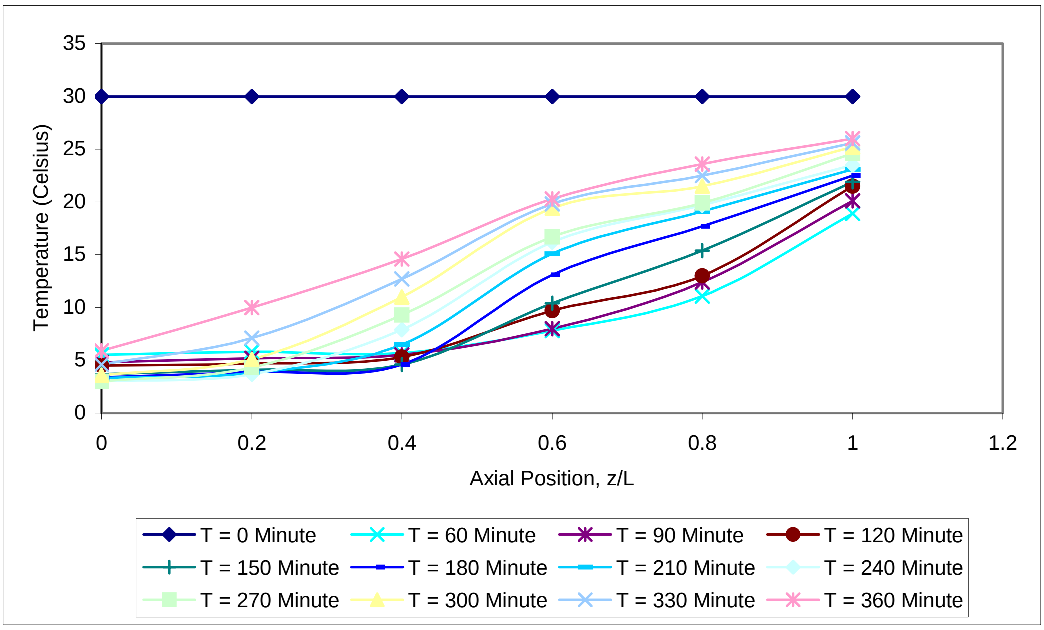
A313: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



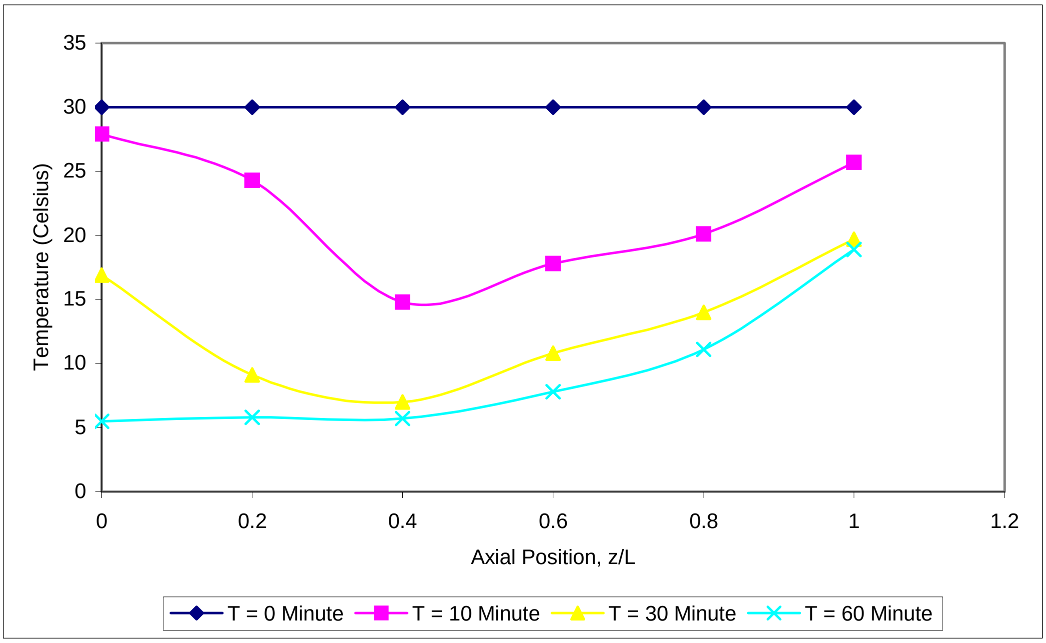
A314: Dimensionless Axial Profile of Temperature at External Wall of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



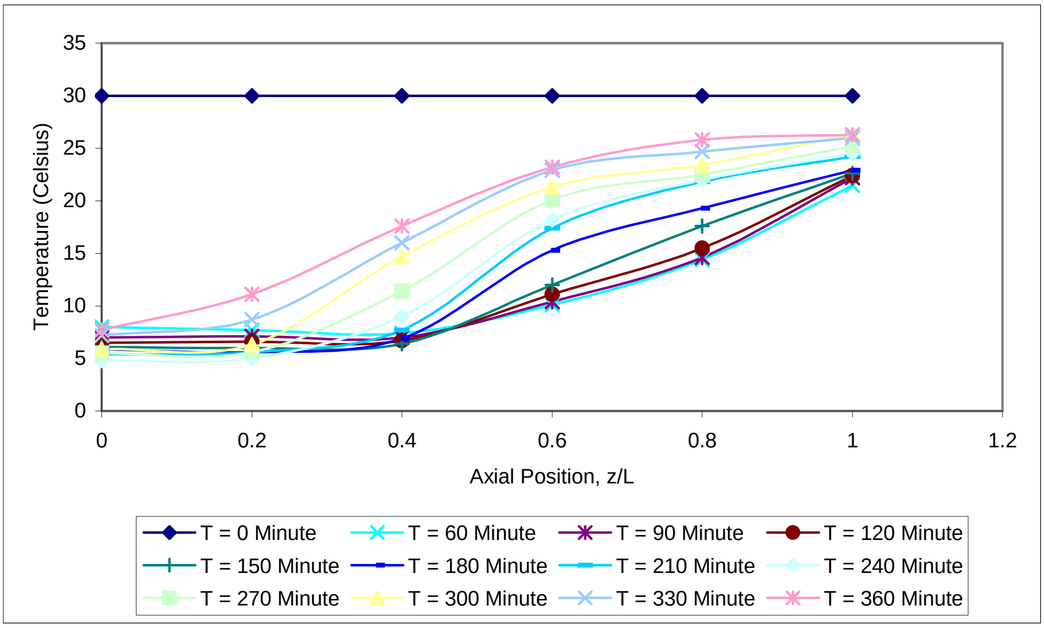
A315: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



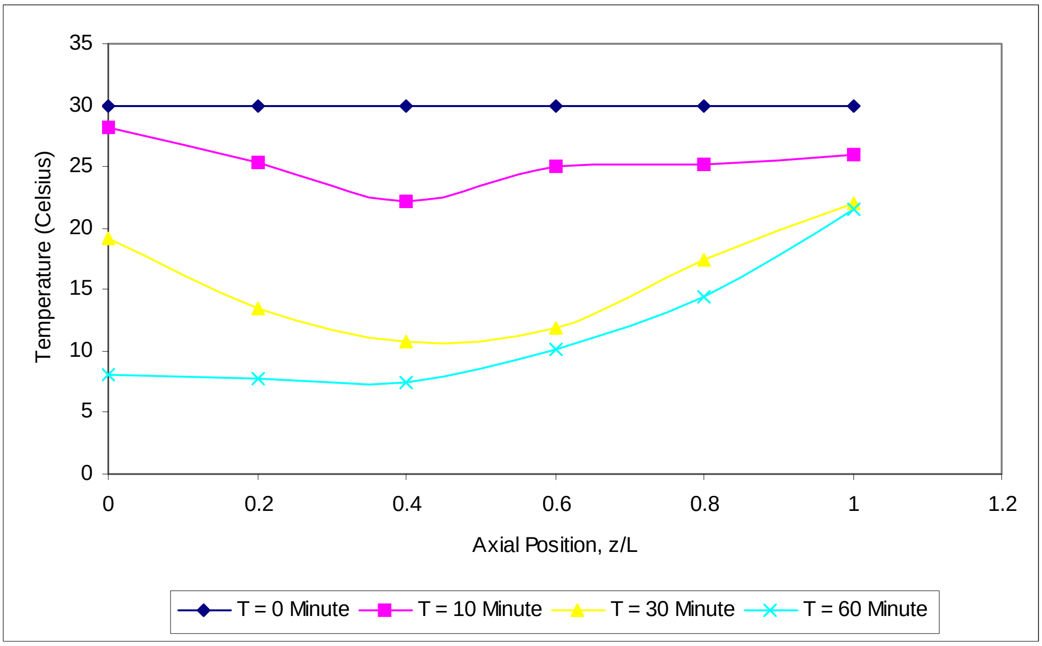
A316: Dimensionless Axial Profile of Temperature at Center of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



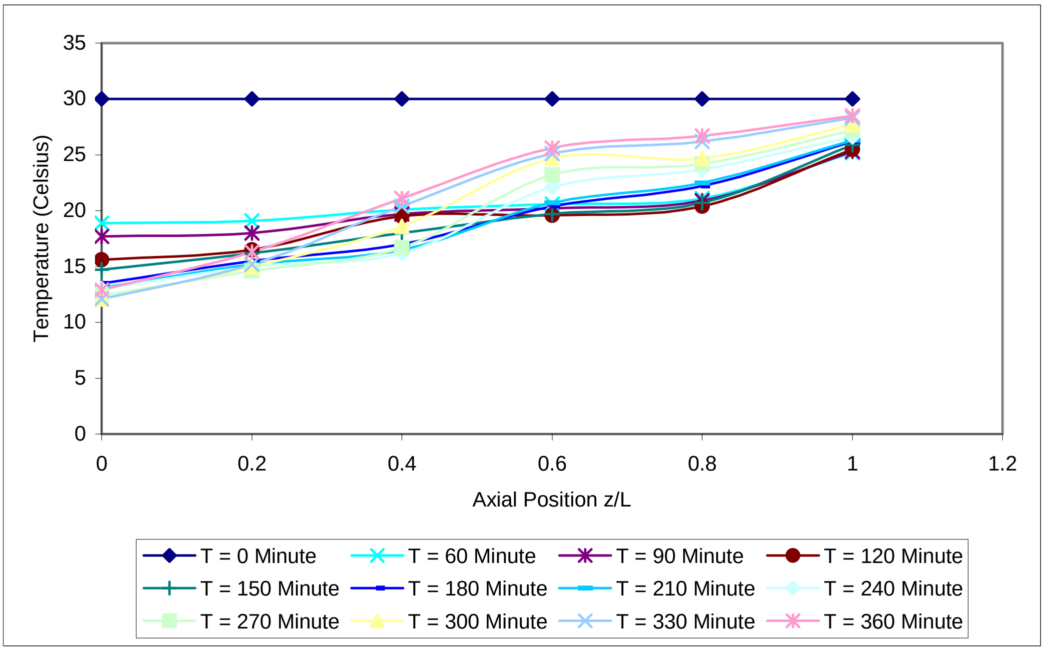
A317: Dimensionless Axial Profile of Temperature at Early Stage at Center of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



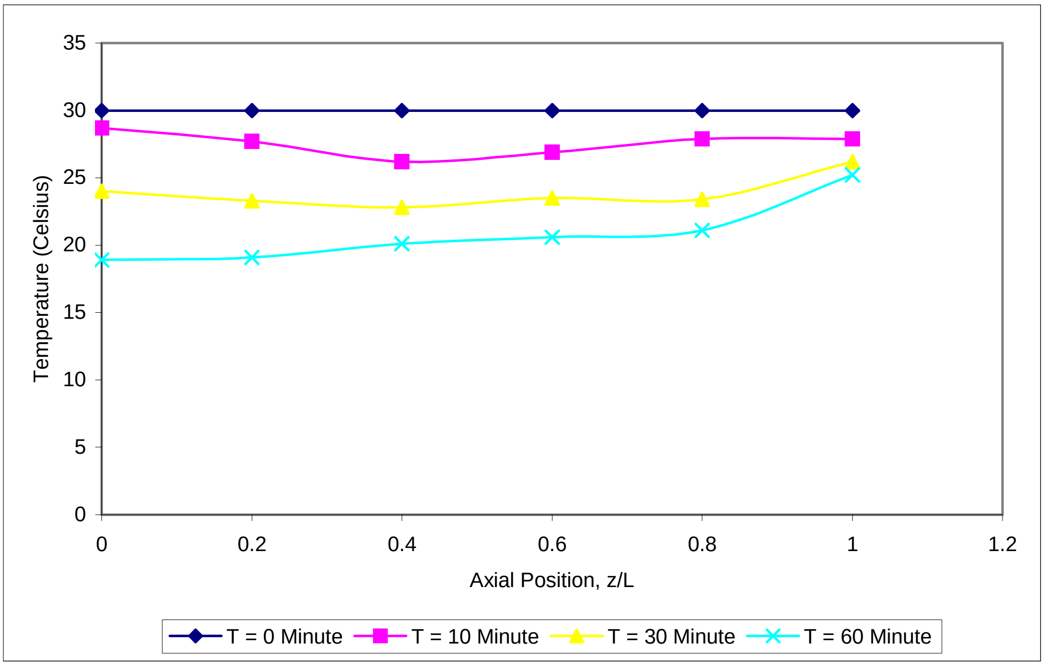
A318: Dimensionless Axial Profile of Temperature at Internal Wall of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



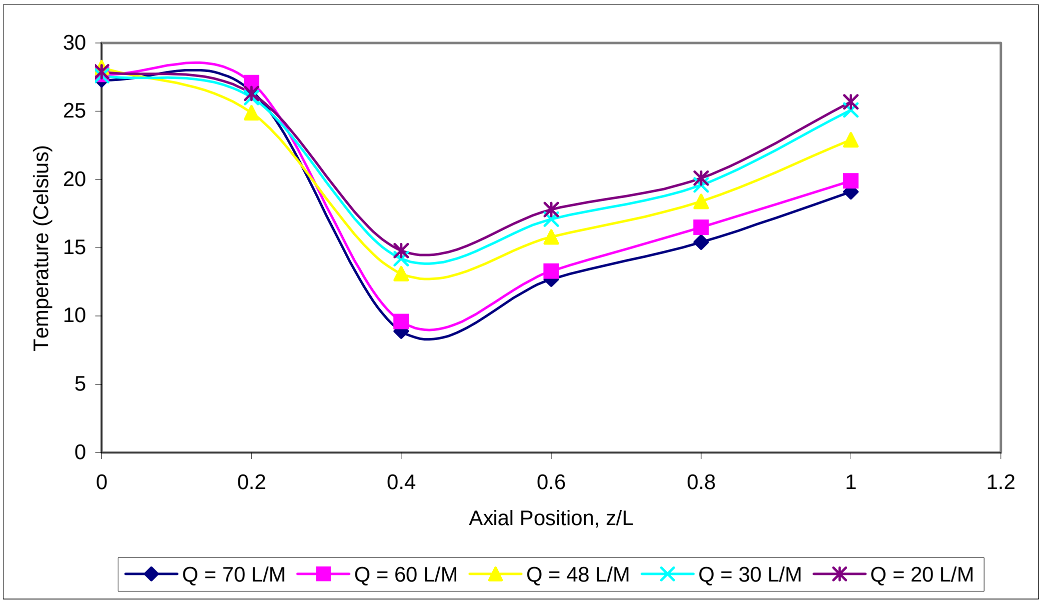
A319: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



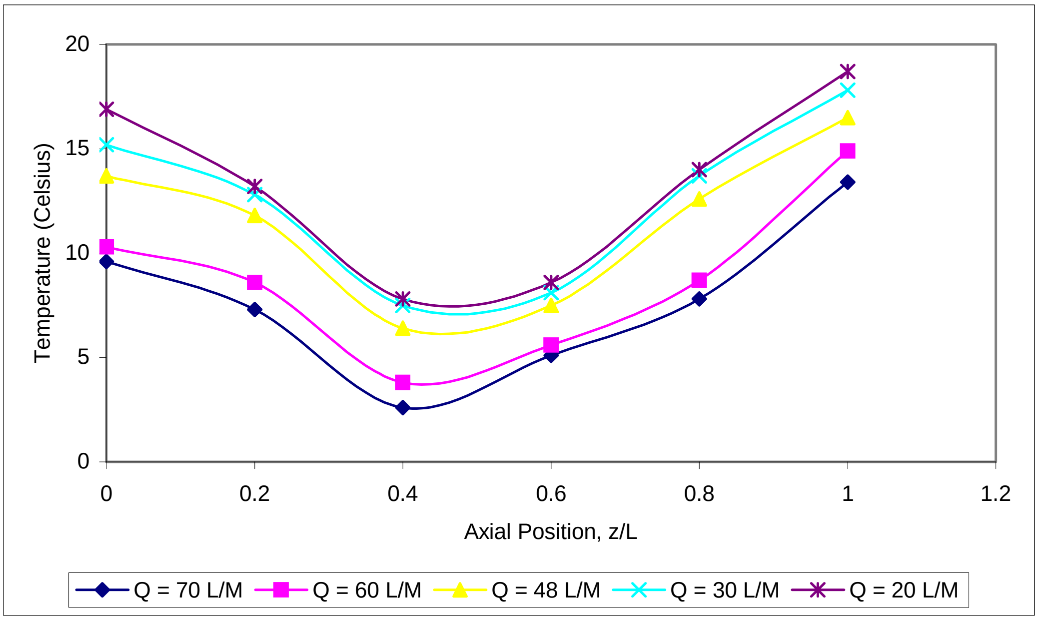
A320: Dimensionless Axial Profile of Temperature at External Wall of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



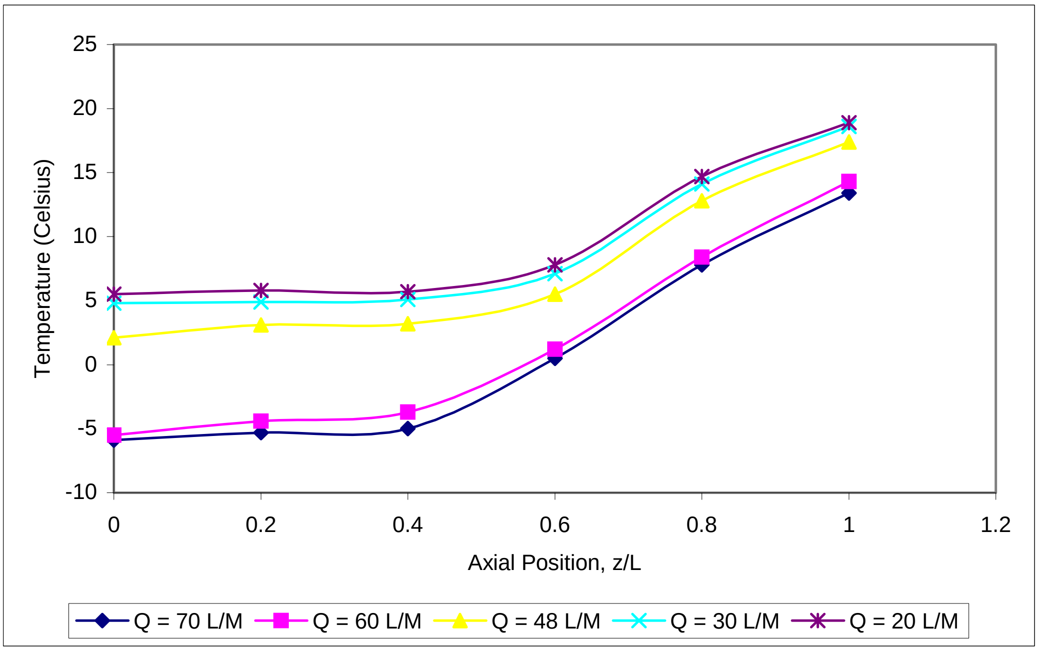
A321: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



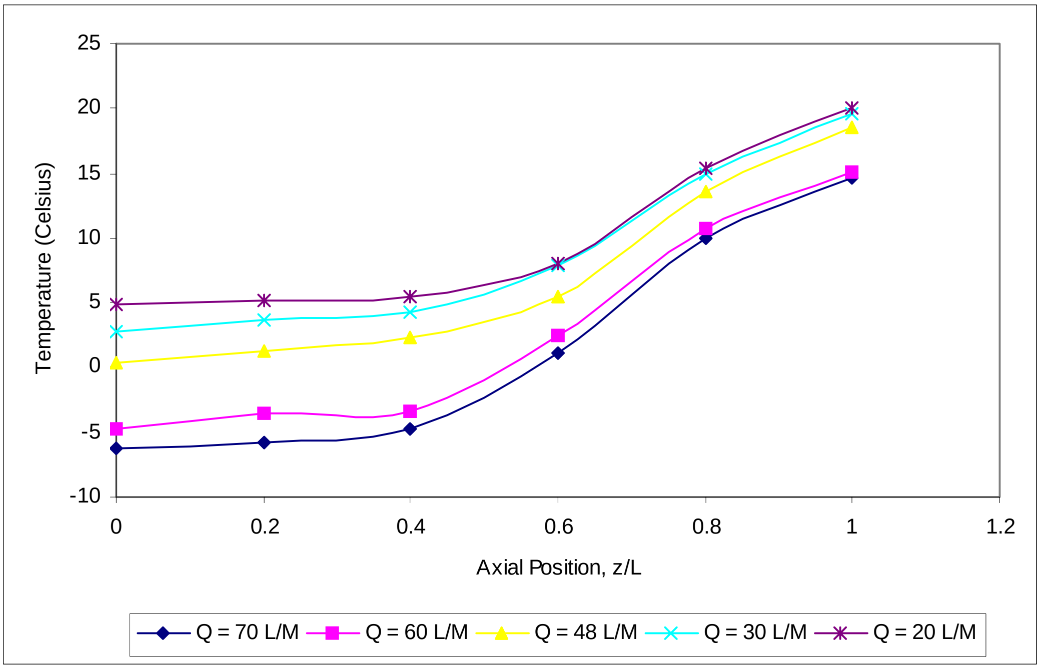
A322: Dimensionless Axial Profile of Temperature at 10 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



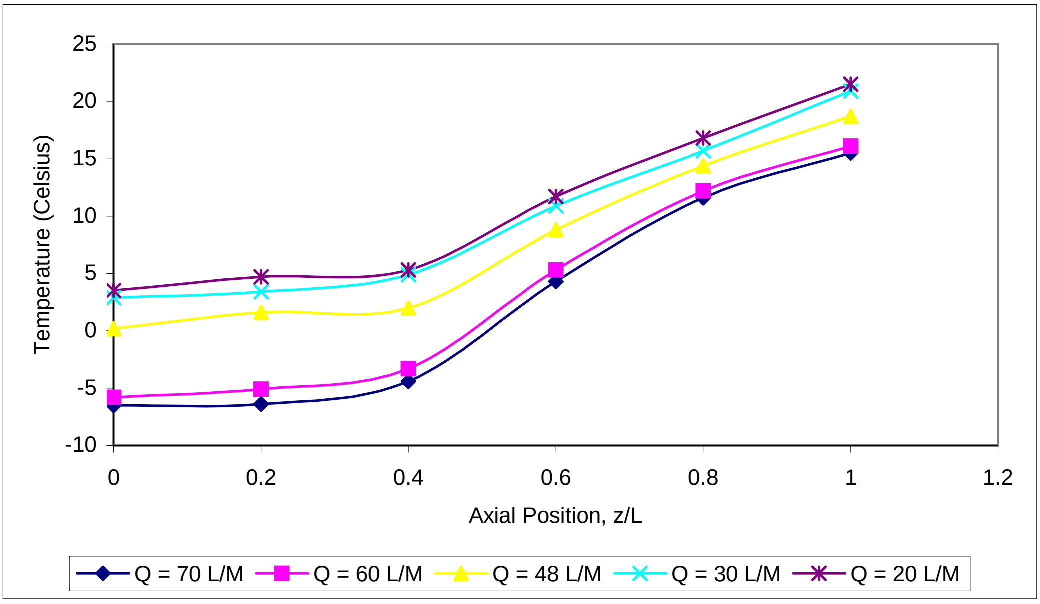
A323: Dimensionless Axial Profile of Temperature at 30 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



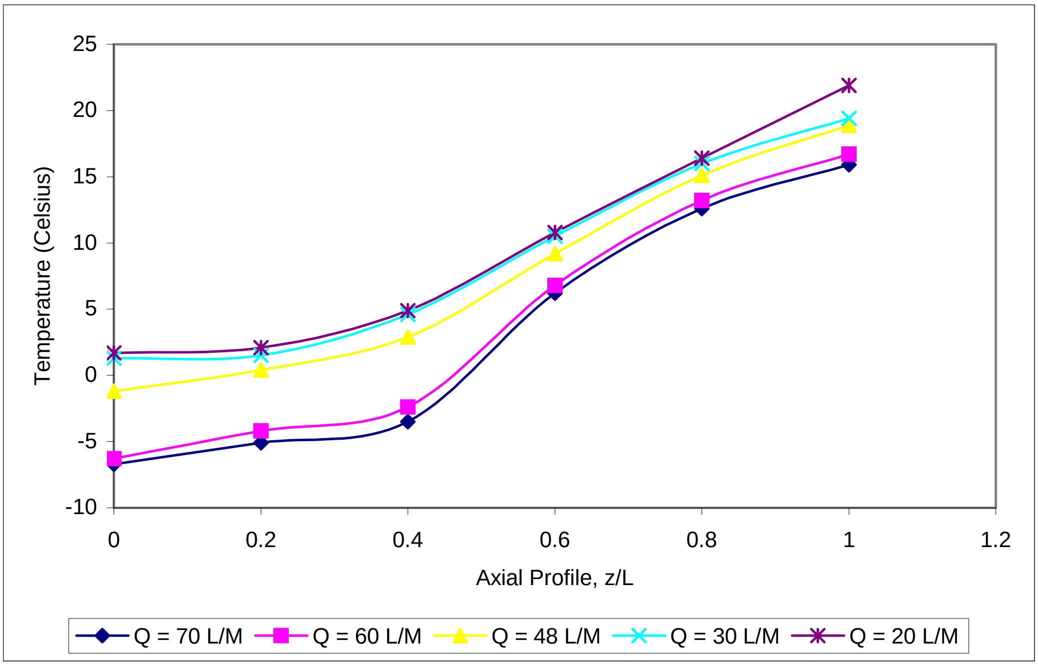
A324: Dimensionless Axial Profile of Temperature at 60 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



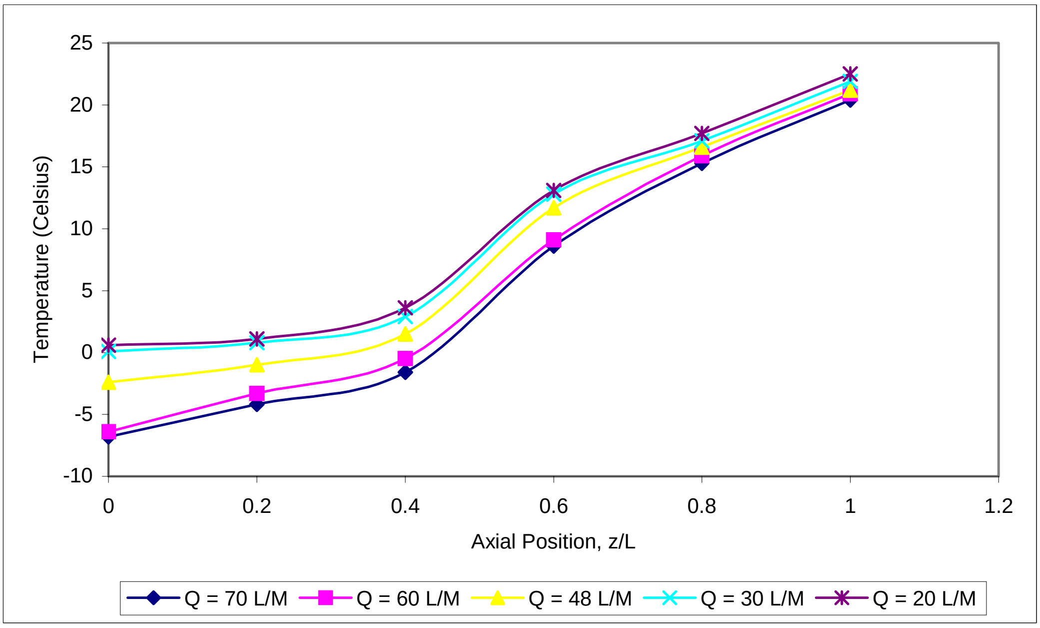
A325: Dimensionless Axial Profile of Temperature at 90 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



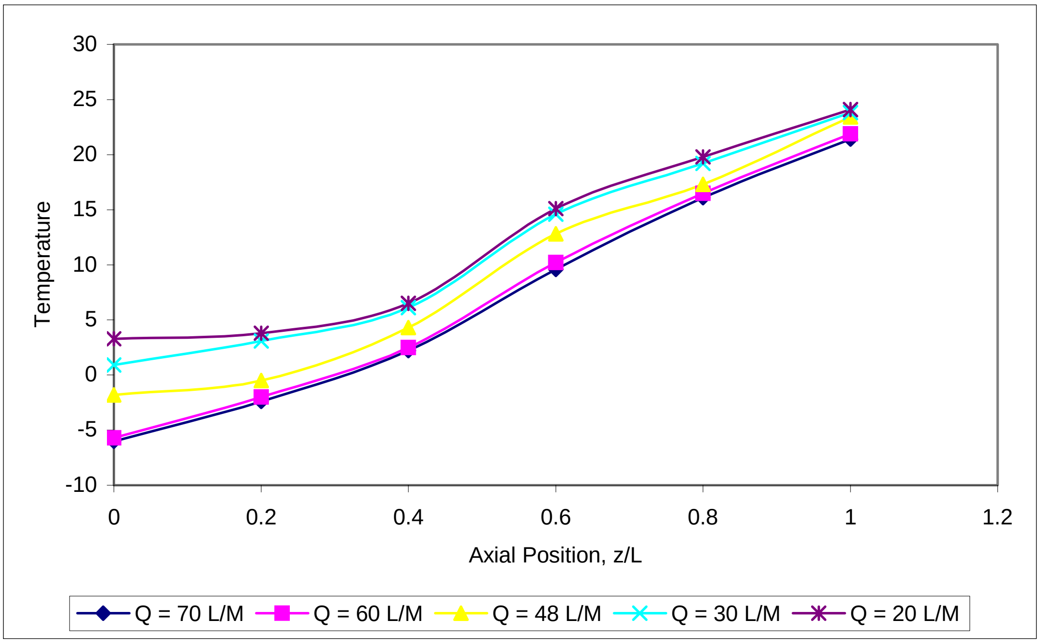
A326: Dimensionless Axial Profile of Temperature at 120 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



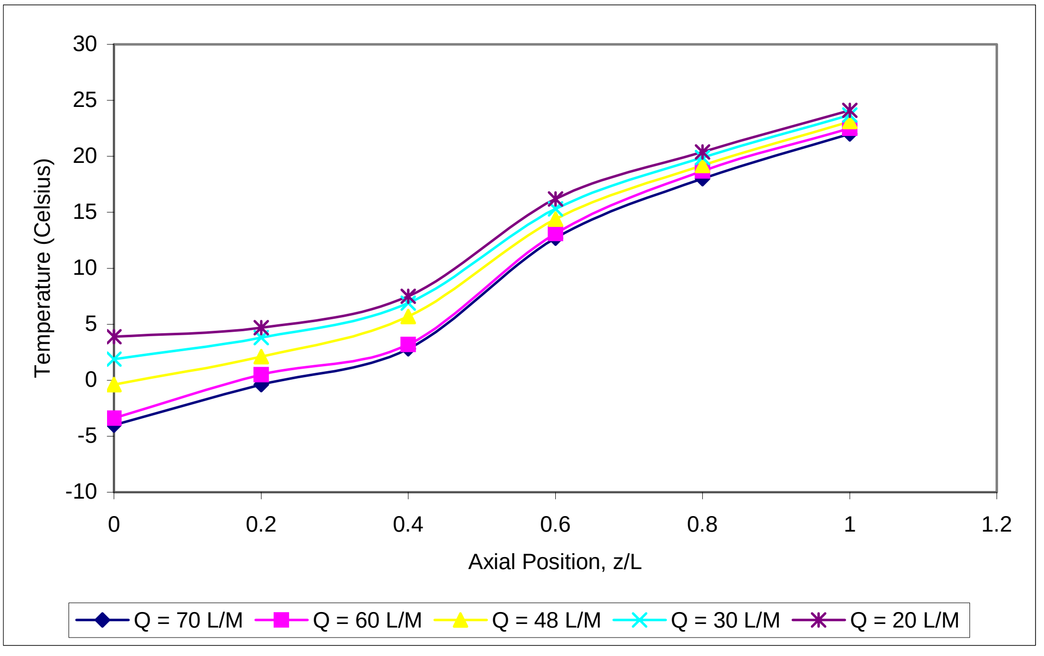
A327: Dimensionless Axial Profile of Temperature at 150 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



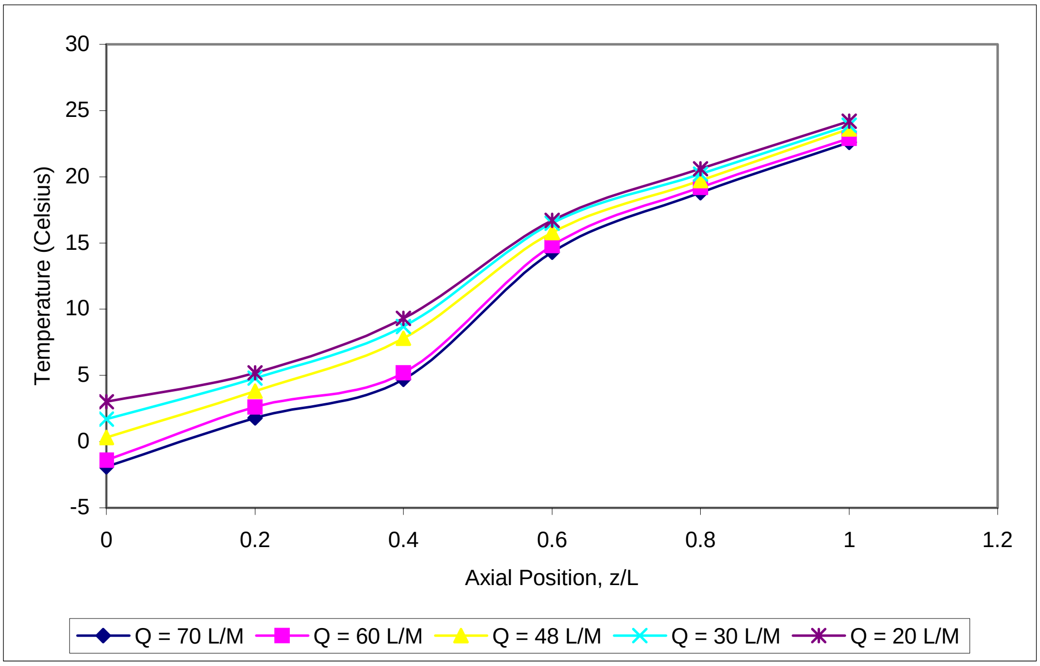
A328: Dimensionless Axial Profile of Temperature at 180 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



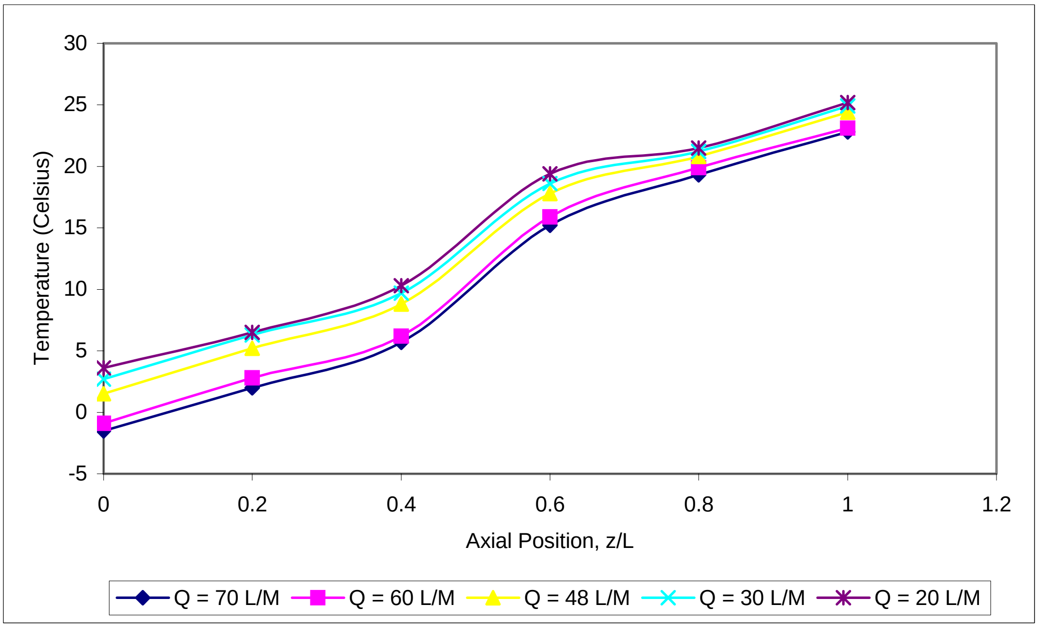
A329: Dimensionless Axial Profile of Temperature at 210 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



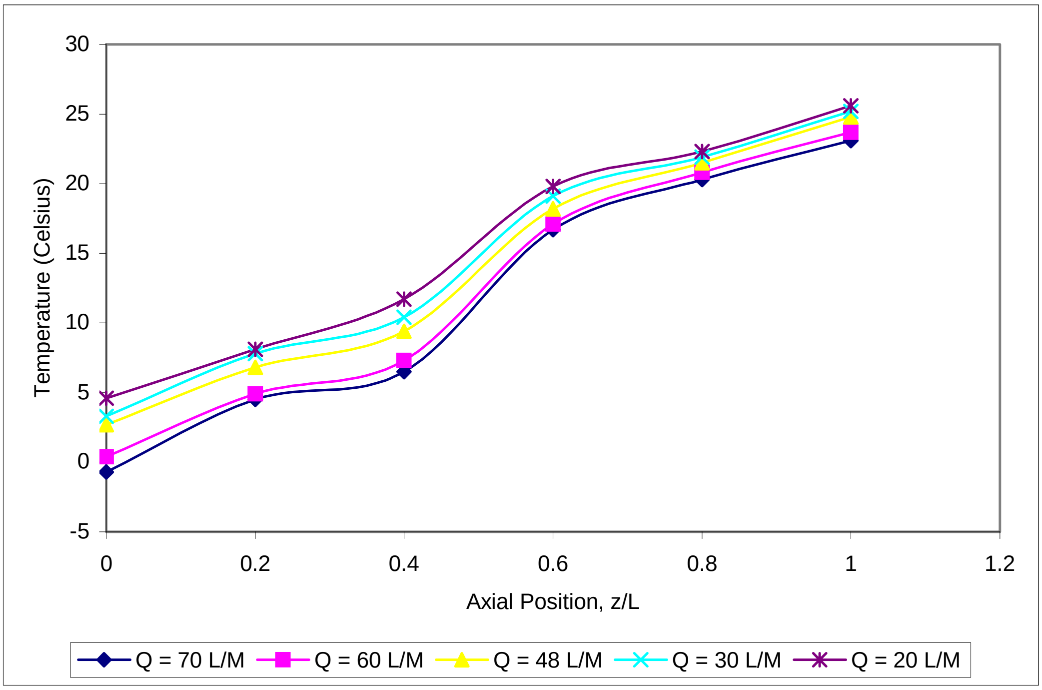
A330: Dimensionless Axial Profile of Temperature at 240 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



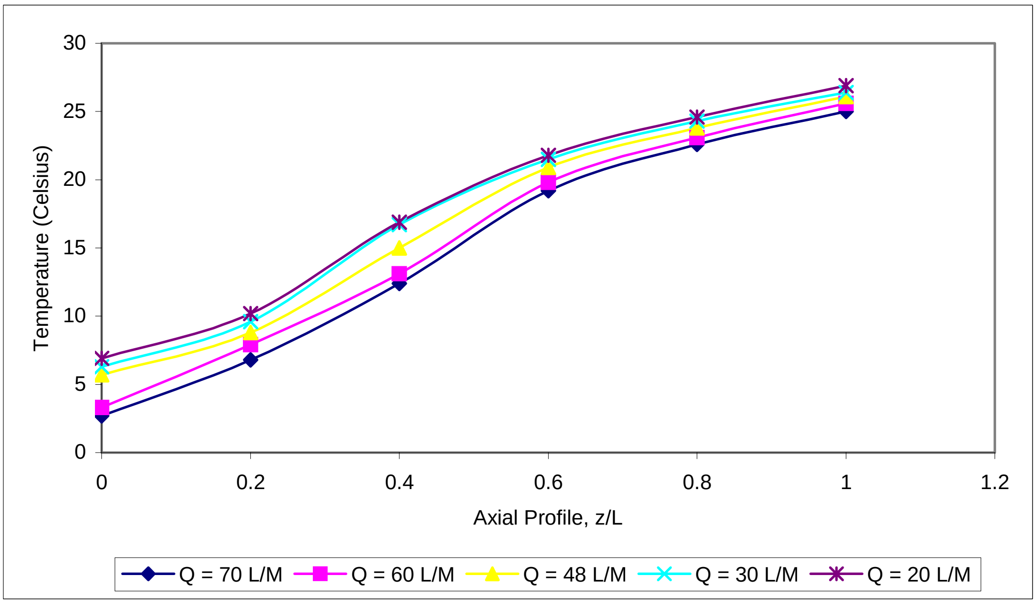
A331: Dimensionless Axial Profile of Temperature at 270 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



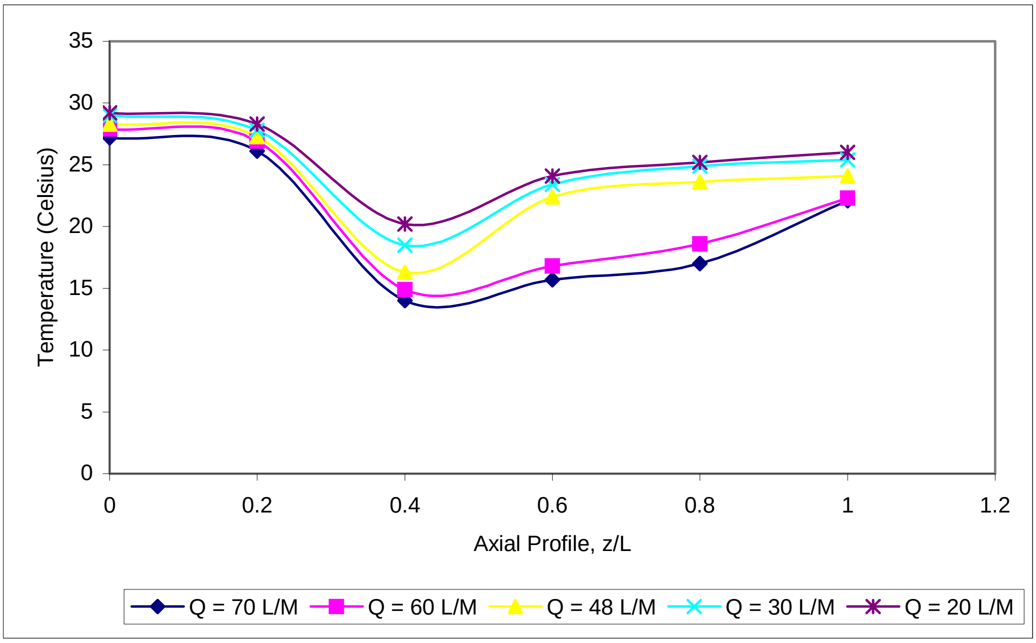
A332: Dimensionless Axial Profile of Temperature at 300 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



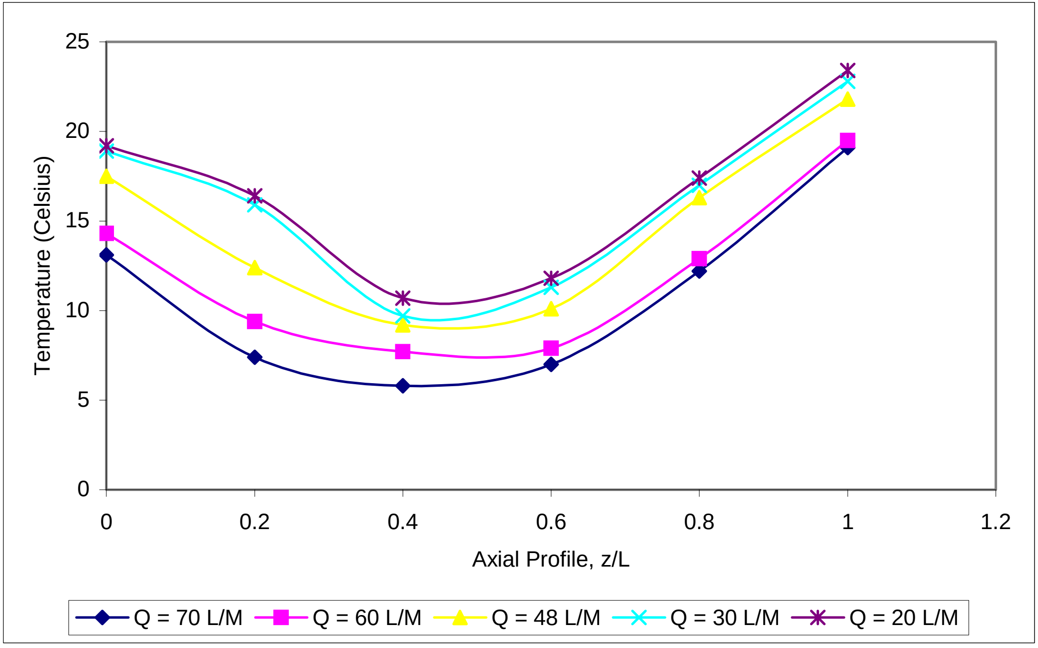
A333: Dimensionless Axial Profile of Temperature at 330 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



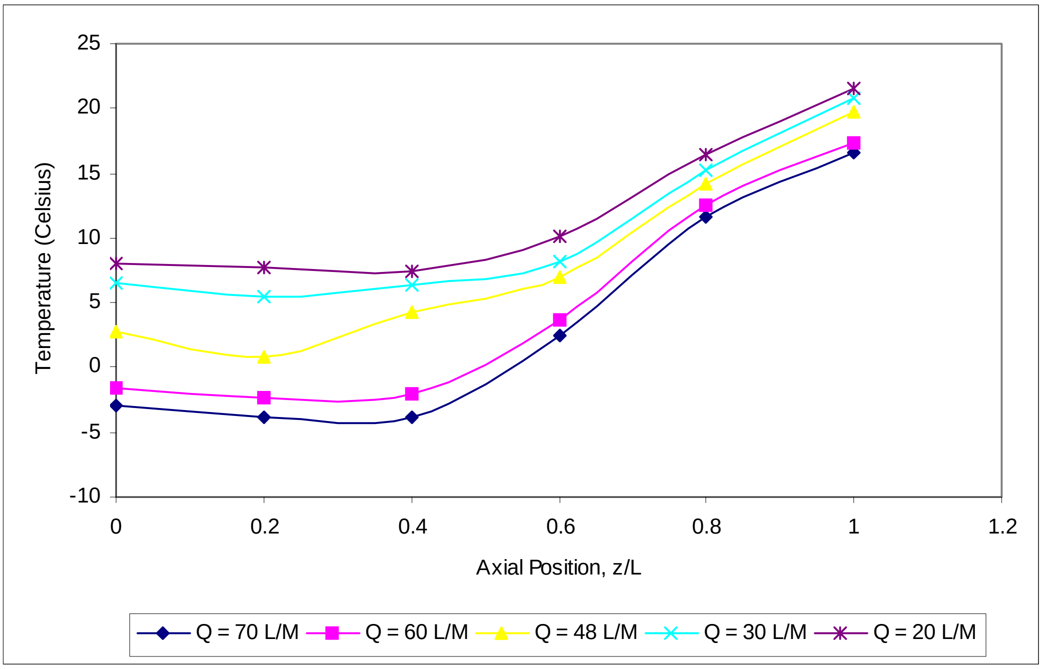
A334: Dimensionless Axial Profile of Temperature at 360 Minute at Center of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



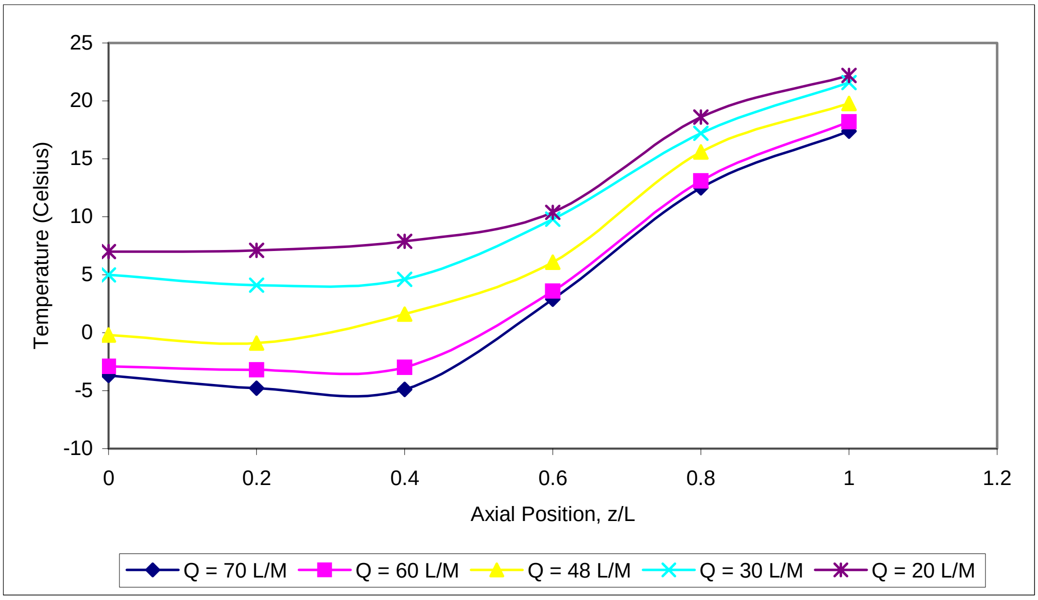
A335: Dimensionless Axial Profile of Temperature at 10 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



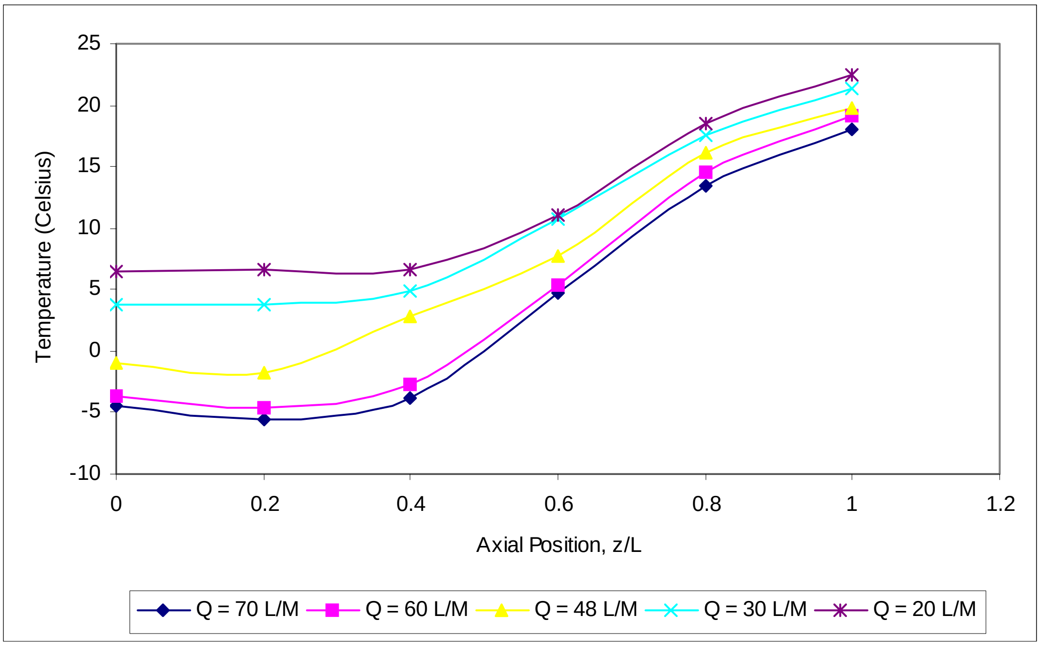
A336: Dimensionless Axial Profile of Temperature at 30 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



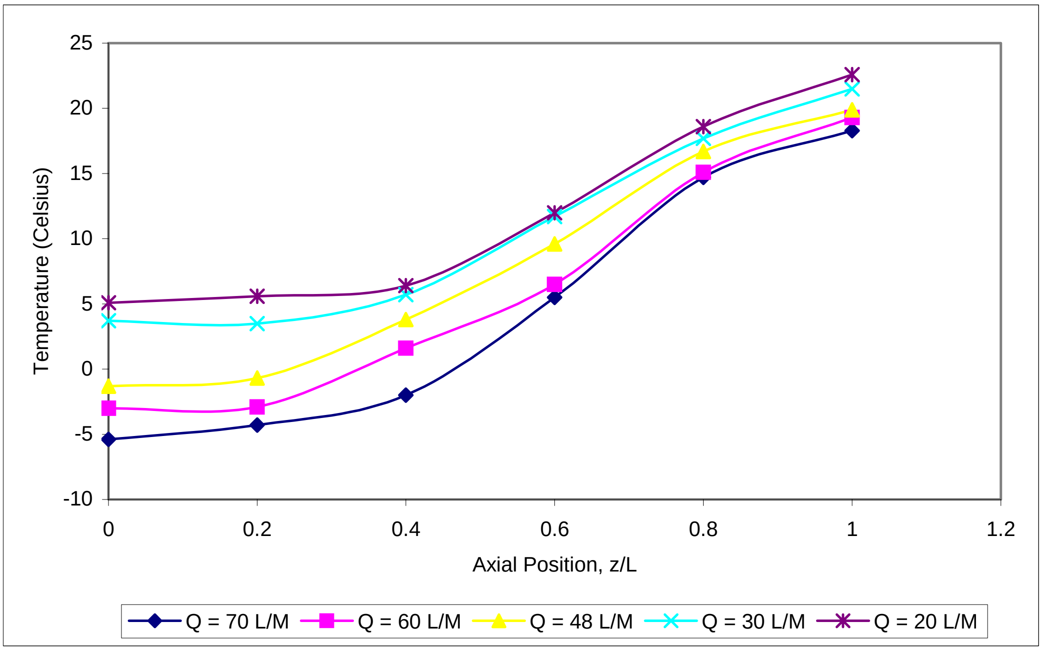
A337: Dimensionless Axial Profile of Temperature at 60 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



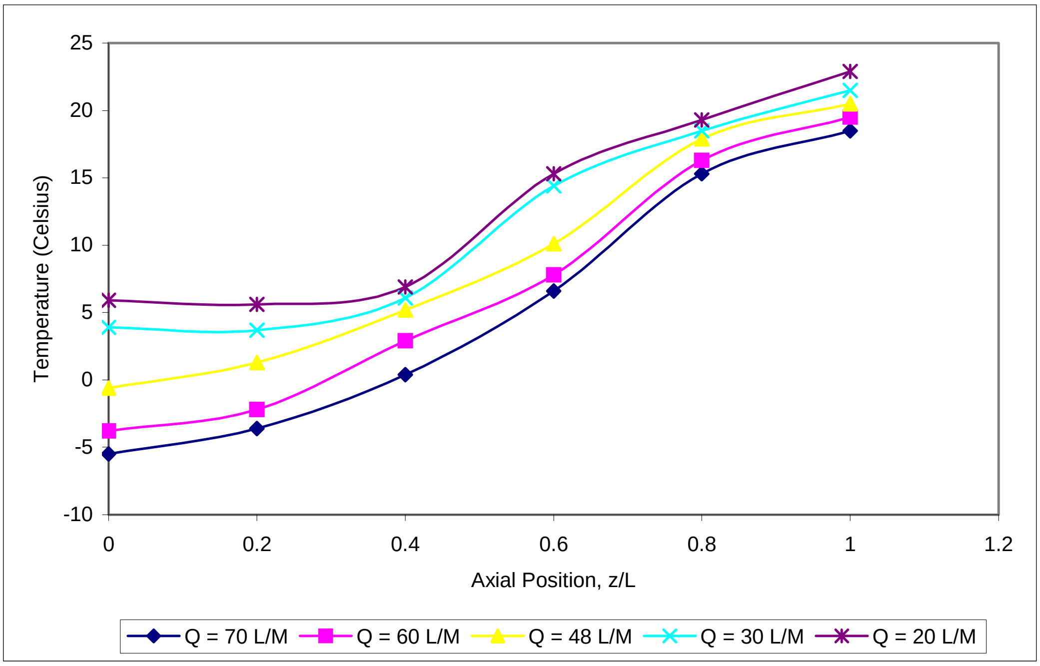
A338: Dimensionless Axial Profile of Temperature at 90 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



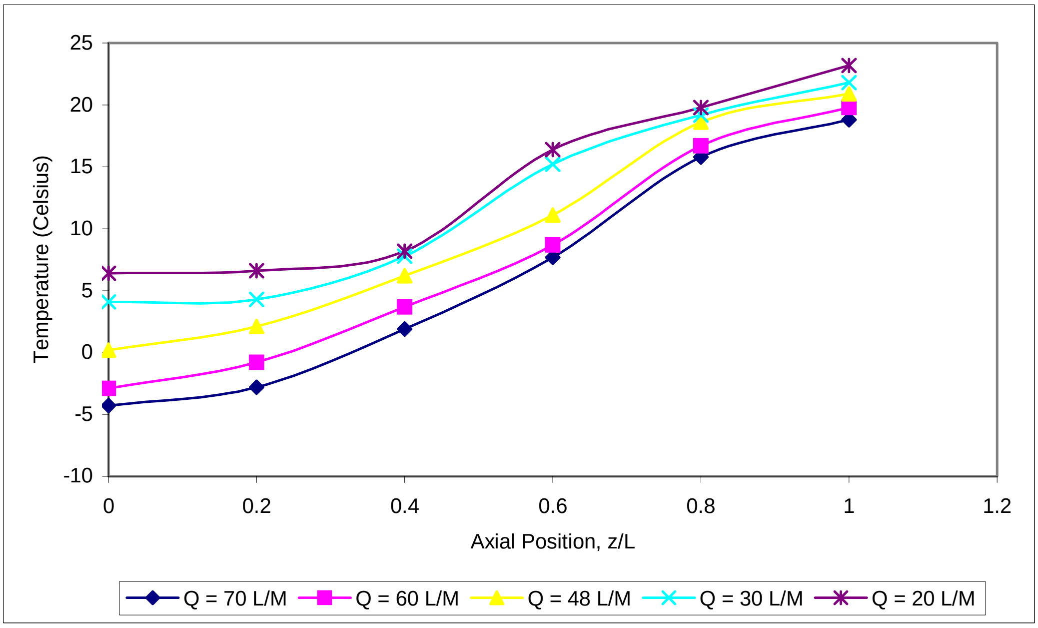
A339: Dimensionless Axial Profile of Temperature at 120 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



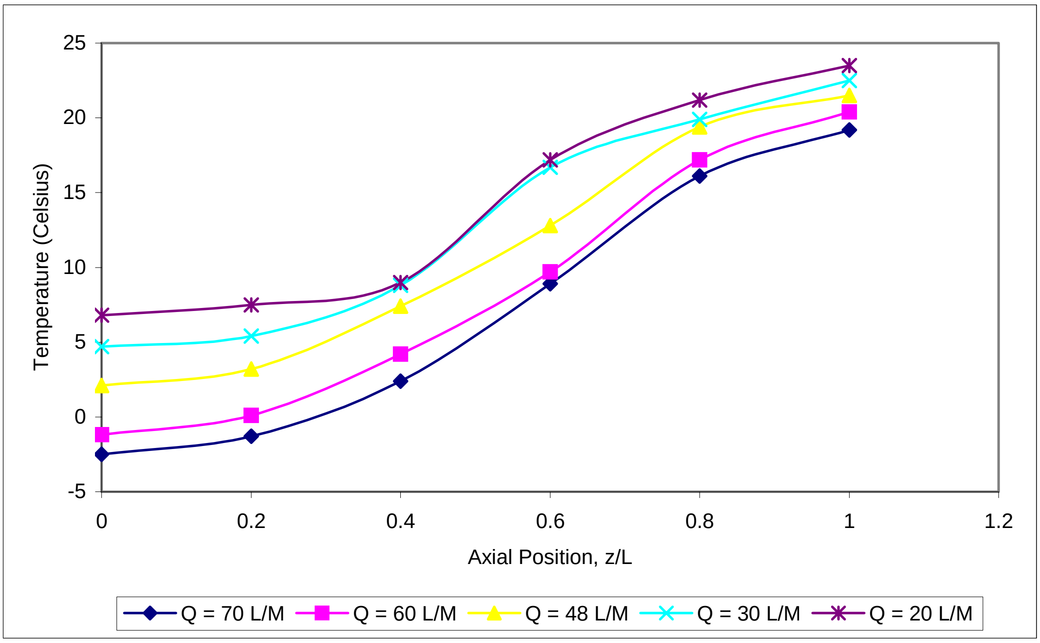
A340: Dimensionless Axial Profile of Temperature at 150 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



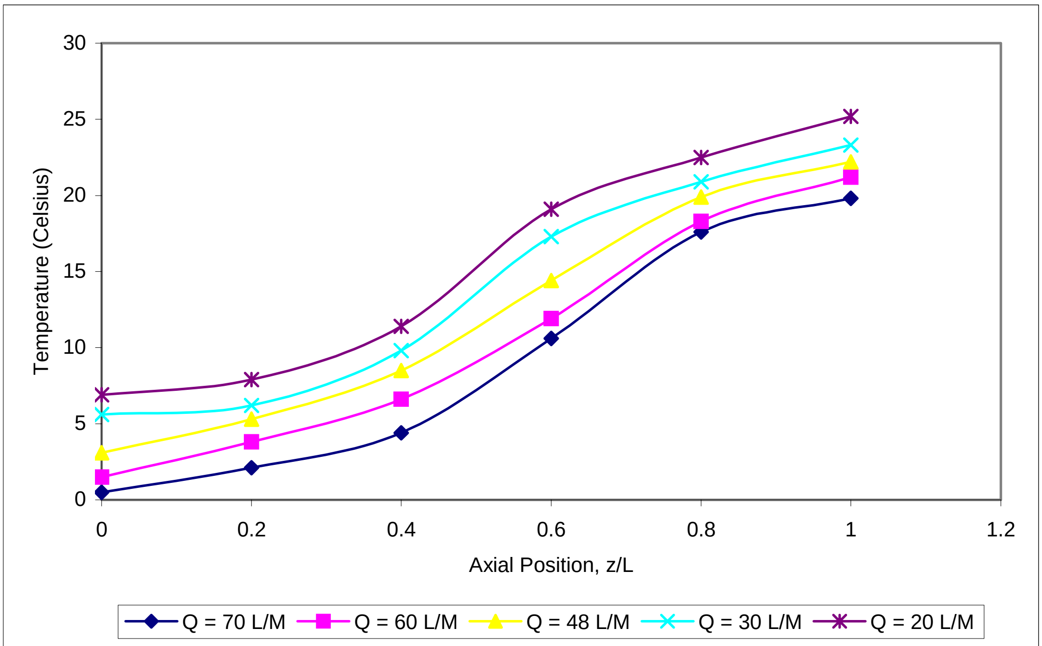
A341: Dimensionless Axial Profile of Temperature at 180 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



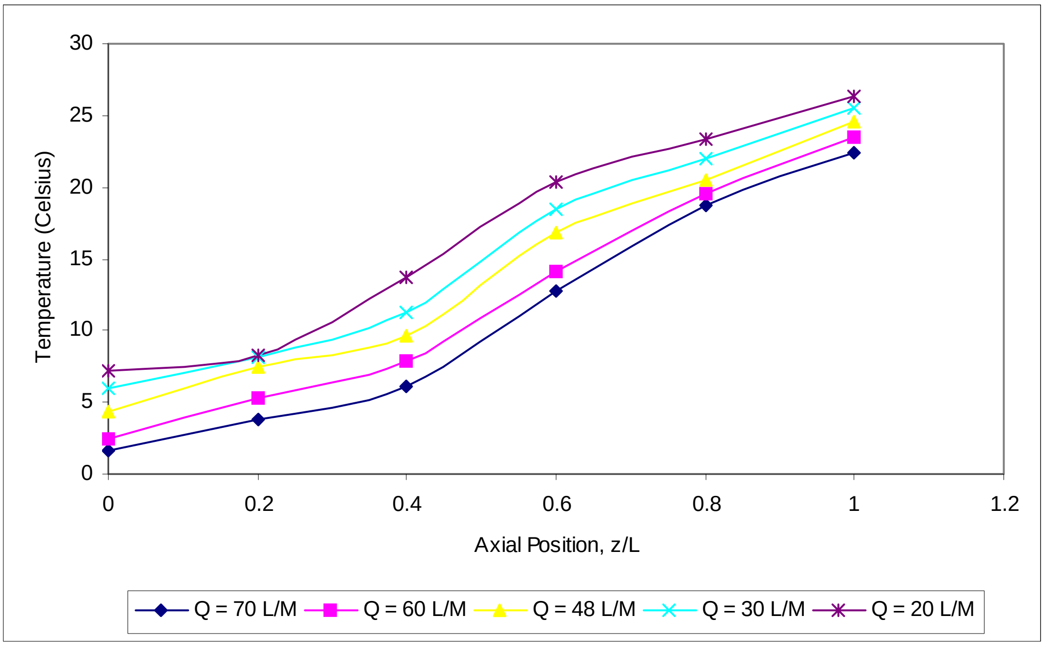
A342: Dimensionless Axial Profile of Temperature at 210 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



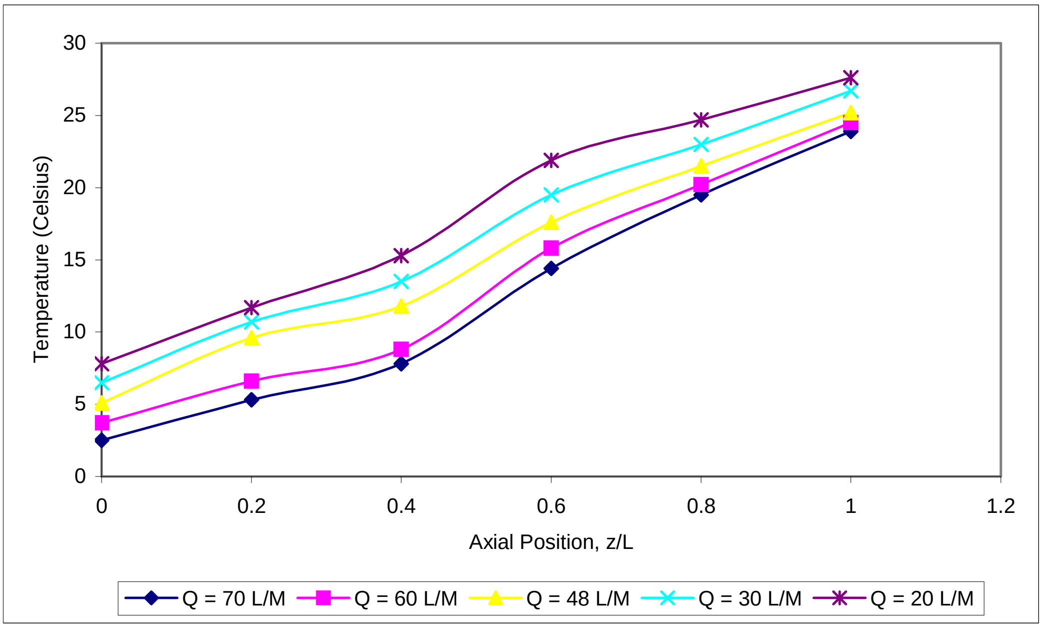
A343: Dimensionless Axial Profile of Temperature at 240 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



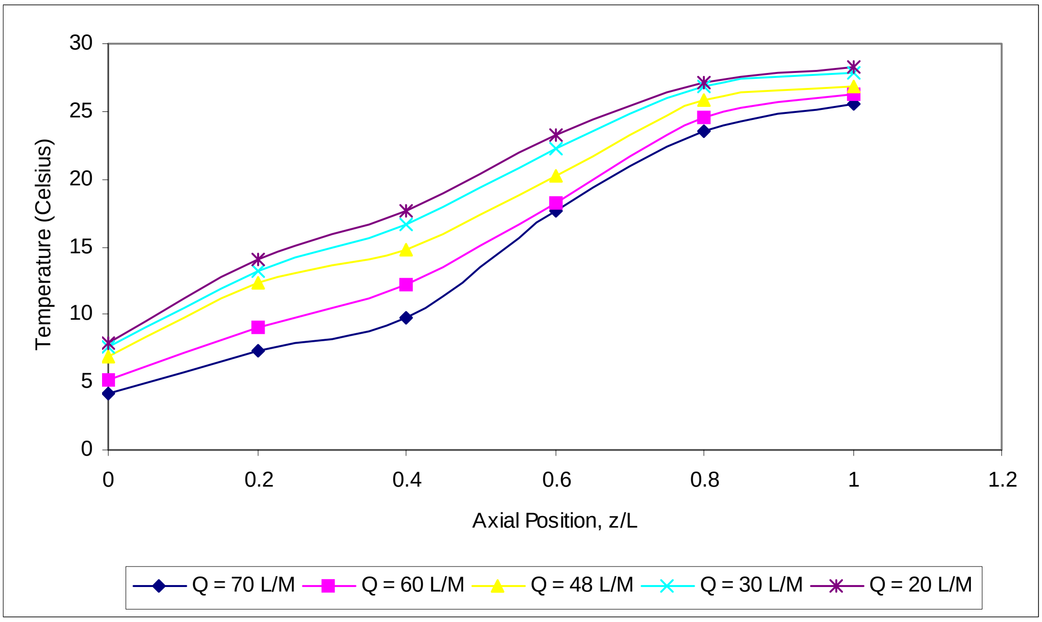
A344: Dimensionless Axial Profile of Temperature at 270 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



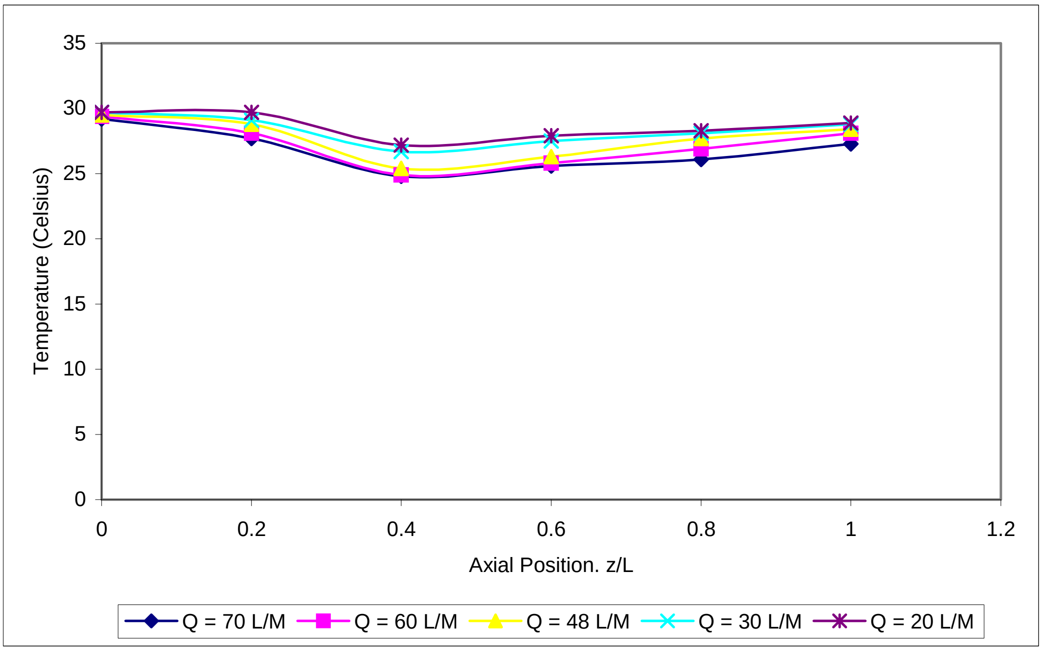
A345: Dimensionless Axial Profile of Temperature at 300 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



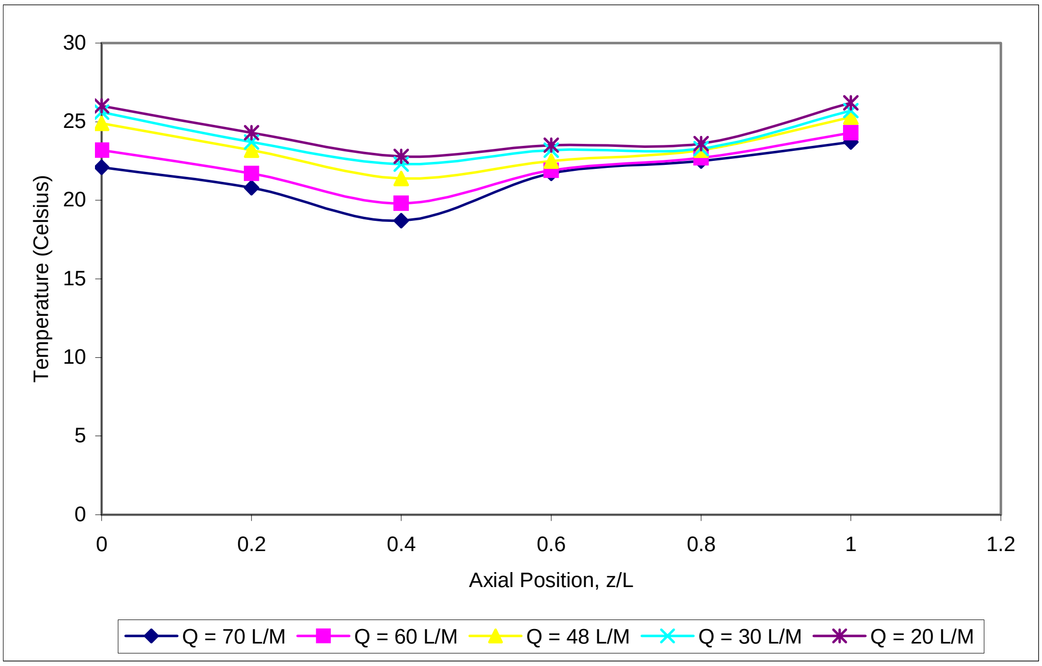
A346: Dimensionless Axial Profile of Temperature at 330 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



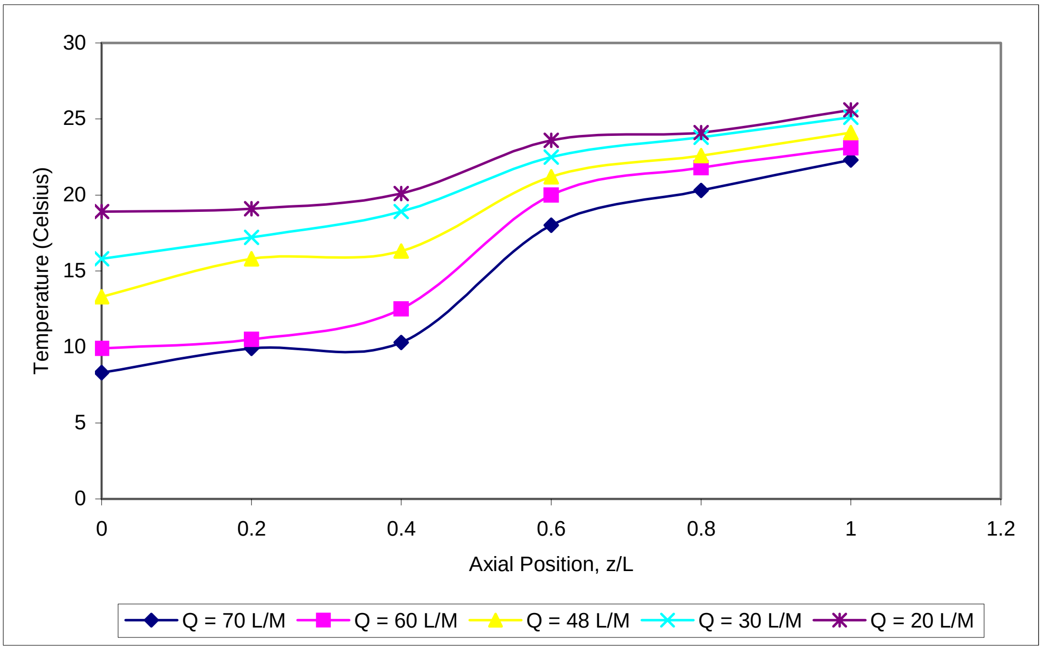
A347: Dimensionless Axial Profile of Temperature at 360 Minute at Internal Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



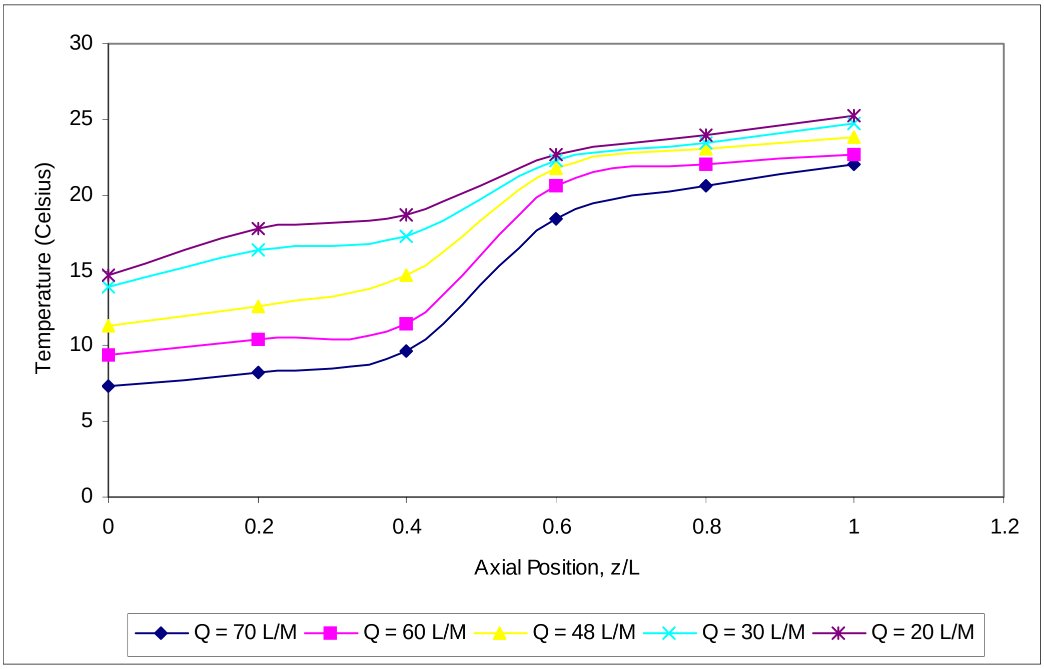
A348: Dimensionless Axial Profile of Temperature at 10 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



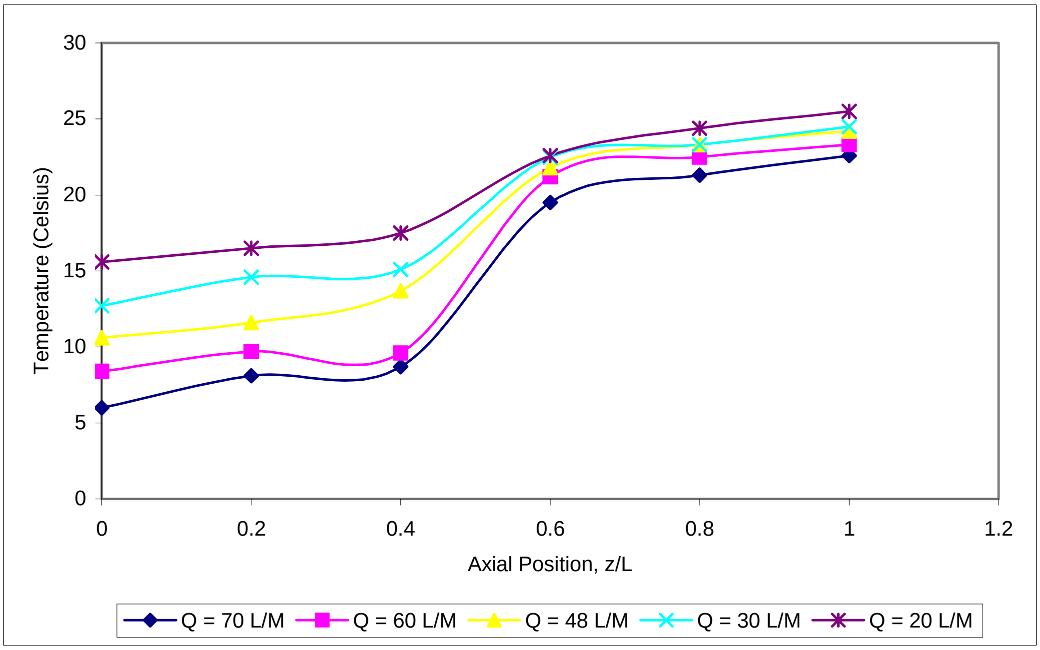
A349: Dimensionless Axial Profile of Temperature at 30 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



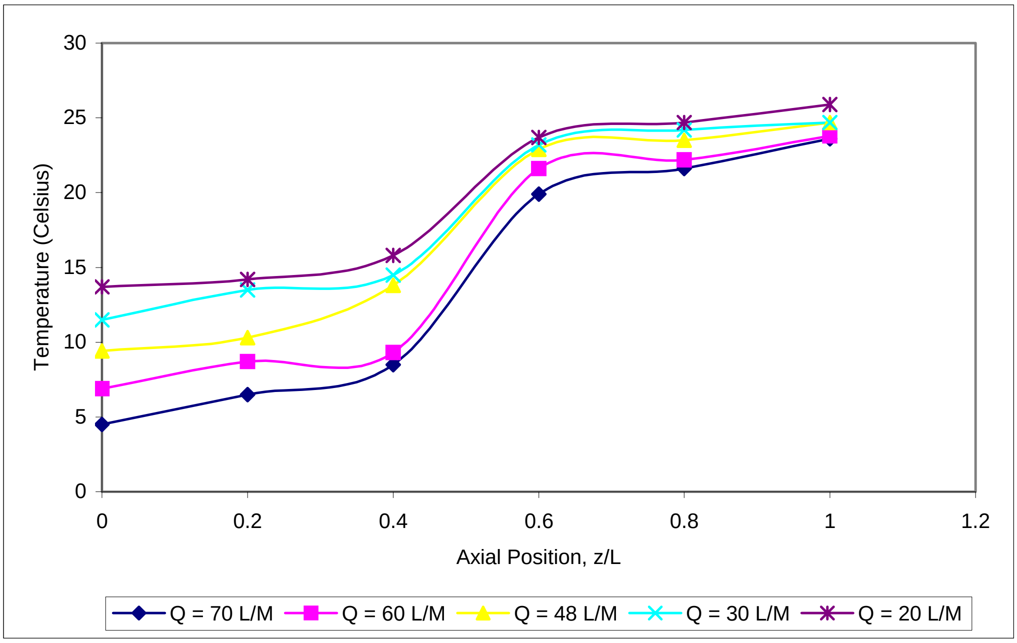
A350: Dimensionless Axial Profile of Temperature at 60 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



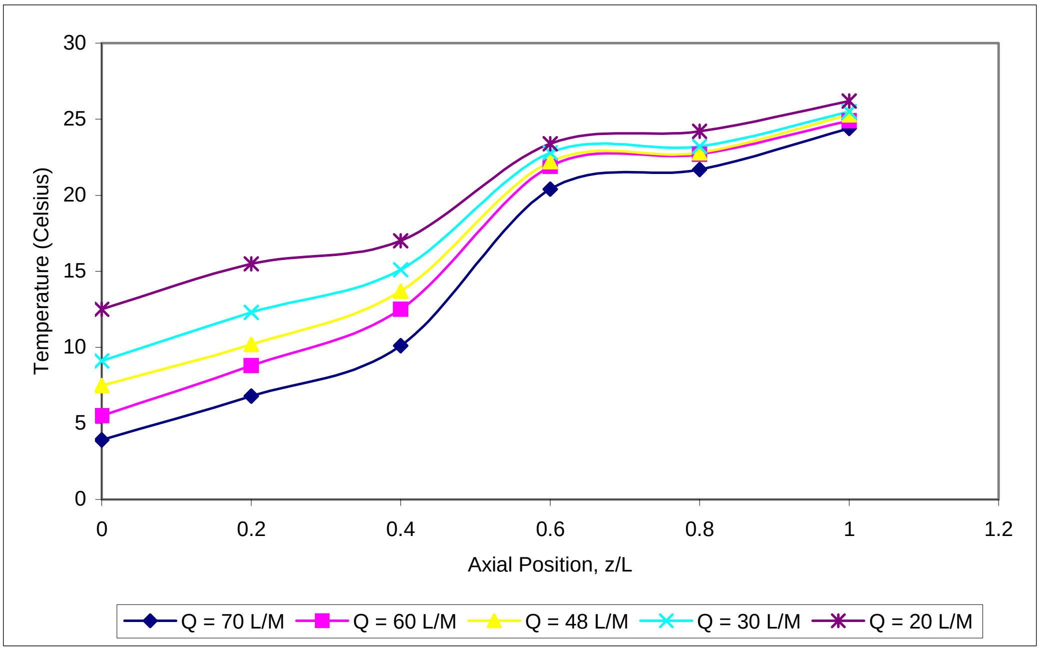
A351: Dimensionless Axial Profile of Temperature at 90 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



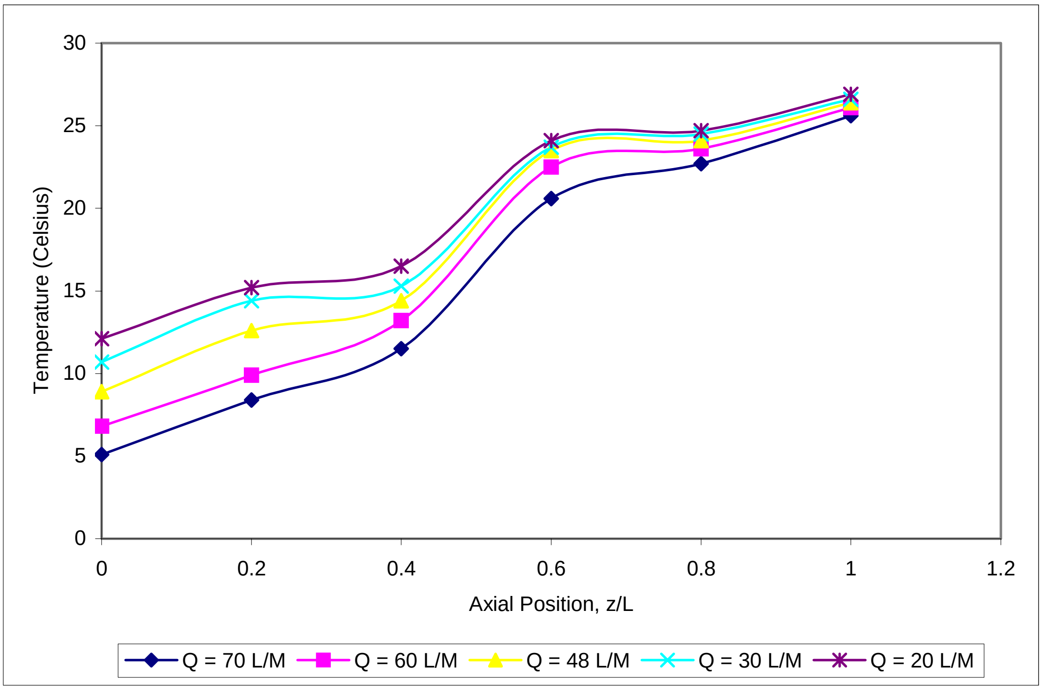
A352: Dimensionless Axial Profile of Temperature at 120 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



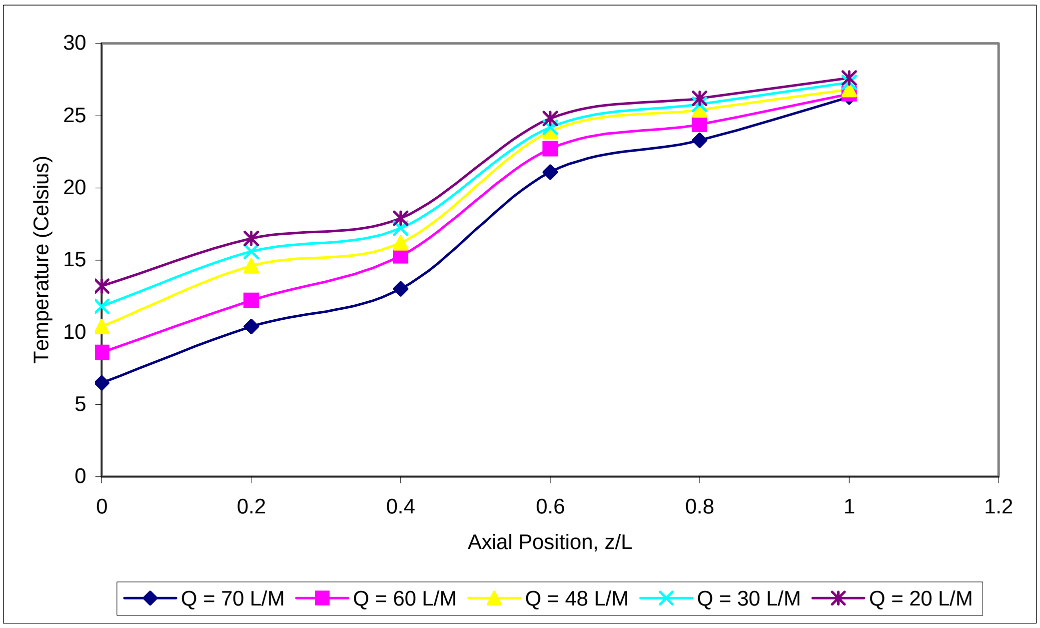
A353: Dimensionless Axial Profile of Temperature at 150 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



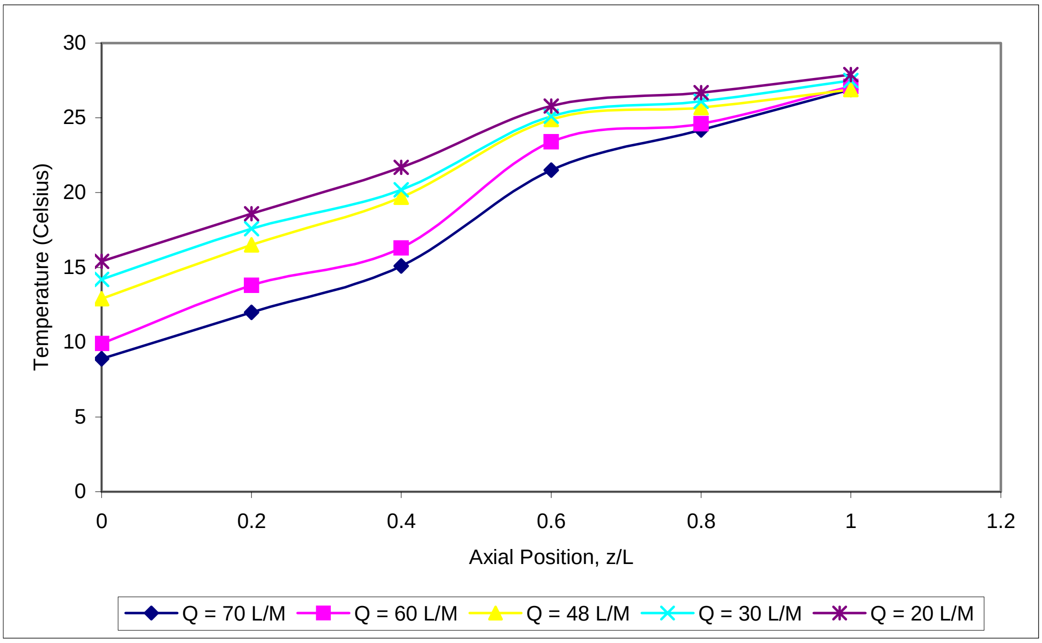
A354: Dimensionless Axial Profile of Temperature at 180 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



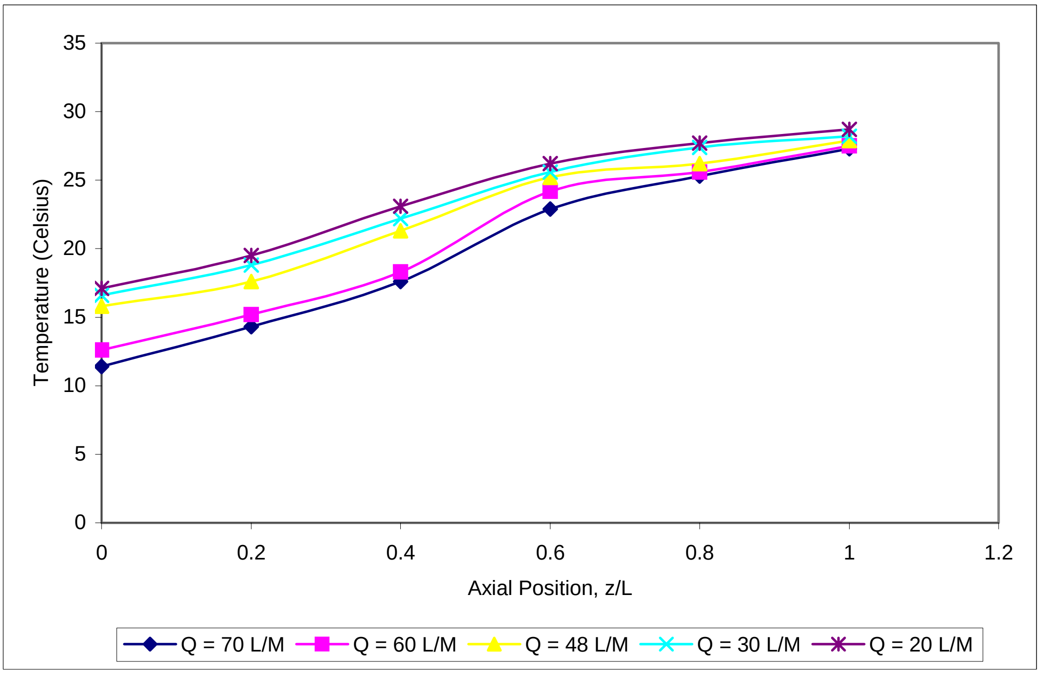
A355: Dimensionless Axial Profile of Temperature at 210 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



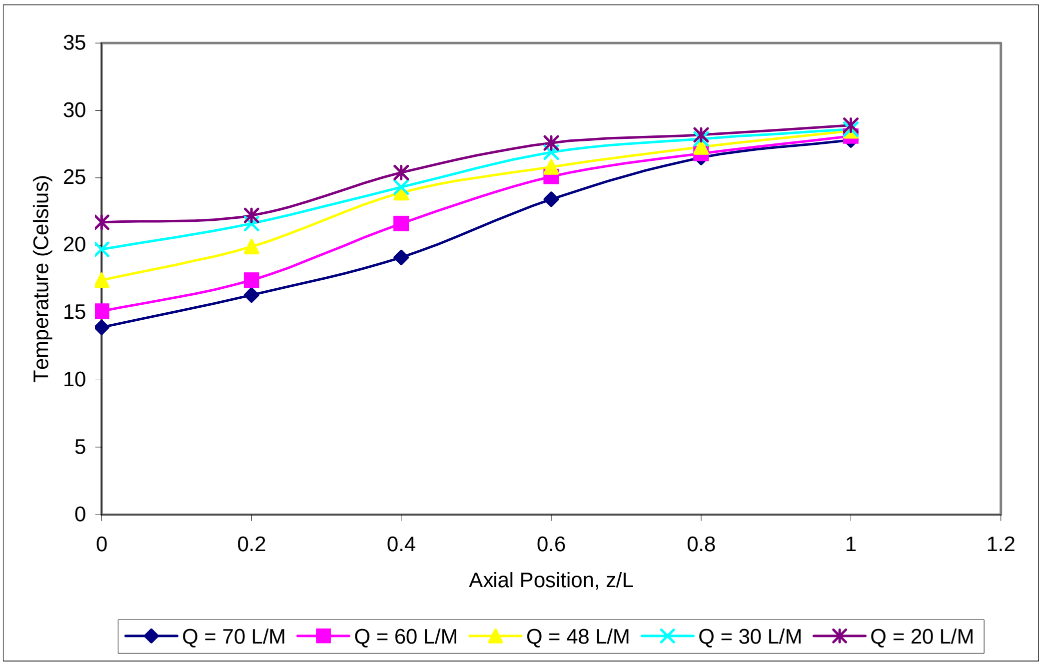
A356: Dimensionless Axial Profile of Temperature at 240 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



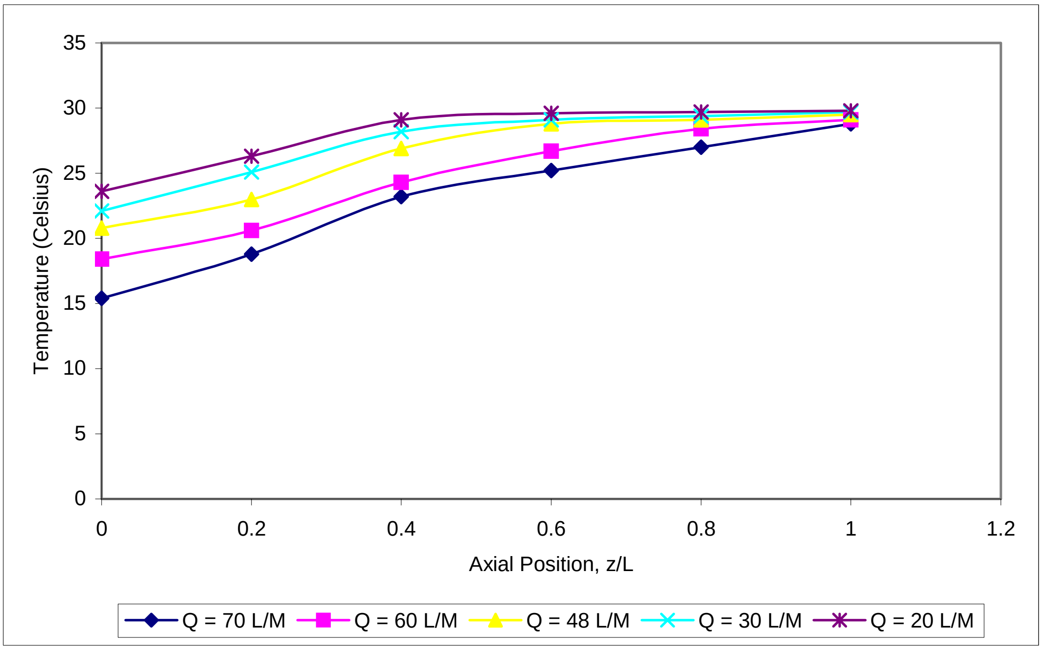
A357: Dimensionless Axial Profile of Temperature at 270 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



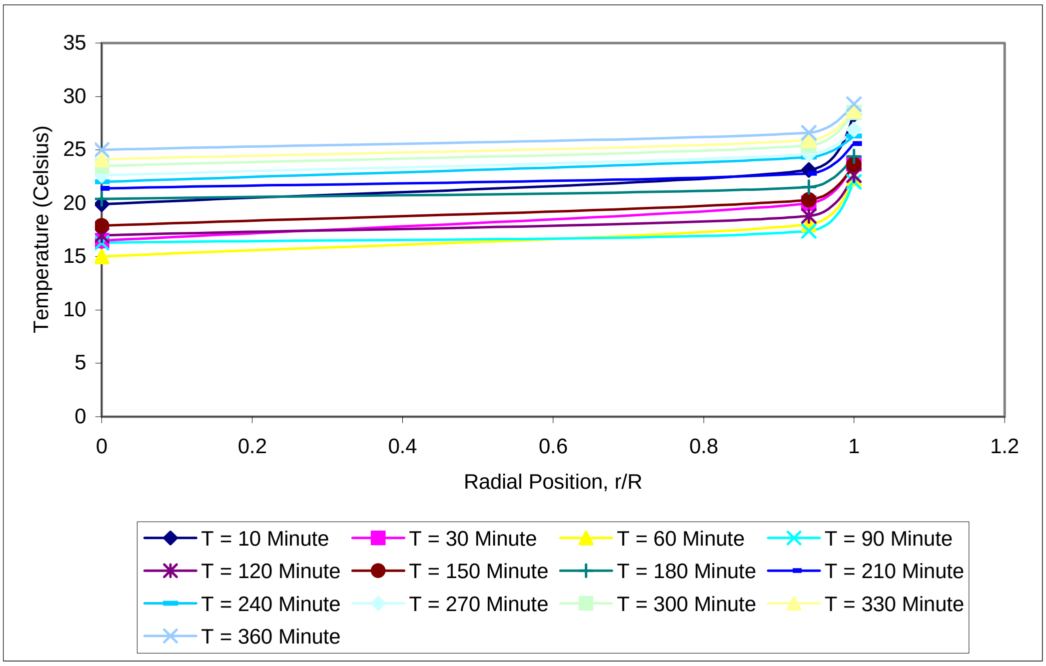
A358: Dimensionless Axial Profile of Temperature at 300 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



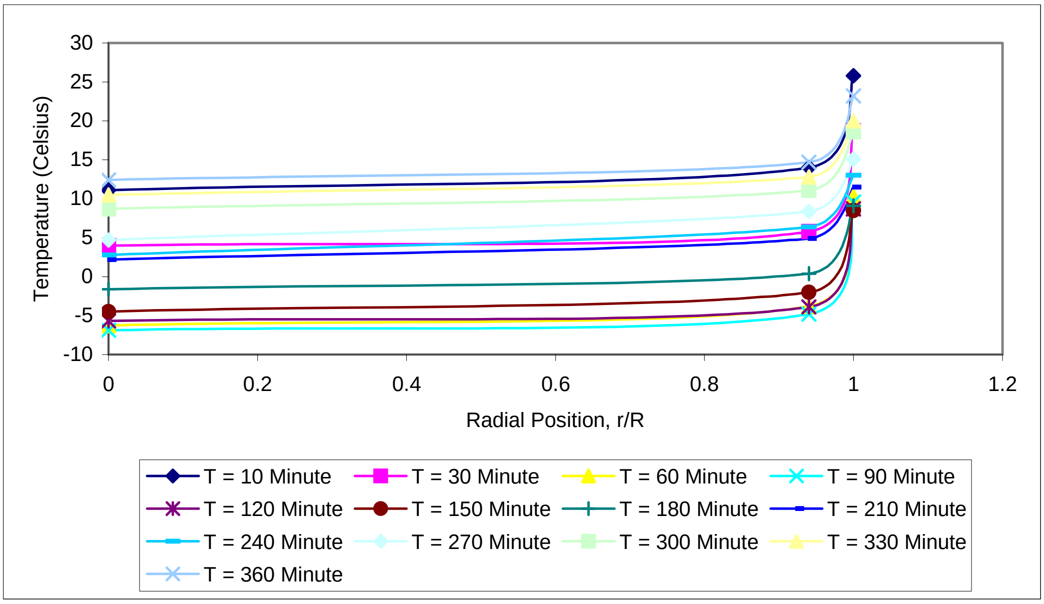
A359: Dimensionless Axial Profile of Temperature at 330 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



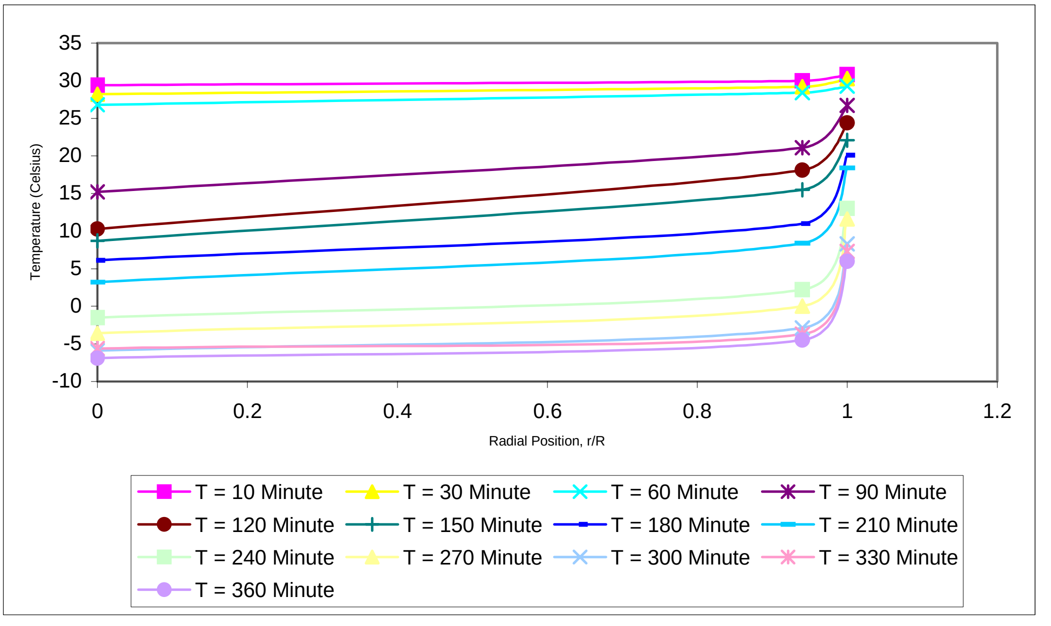
A360: Dimensionless Axial Profile of Temperature at 360 Minute at External Wall of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



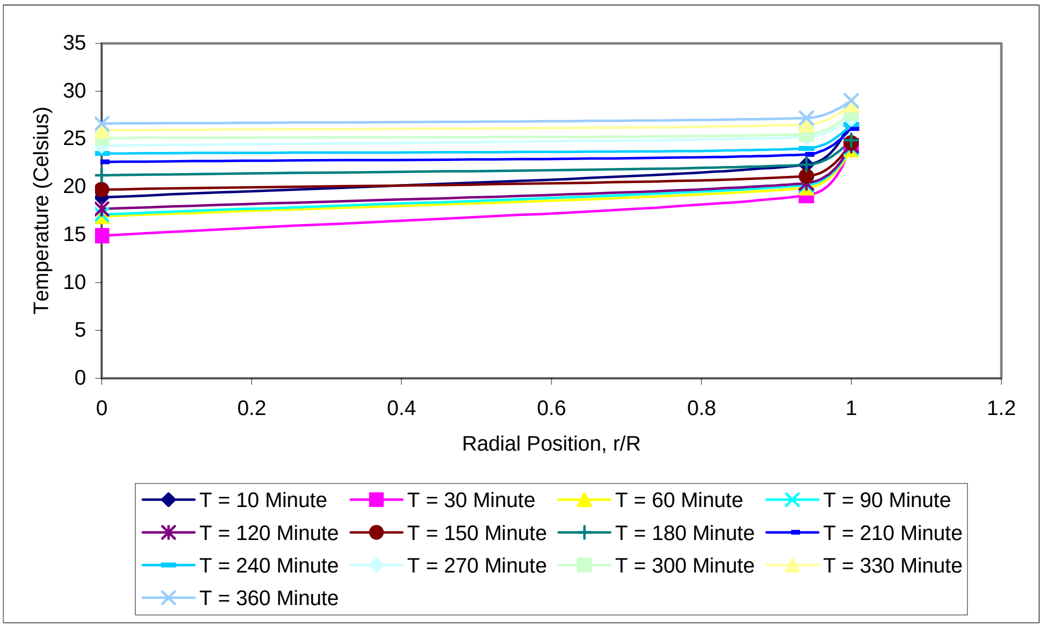
A361: Dimensionless Radial Profile of Temperature at Level 1 of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



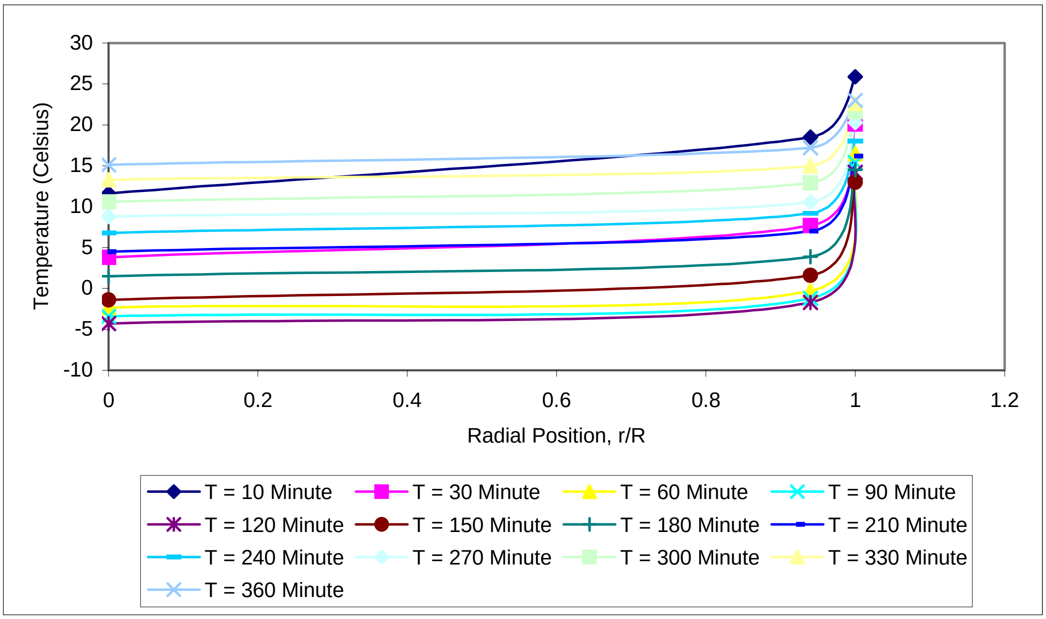
A362: Dimensionless Radial Profile of Temperature at Level 4 of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



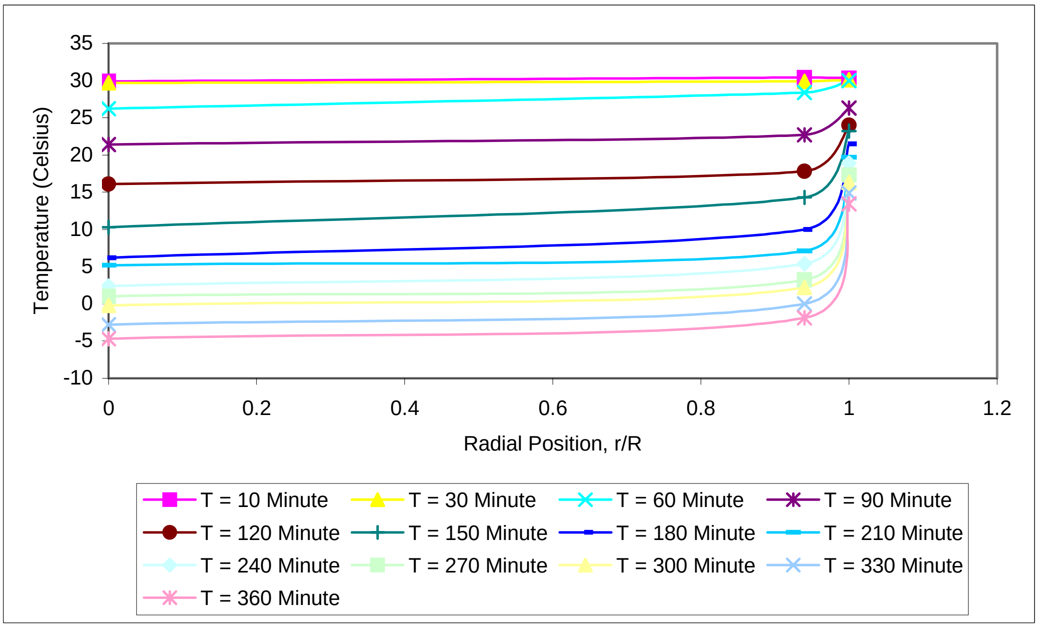
A363: Dimensionless Radial Profile of Temperature at Level 6 of Flow rate of 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



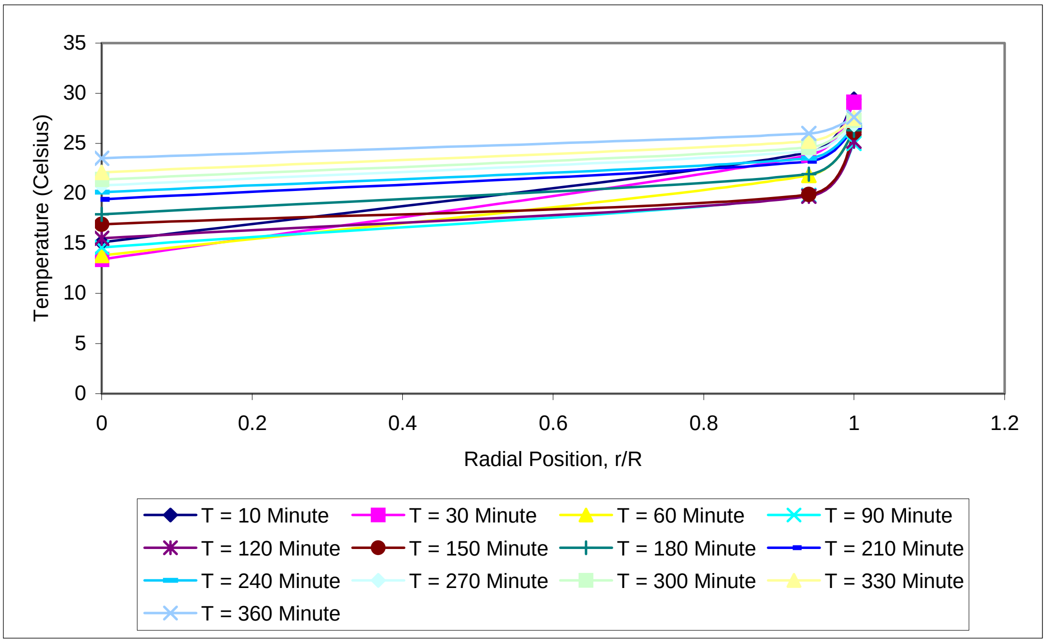
A364: Dimensionless Radial Profile of Temperature at Level 1 of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



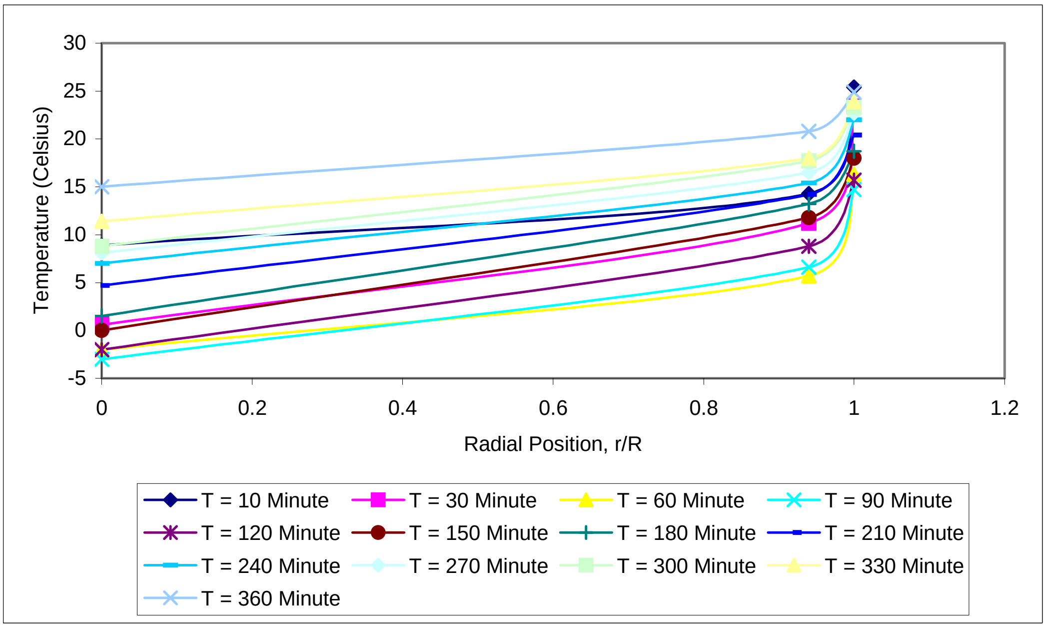
A365: Dimensionless Radial Profile of Temperature at Level 4 of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



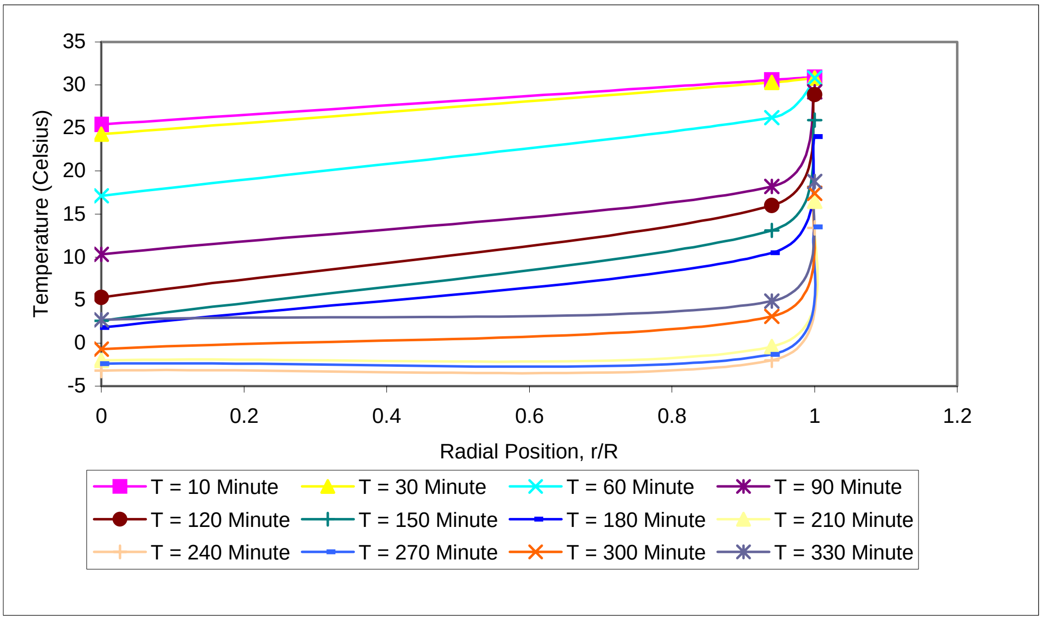
A366: Dimensionless Radial Profile of Temperature at Level 6 of Flow rate of 60 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



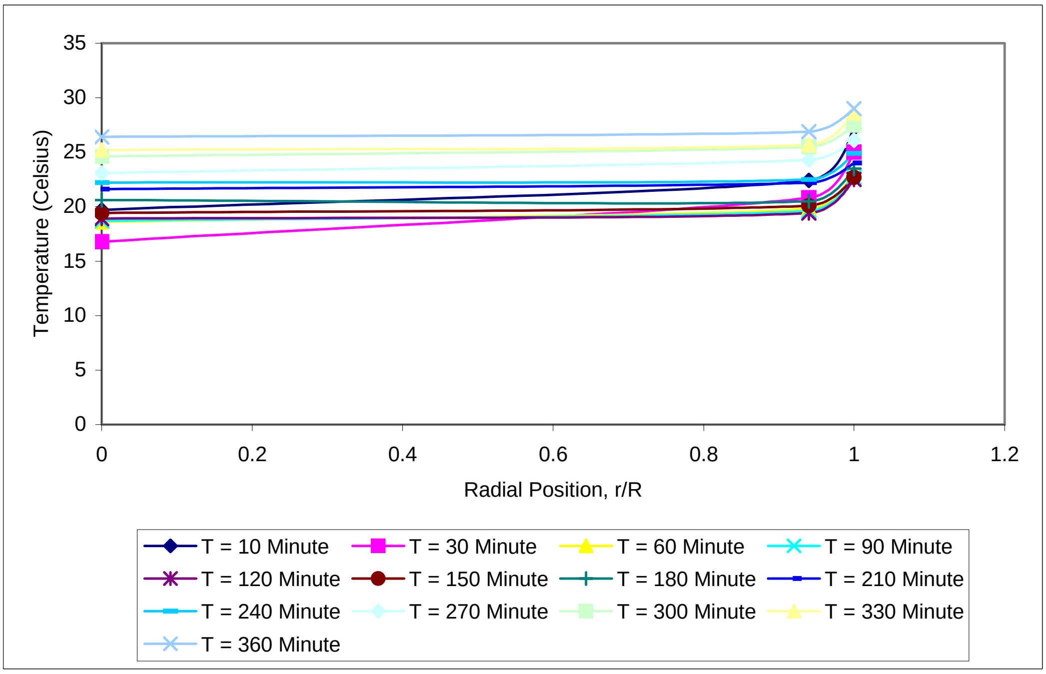
A367: Dimensionless Radial Profile of Temperature at Level 1 of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



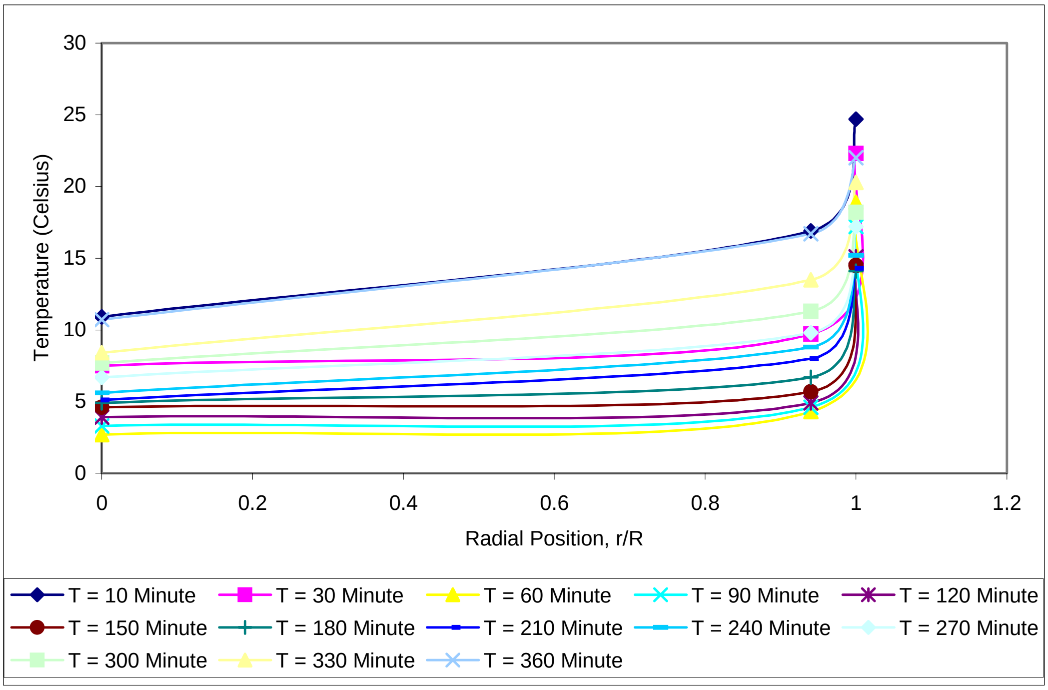
A368: Dimensionless Radial Profile of Temperature at Level 4 of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



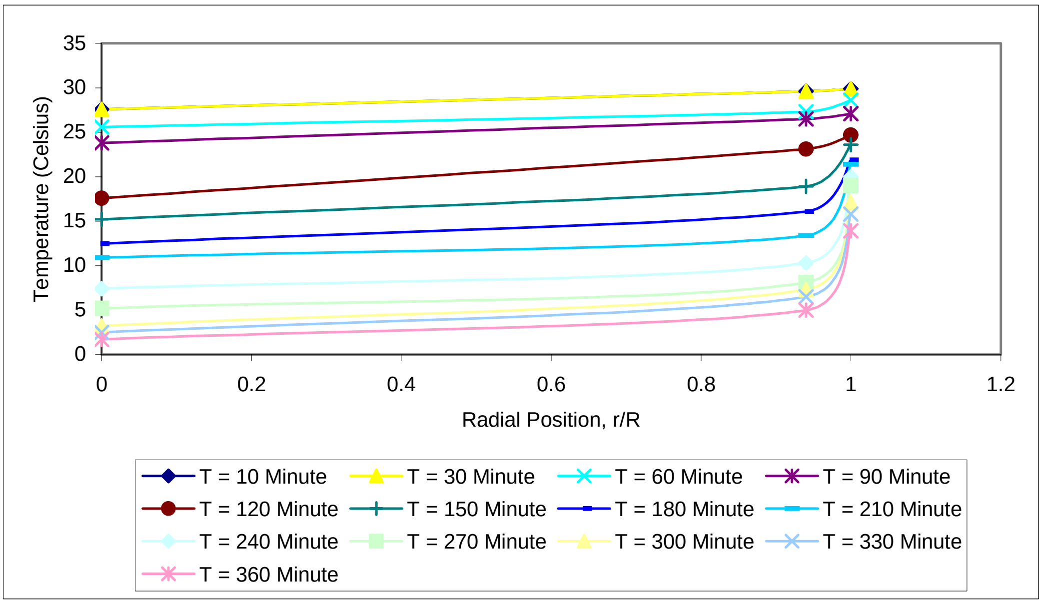
A369: Dimensionless Radial Profile of Temperature at Level 6 of Flow rate of 48 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



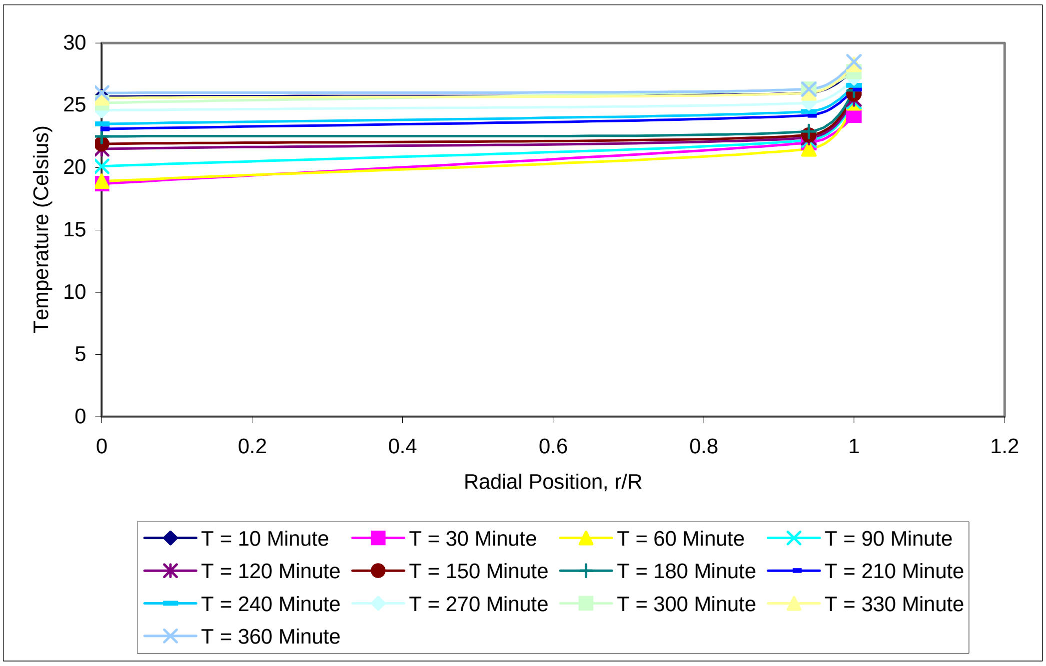
A370: Dimensionless Radial Profile of Temperature at Level 1 of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



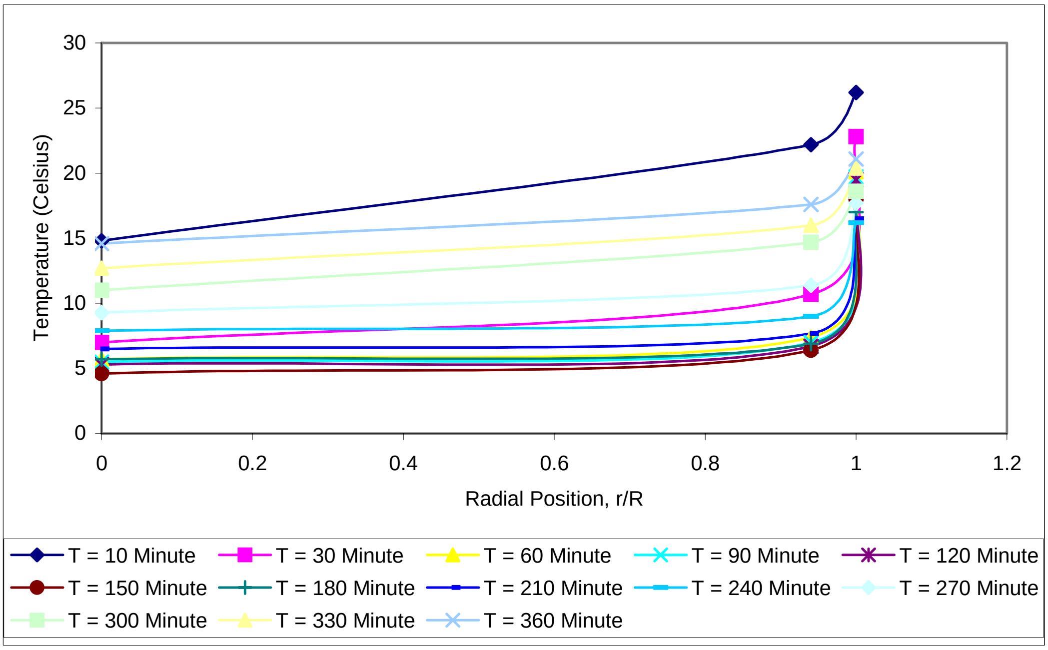
A371: Dimensionless Radial Profile of Temperature at Level 4 of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



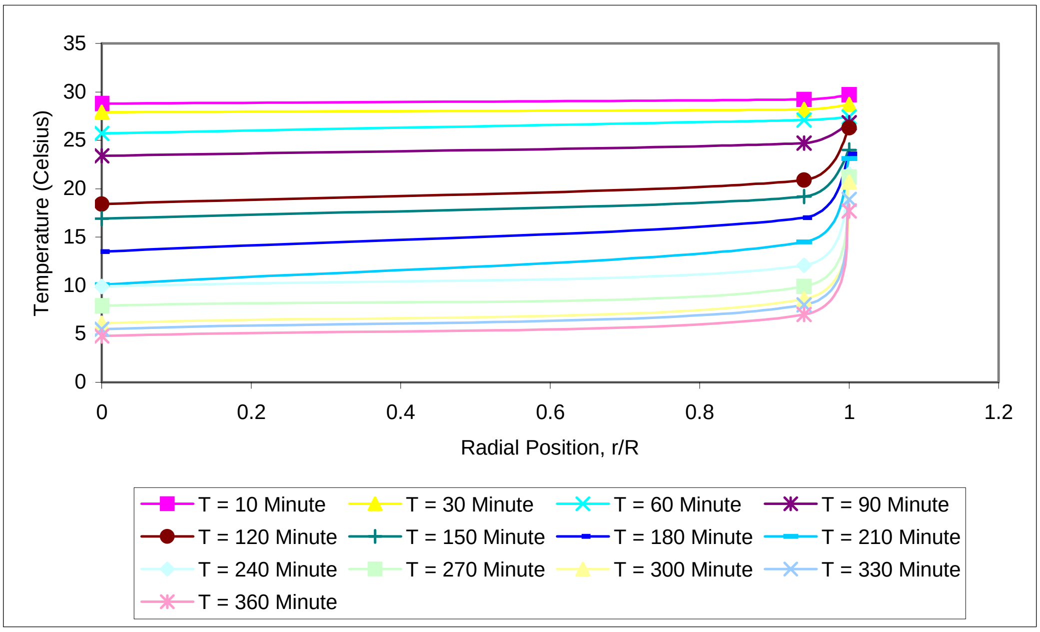
A372: Dimensionless Radial Profile of Temperature at Level 6 of Flow rate of 30 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



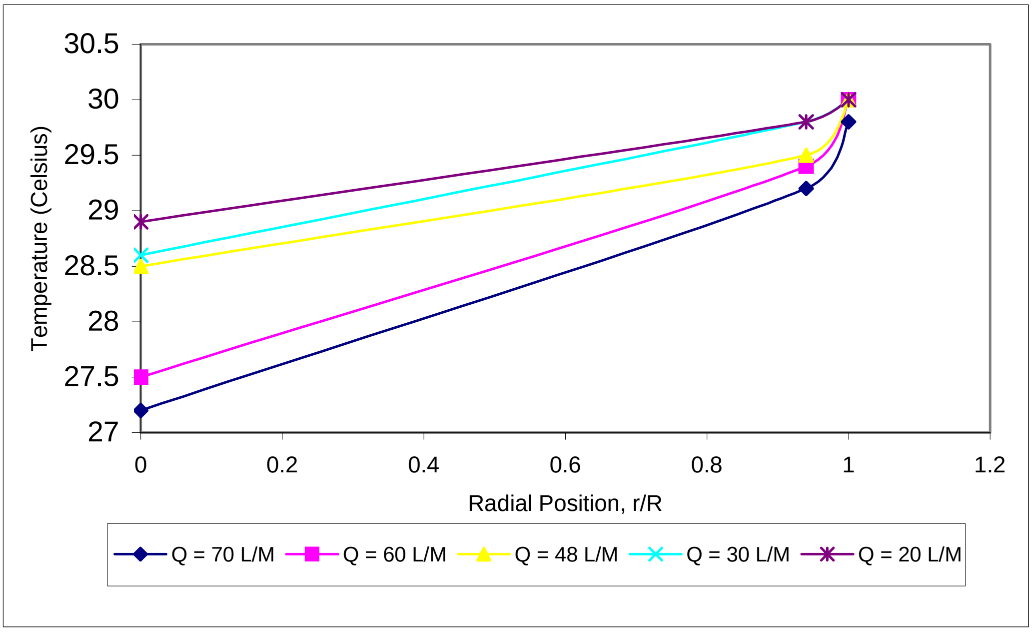
A373: Dimensionless Radial Profile of Temperature at Level 1 of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



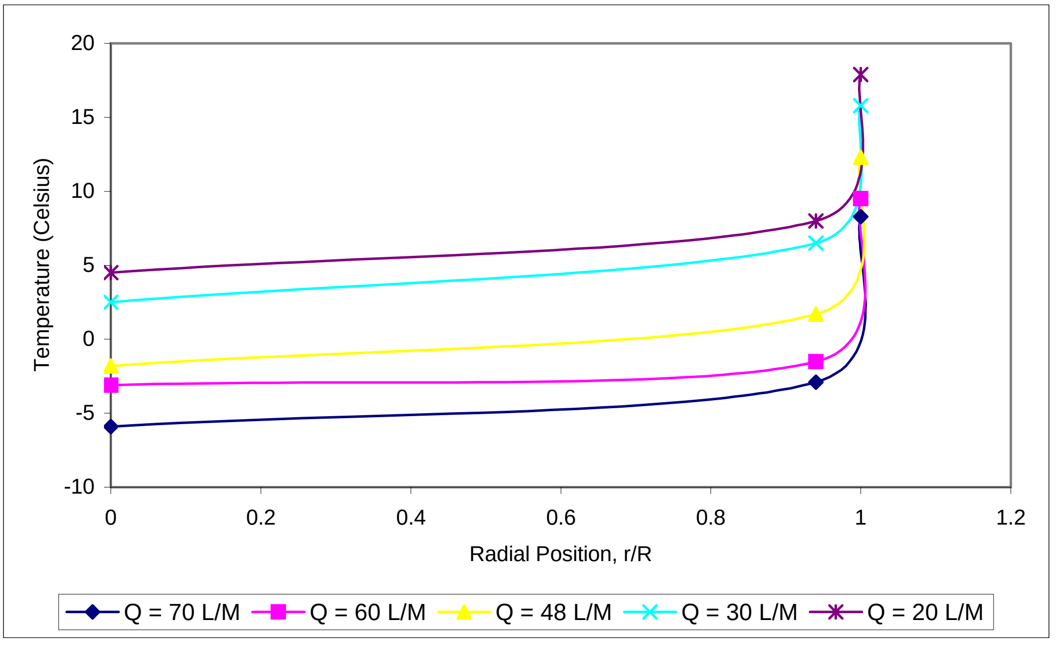
A374: Dimensionless Radial Profile of Temperature at Level 4 of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



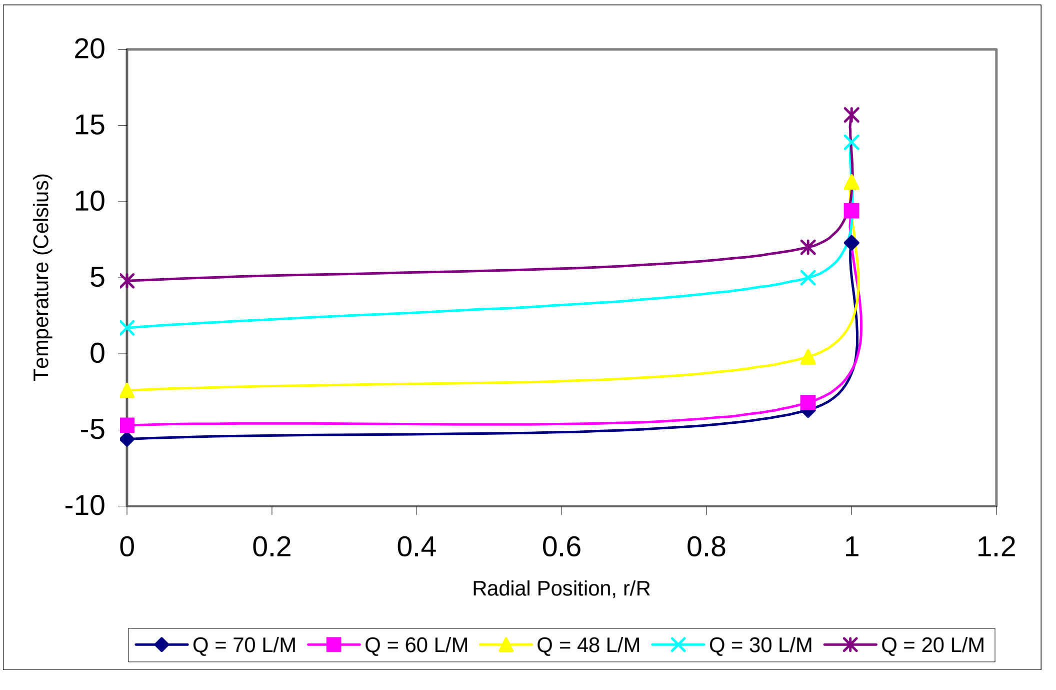
A375: Dimensionless Radial Profile of Temperature at Level 6 of Flow rate of 20 liter/minute at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



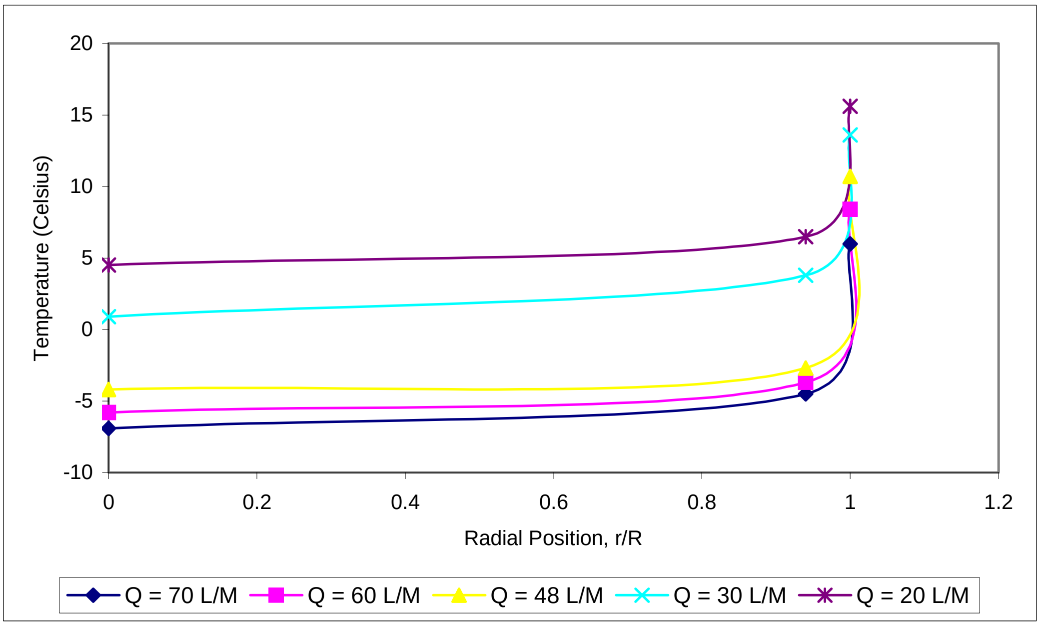
A376: Dimensionless Radial Profile of Temperature at Level 6 at 10 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



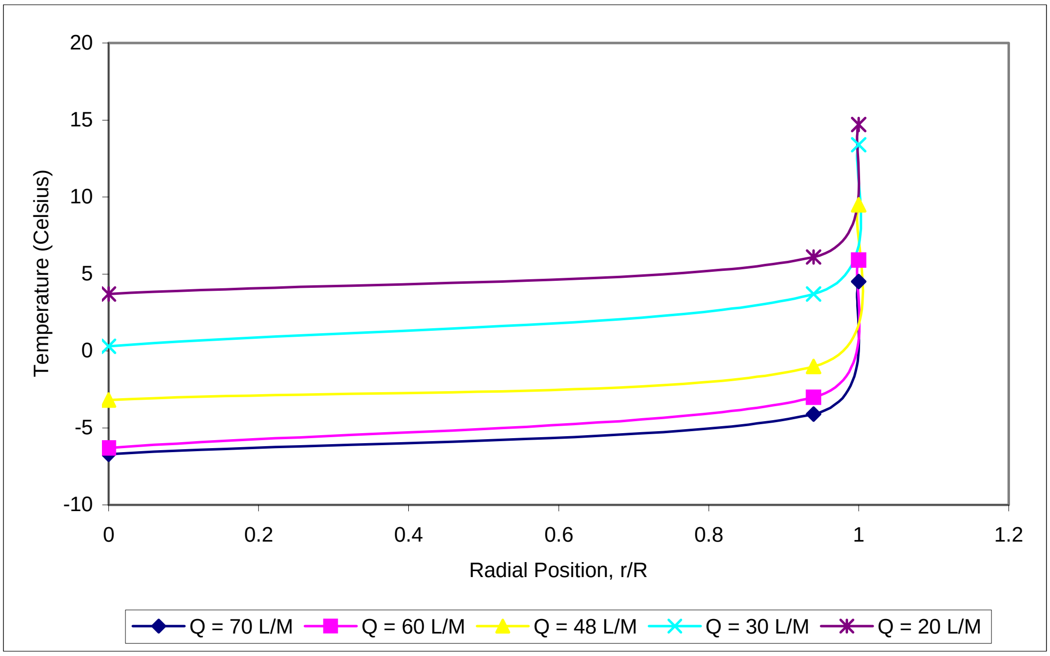
A377: Dimensionless Radial Profile of Temperature at Level 6 at 60 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



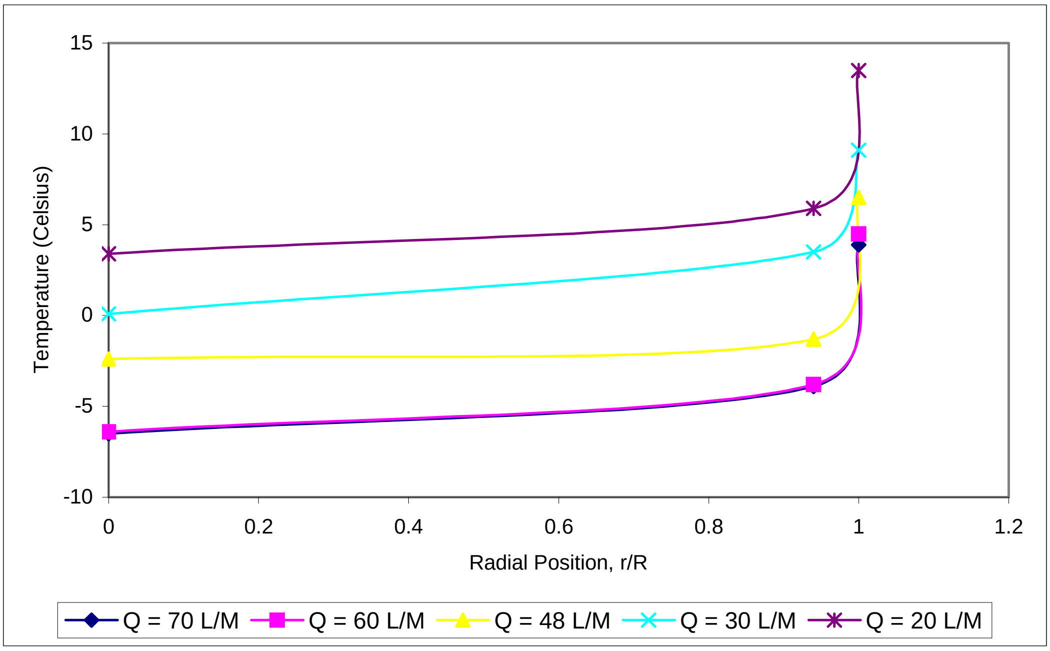
A378: Dimensionless Radial Profile of Temperature at Level 6 at 90 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



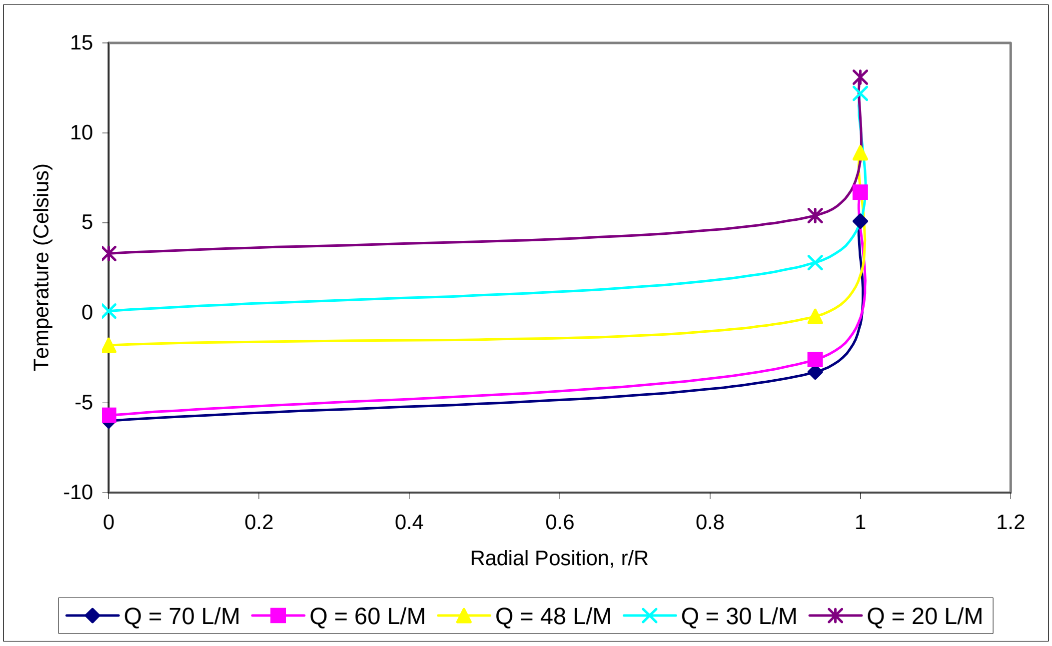
A379: Dimensionless Radial Profile of Temperature at Level 6 at 120 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



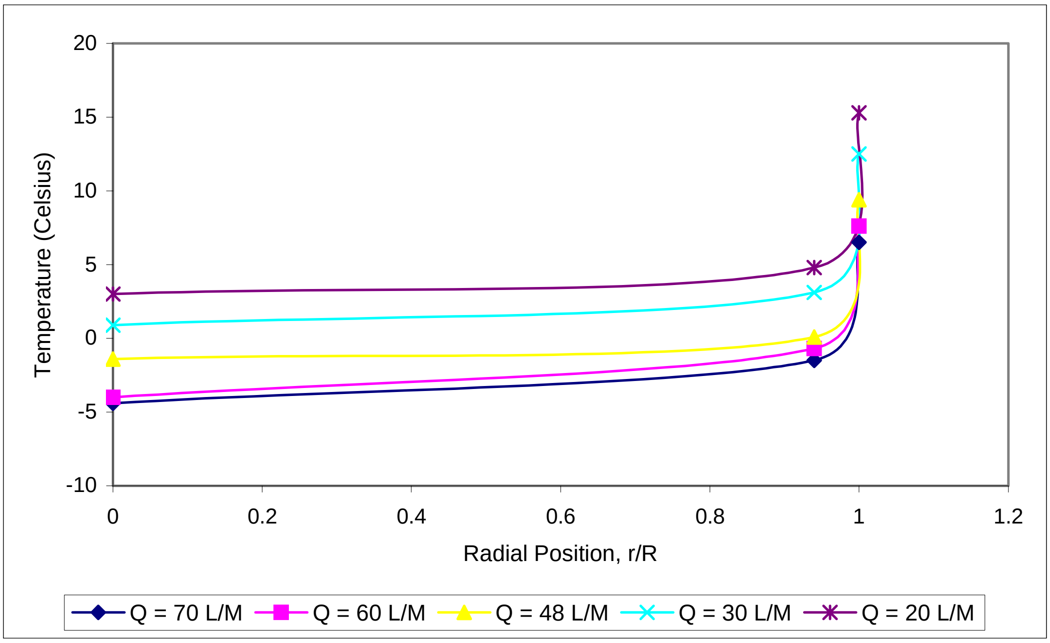
A380: Dimensionless Radial Profile of Temperature at Level 6 at 150 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



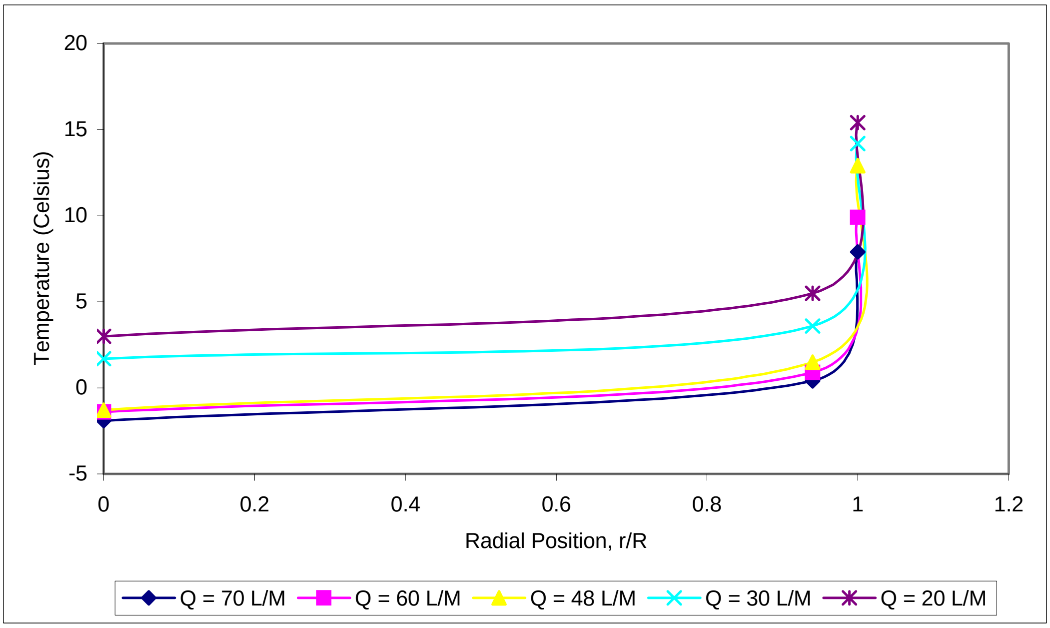
A381: Dimensionless Radial Profile of Temperature at Level 6 at 180 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



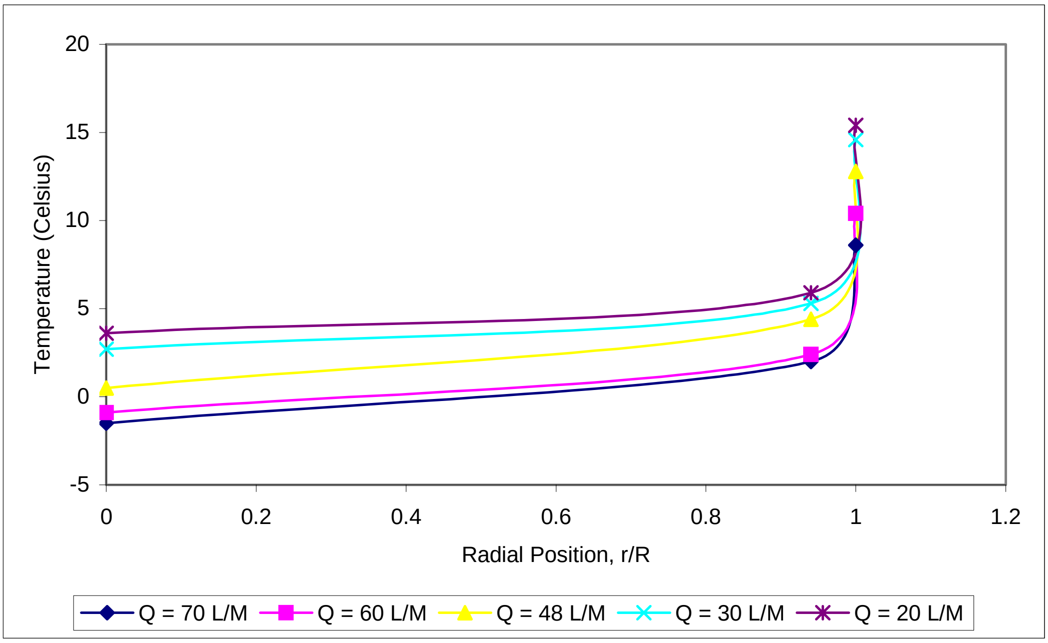
A382: Dimensionless Radial Profile of Temperature at Level 6 at 210 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



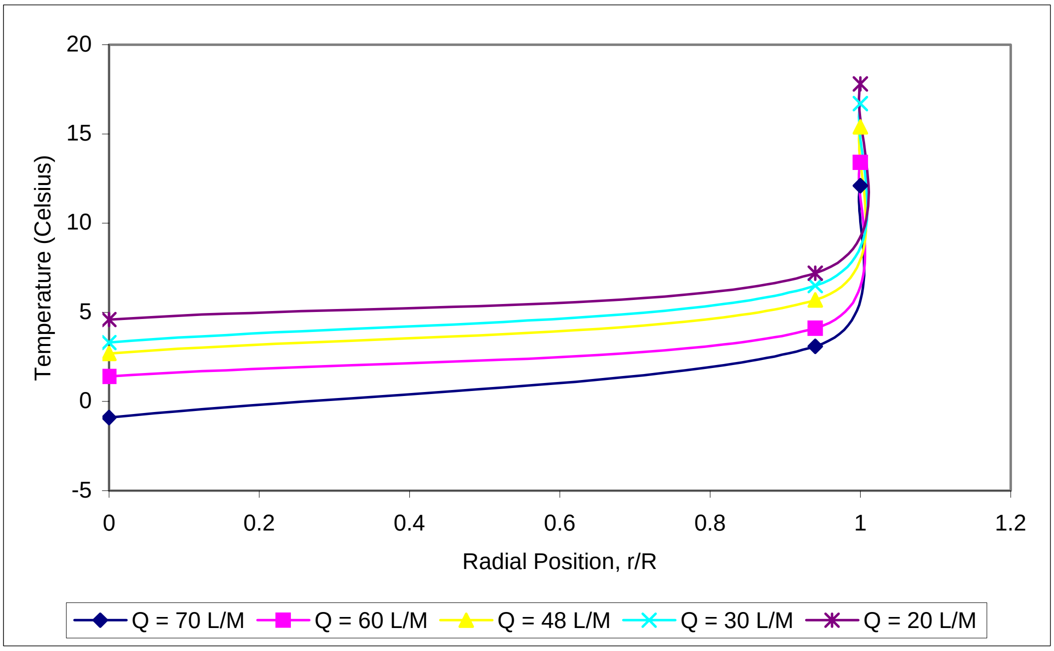
A383: Dimensionless Radial Profile of Temperature at Level 6 at 240 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



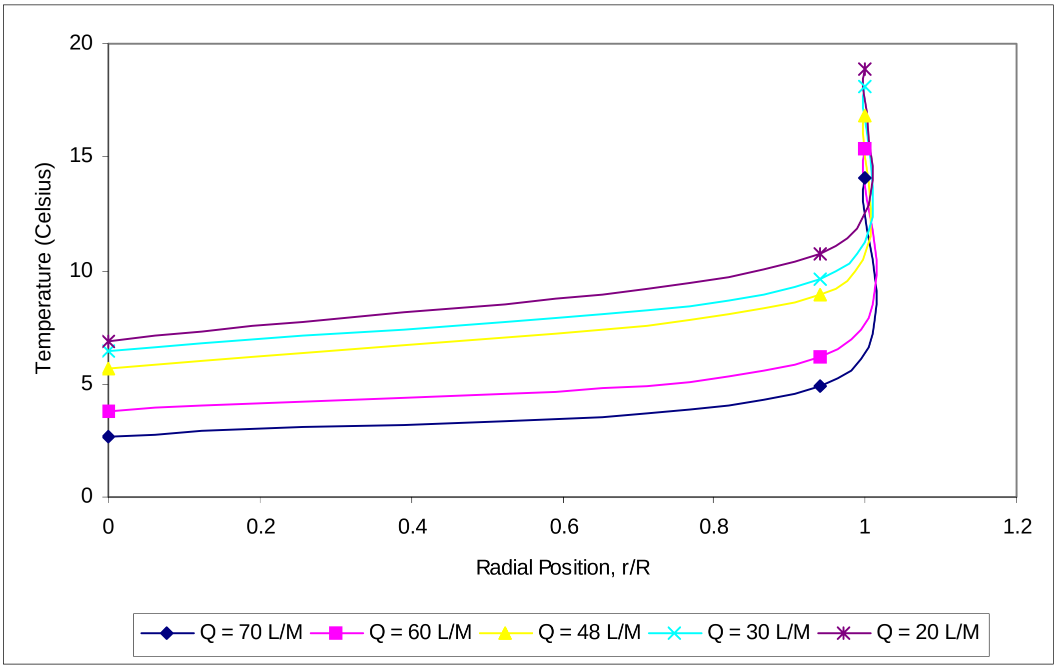
A384: Dimensionless Radial Profile of Temperature at Level 6 at 270 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



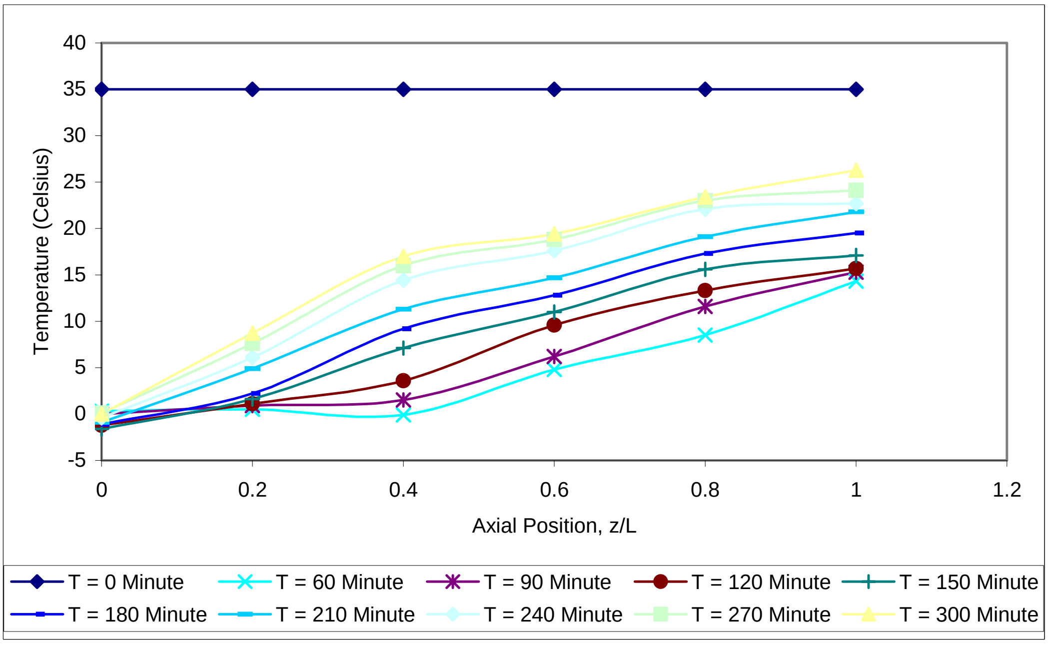
A385: Dimensionless Radial Profile of Temperature at Level 6 at 300 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



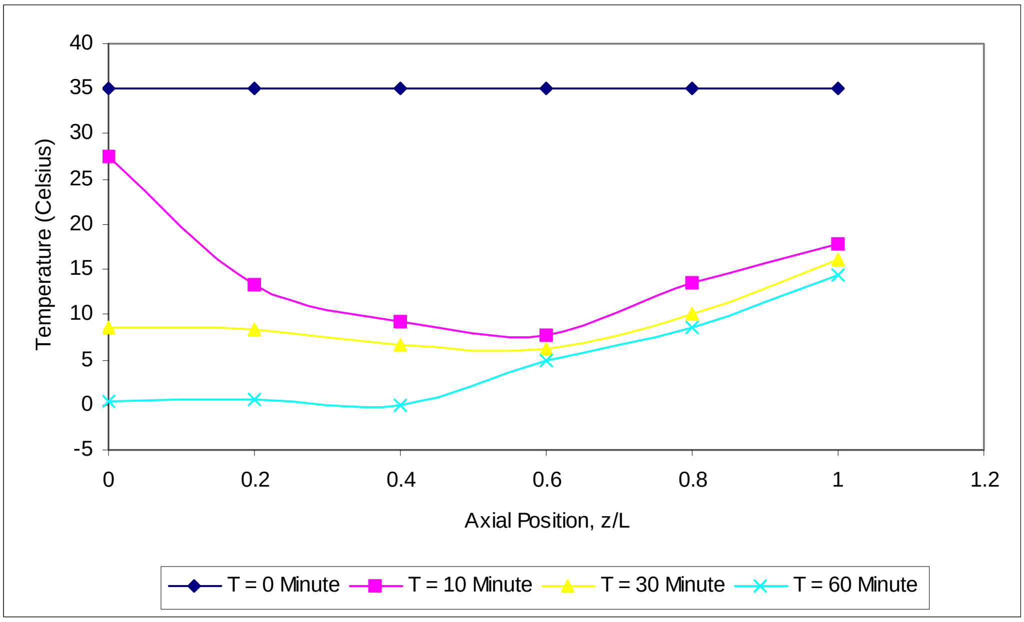
A386: Dimensionless Radial Profile of Temperature at Level 6 at 330 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg



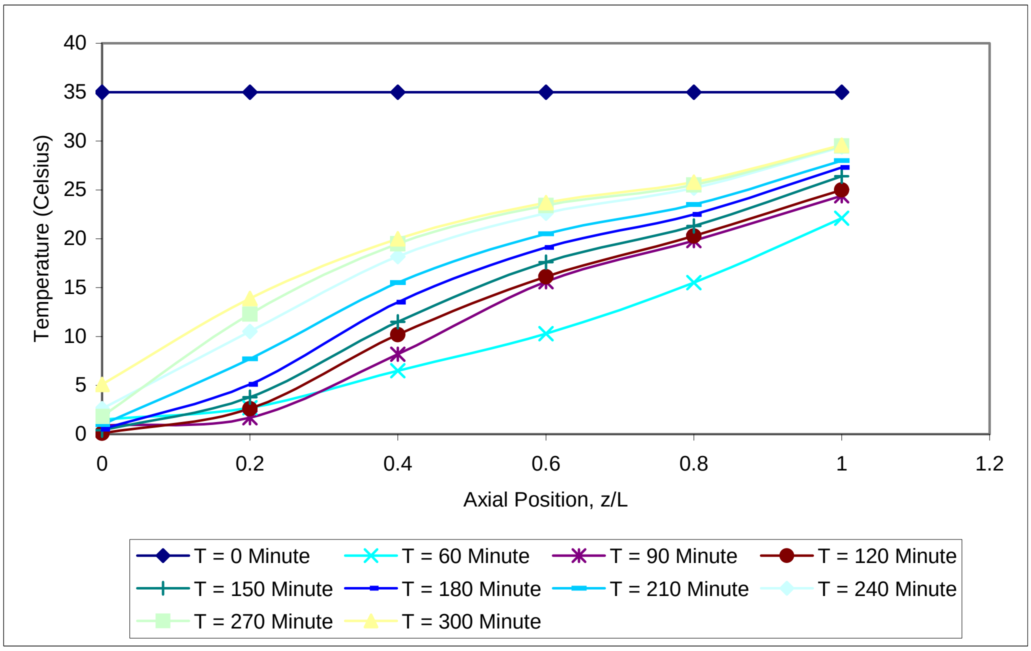
A387: Dimensionless Radial Profile of Temperature at Level 6 at 360 Minute of Various Flow rate at Composition of 4060, Surrounding Temperature of 30°C and Weight of 6 kg



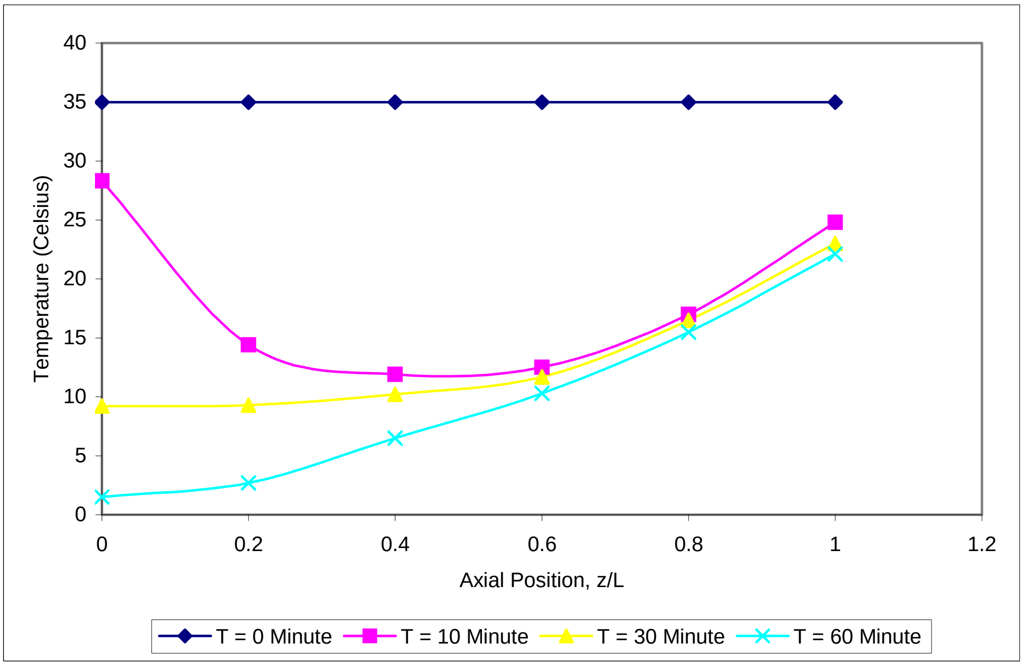
A388: Dimensionless Axial Profile of Temperature at Center of Surrounding Temperature of 35°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



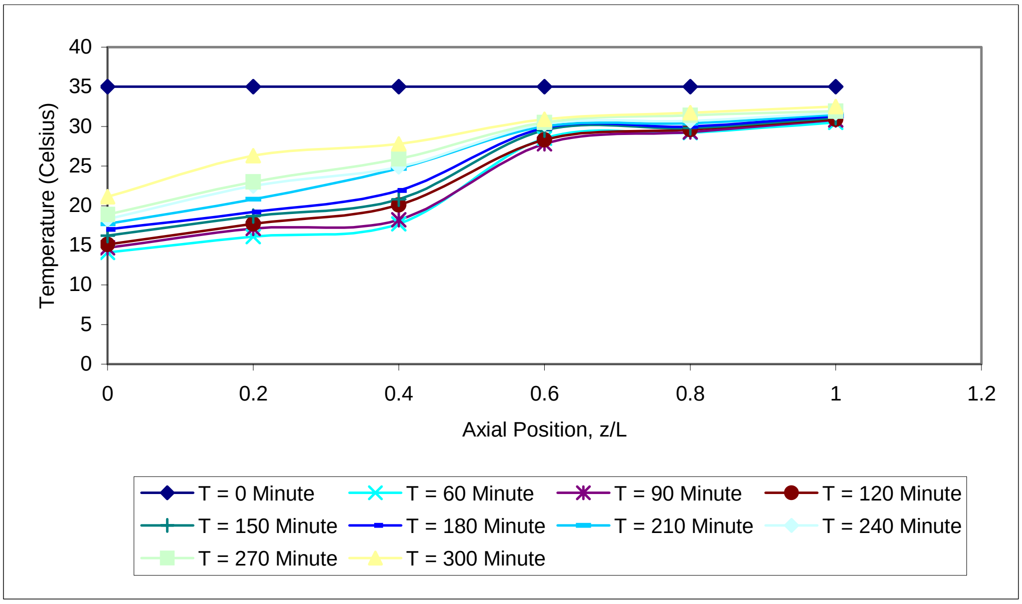
A389: Dimensionless Axial Profile of Temperature at Early Stage at Center of Surrounding Temperature of 35°C Commercial at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



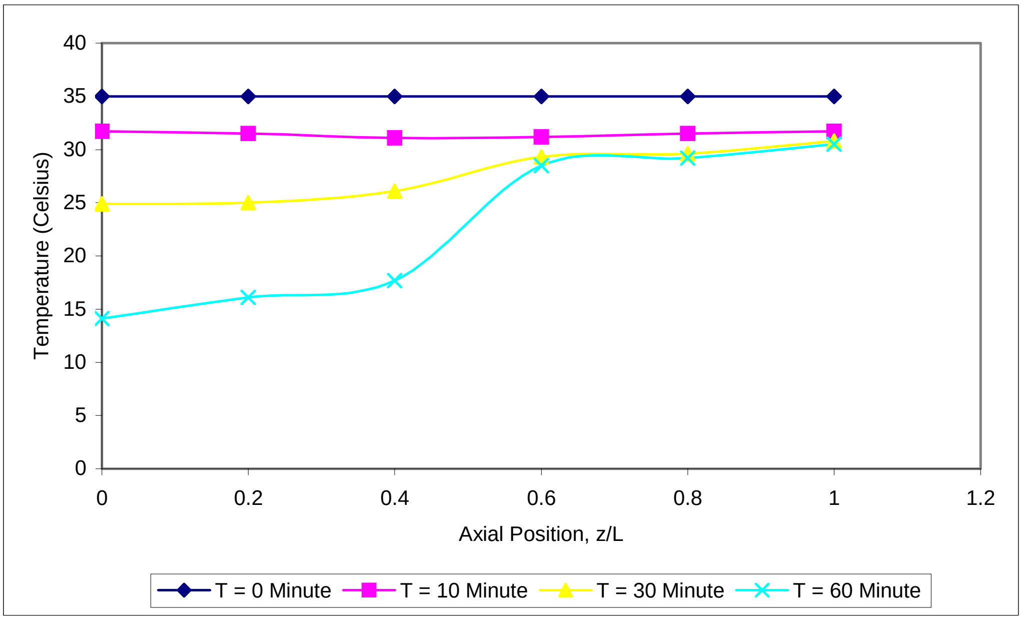
A390: Dimensionless Axial Profile of Temperature at Internal Wall of Surrounding Temperature of 35°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



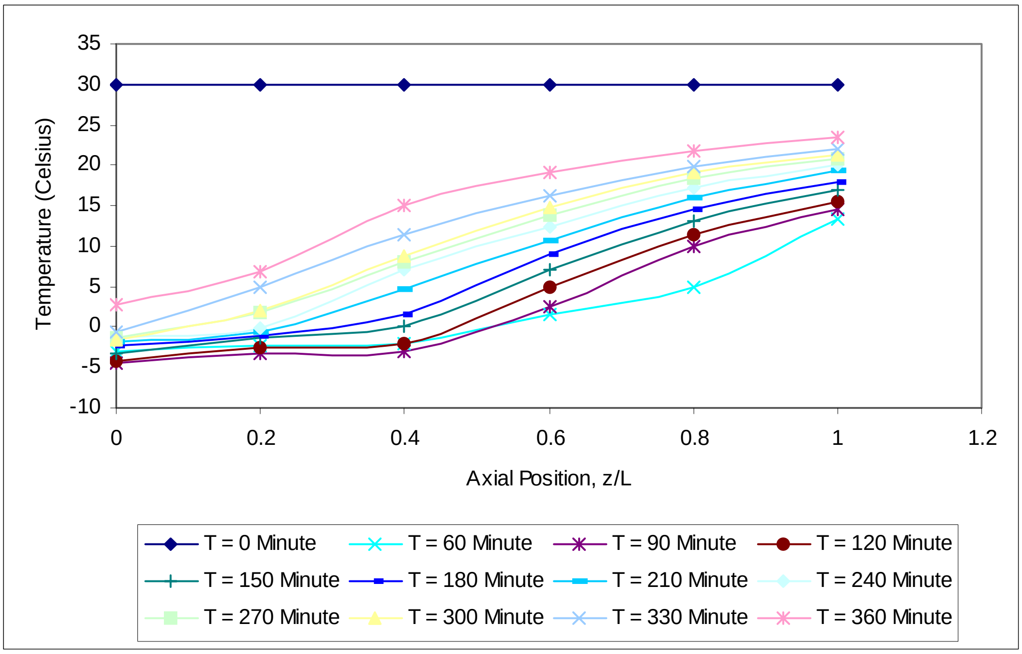
A391: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Surrounding Temperature of 35°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



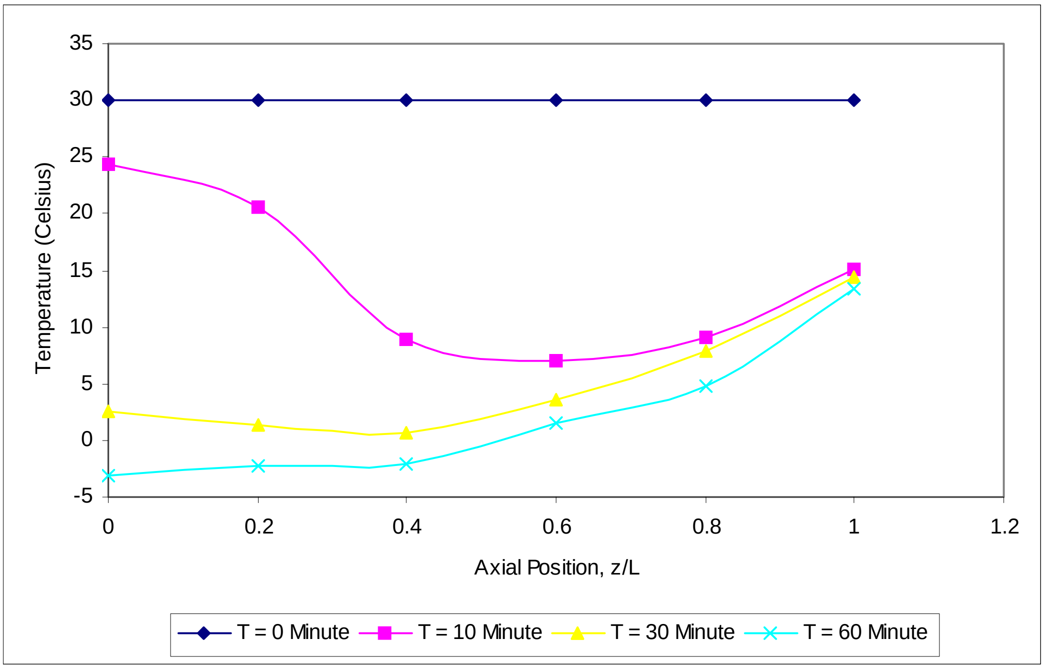
A392: Dimensionless Axial Profile of Temperature at External Wall of Surrounding Temperature of 35°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



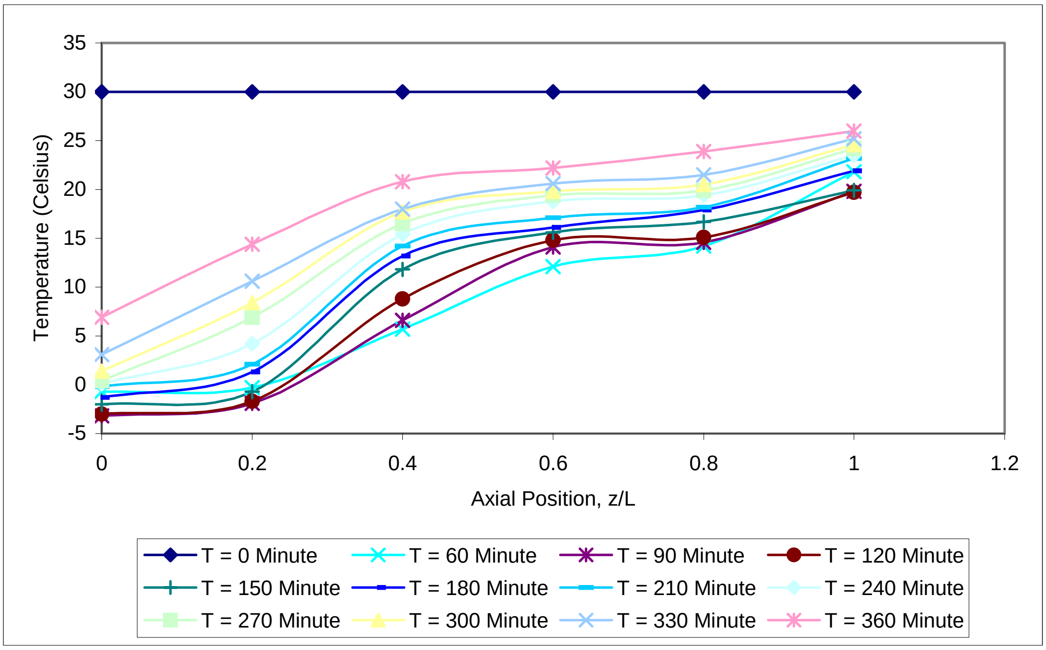
A393: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Surrounding Temperature of 35^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



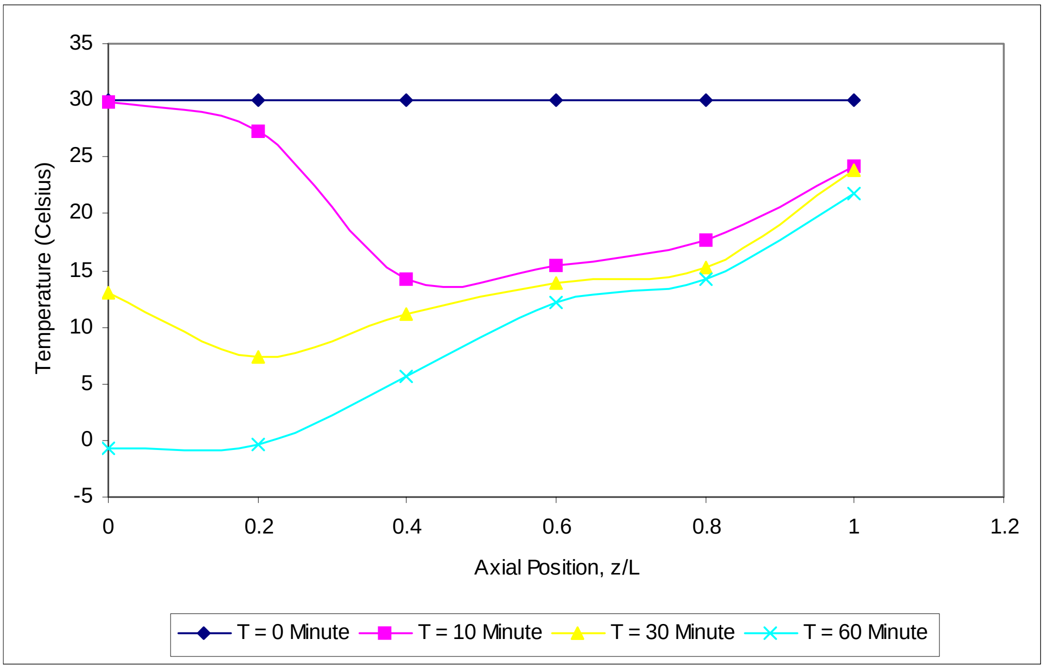
A394: Dimensionless Axial Profile of Temperature at Center of Surrounding Temperature of 30^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



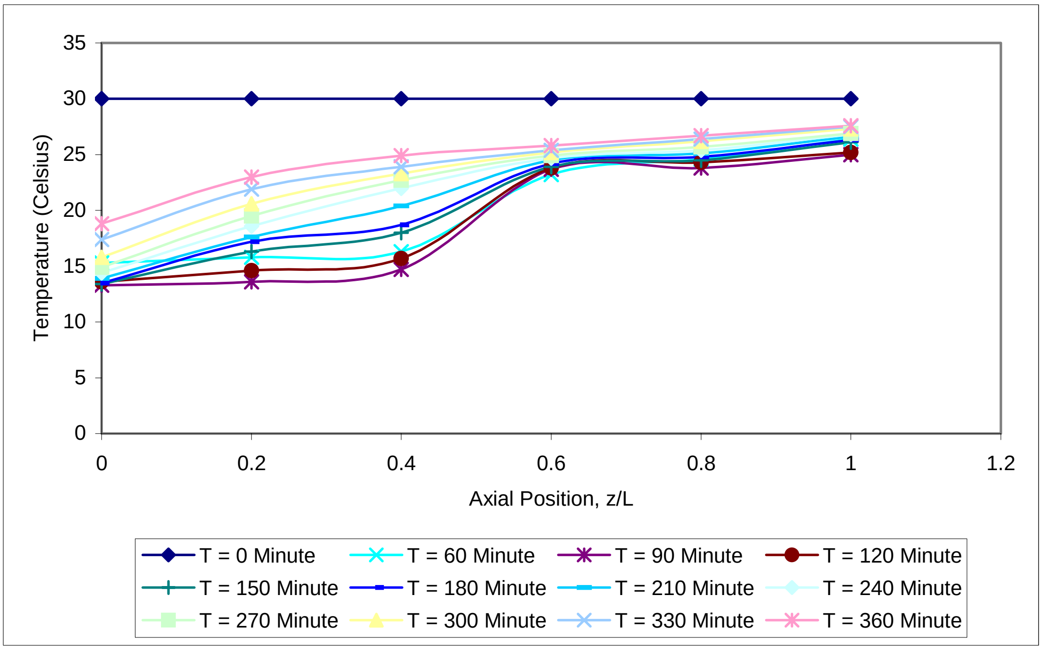
A395: Dimensionless Axial Profile of Temperature at Early Stage at Center of Surrounding Temperature of 30°C Commercial at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



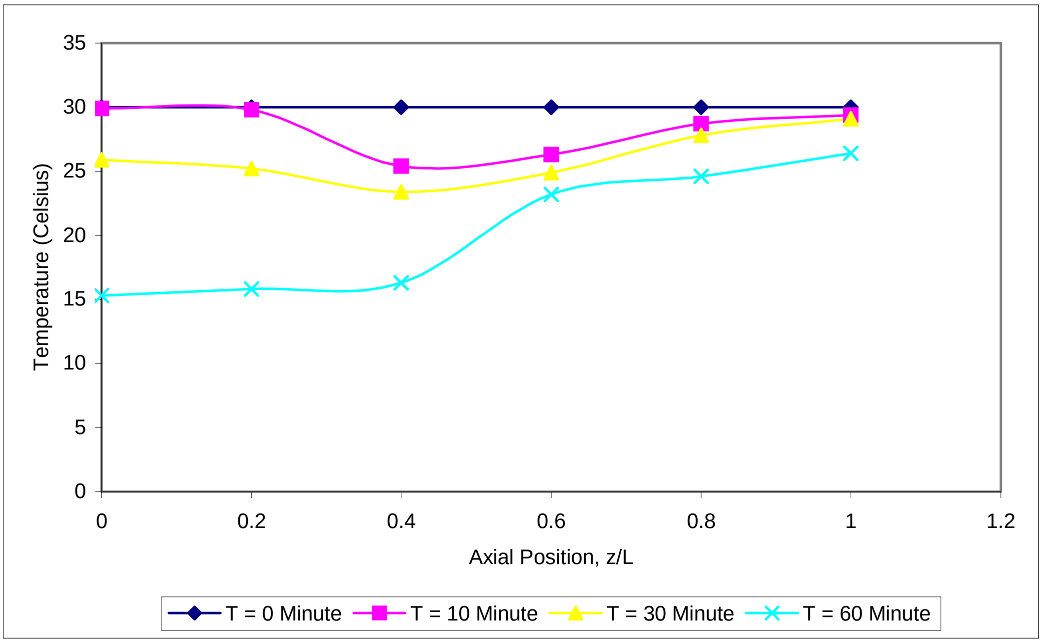
A396: Dimensionless Axial Profile of Temperature at Internal Wall of Surrounding Temperature of 30°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



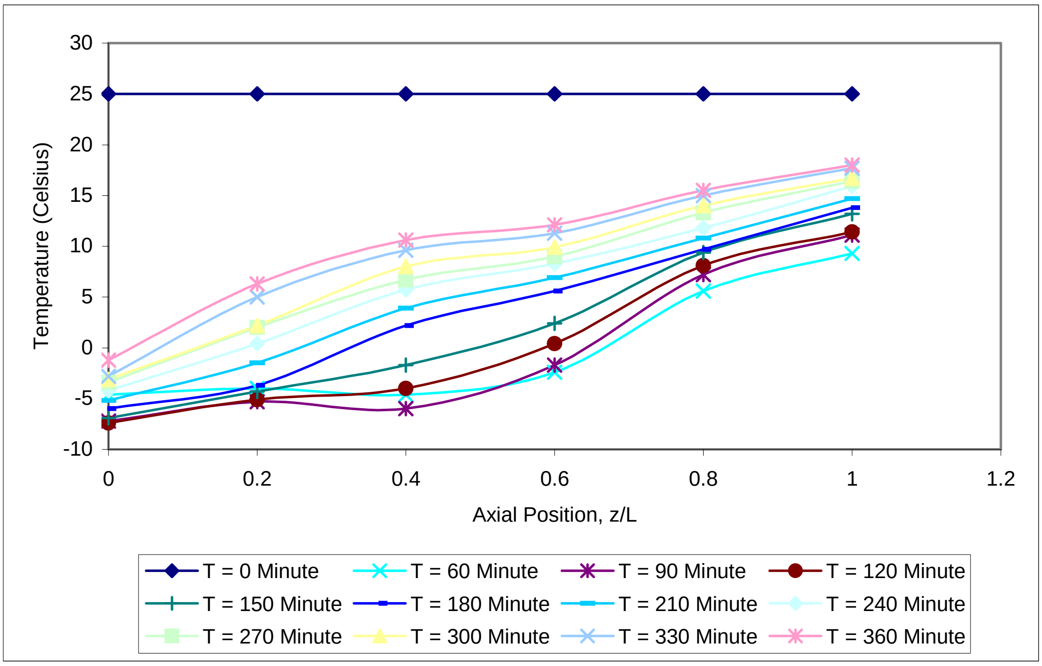
A397: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Surrounding Temperature of 30°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



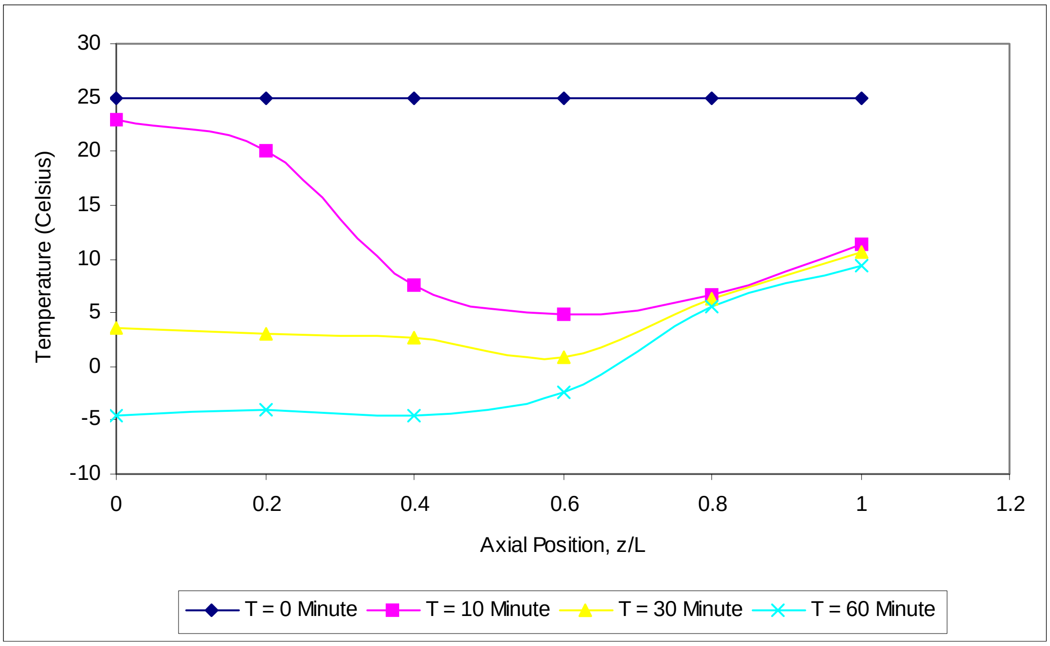
A398: Dimensionless Axial Profile of Temperature at External Wall of Surrounding Temperature of 30°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



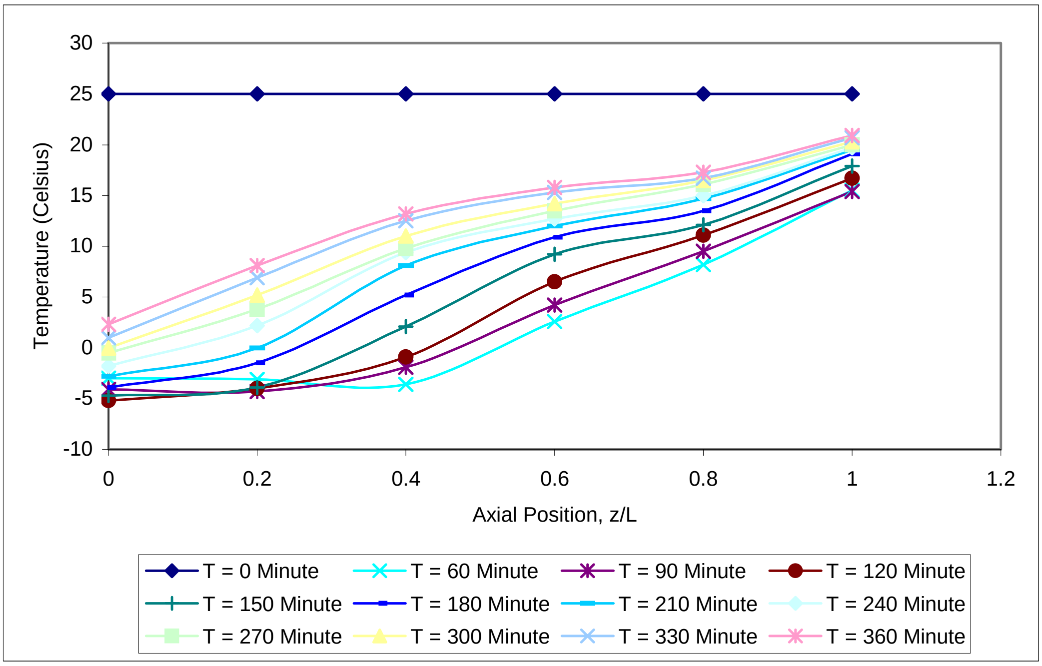
A399: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Surrounding Temperature of 30°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



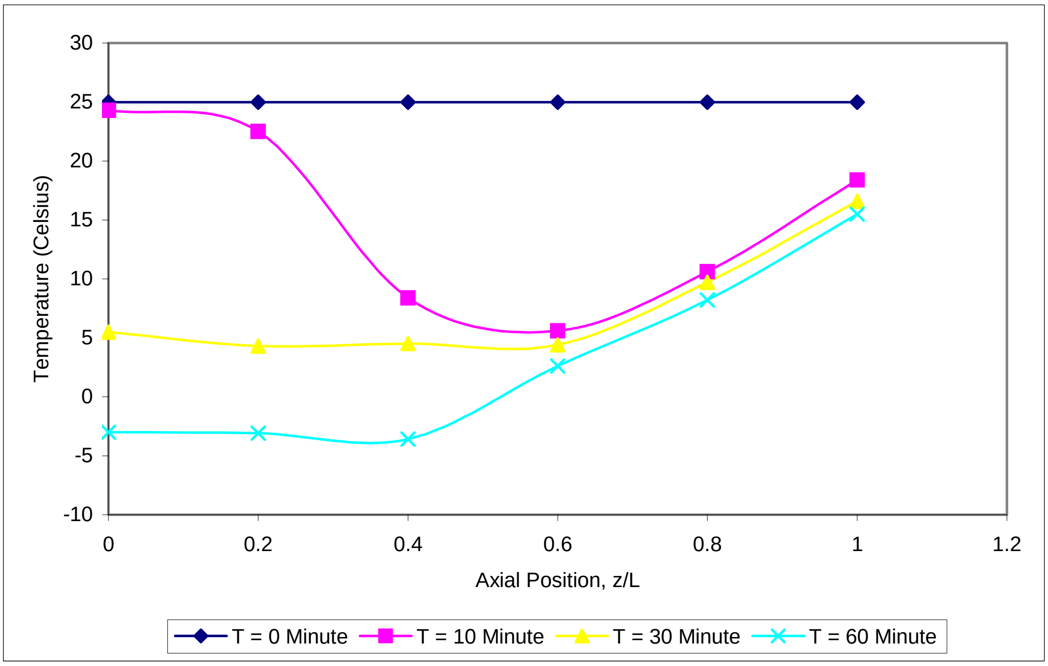
A400: Dimensionless Axial Profile of Temperature at Center of Surrounding Temperature of 25°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



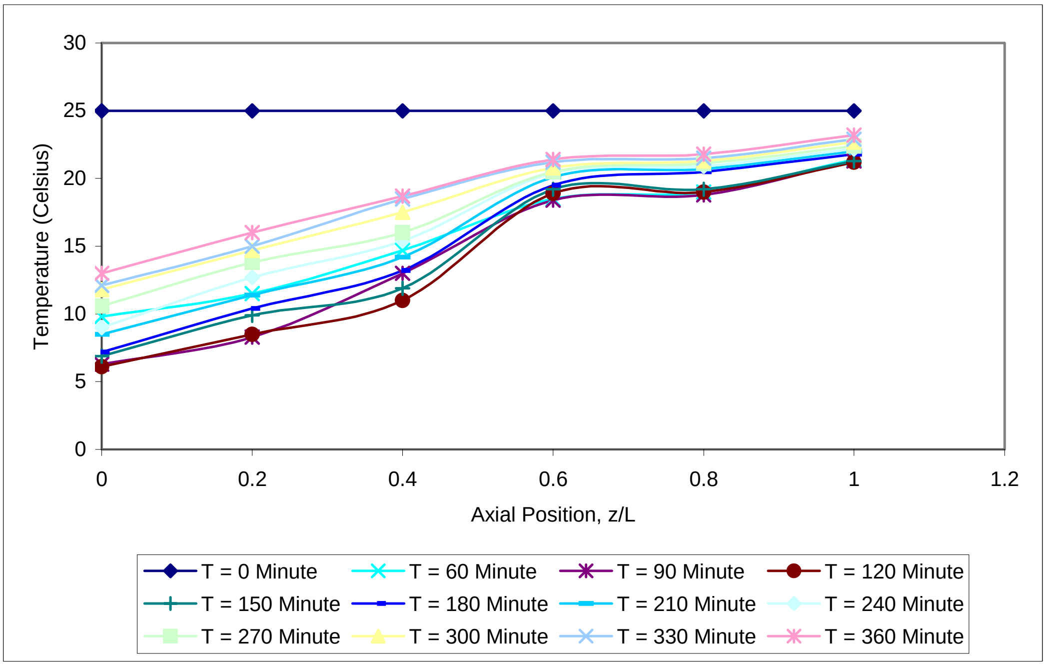
A401: Dimensionless Axial Profile of Temperature at Early Stage at Center of Surrounding Temperature of 25°C Commercial at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



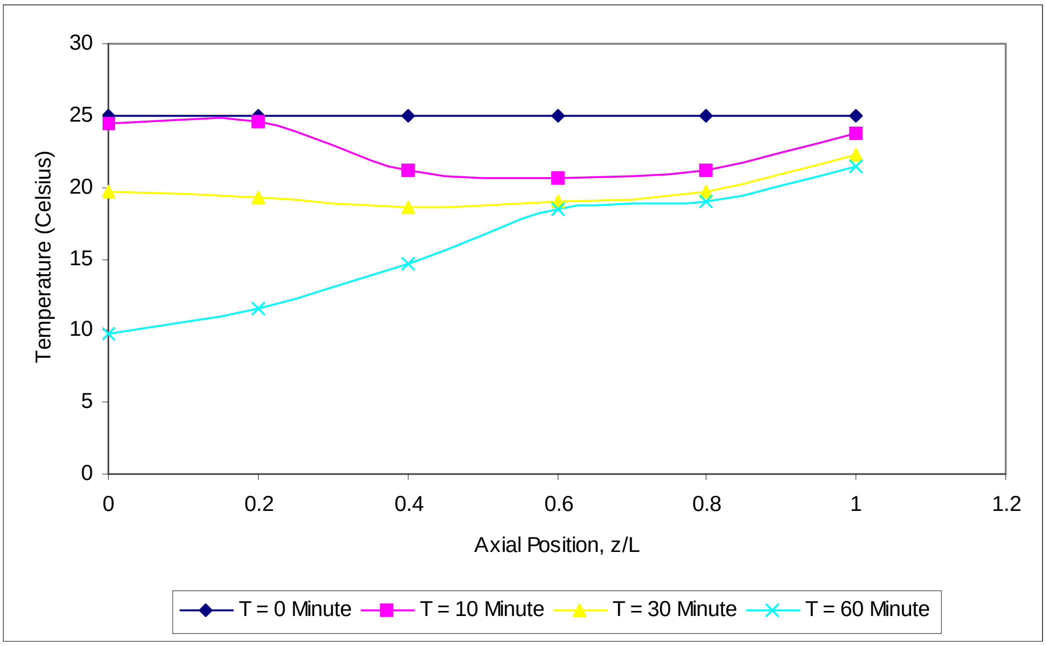
A402: Dimensionless Axial Profile of Temperature at Internal Wall of Surrounding Temperature of 25°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



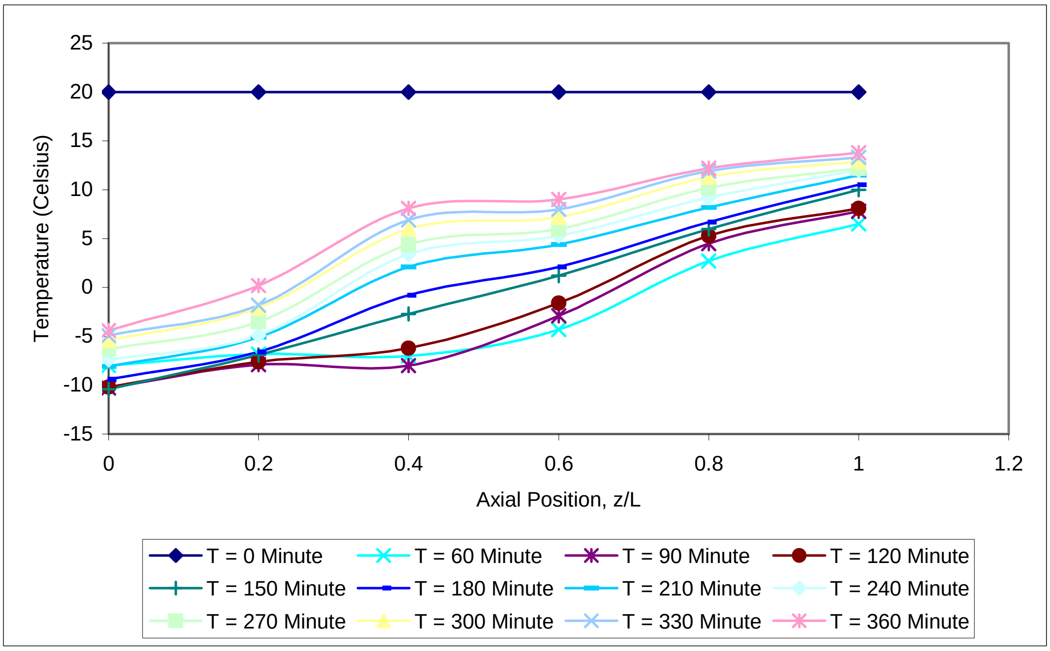
A403: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Surrounding Temperature of 25°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



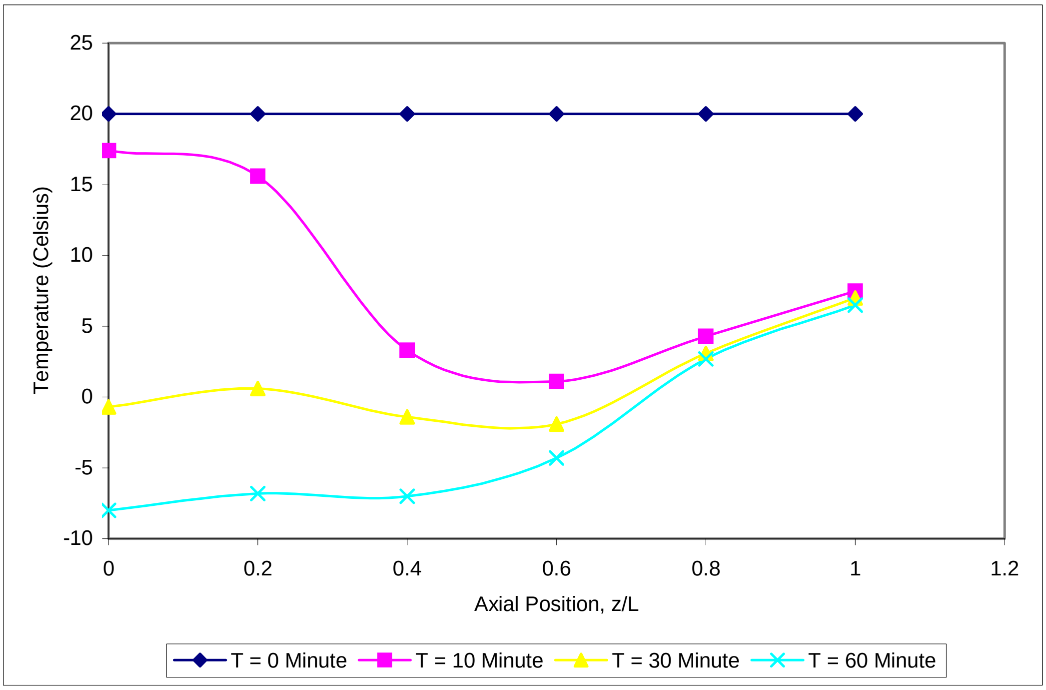
A404: Dimensionless Axial Profile of Temperature at External Wall of Surrounding Temperature of 25°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



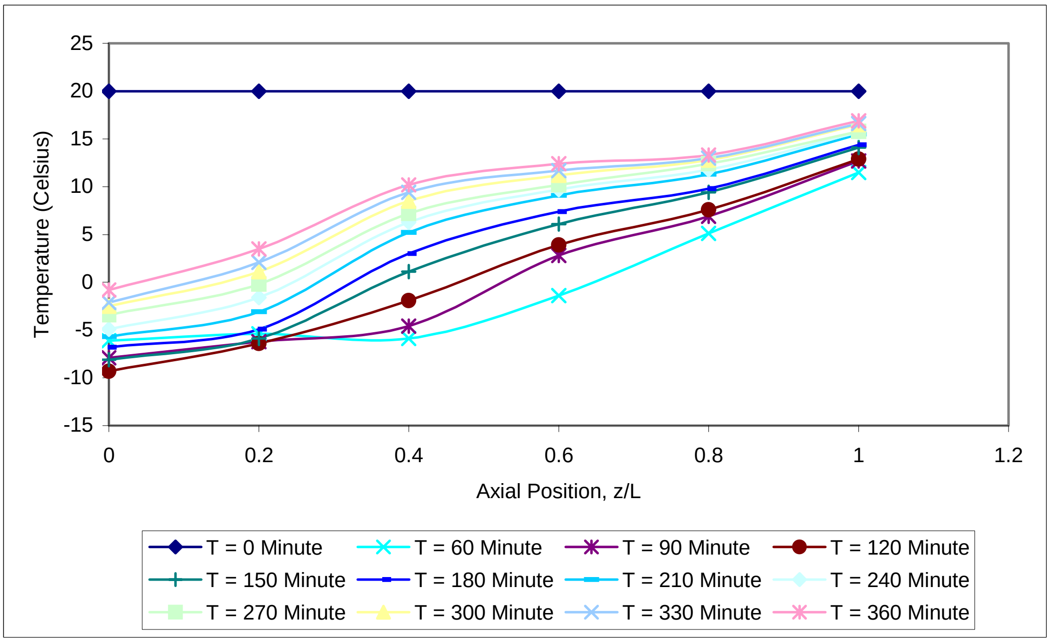
A405: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Surrounding Temperature of 25°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



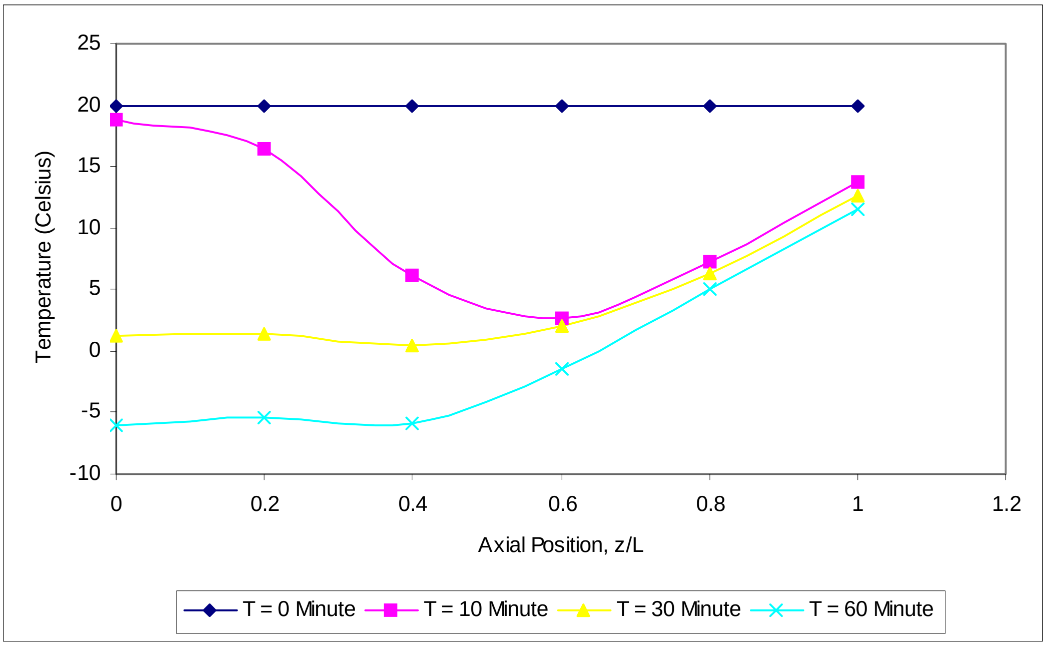
A406: Dimensionless Axial Profile of Temperature at Center of Surrounding Temperature of 20°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



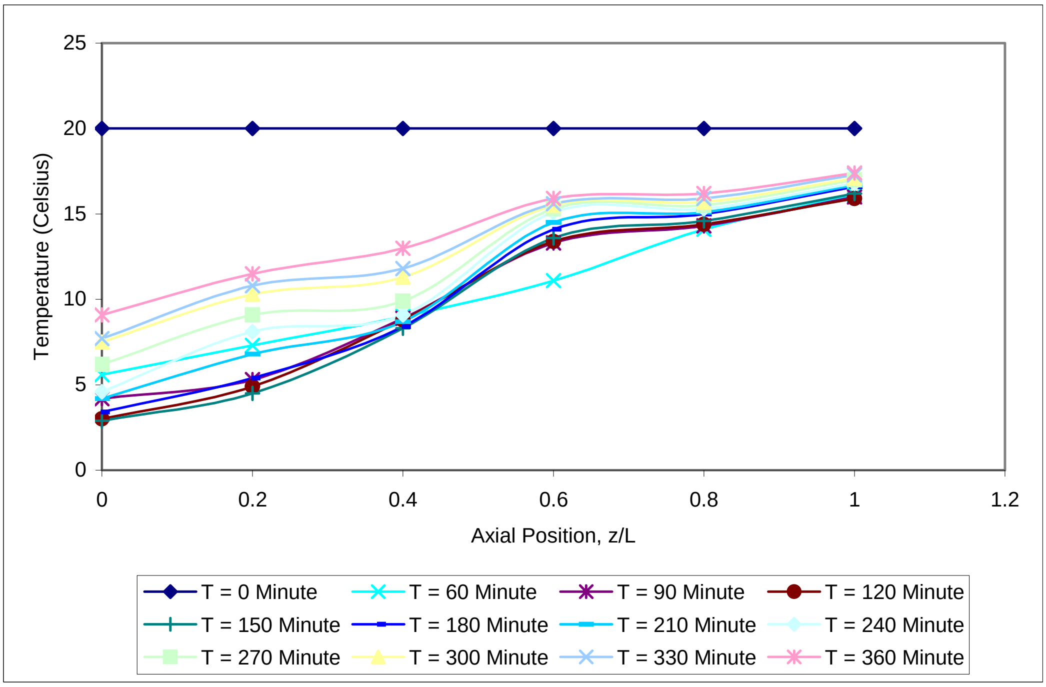
A407: Dimensionless Axial Profile of Temperature at Early Stage at Center of Surrounding Temperature of 20°C Commercial at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



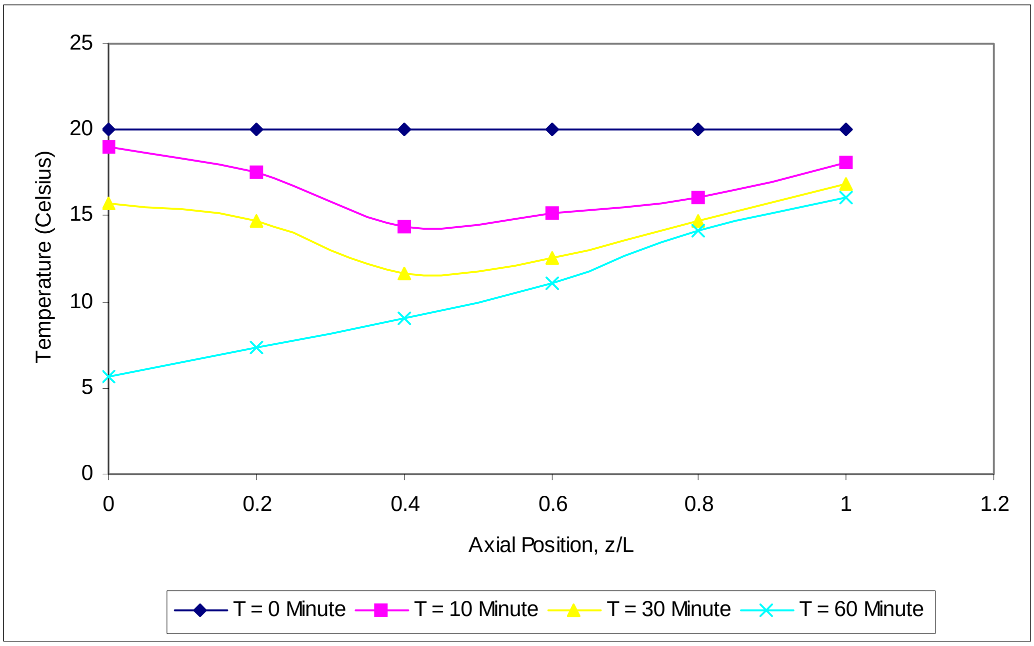
A408: Dimensionless Axial Profile of Temperature at Internal Wall of Surrounding Temperature of 20°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



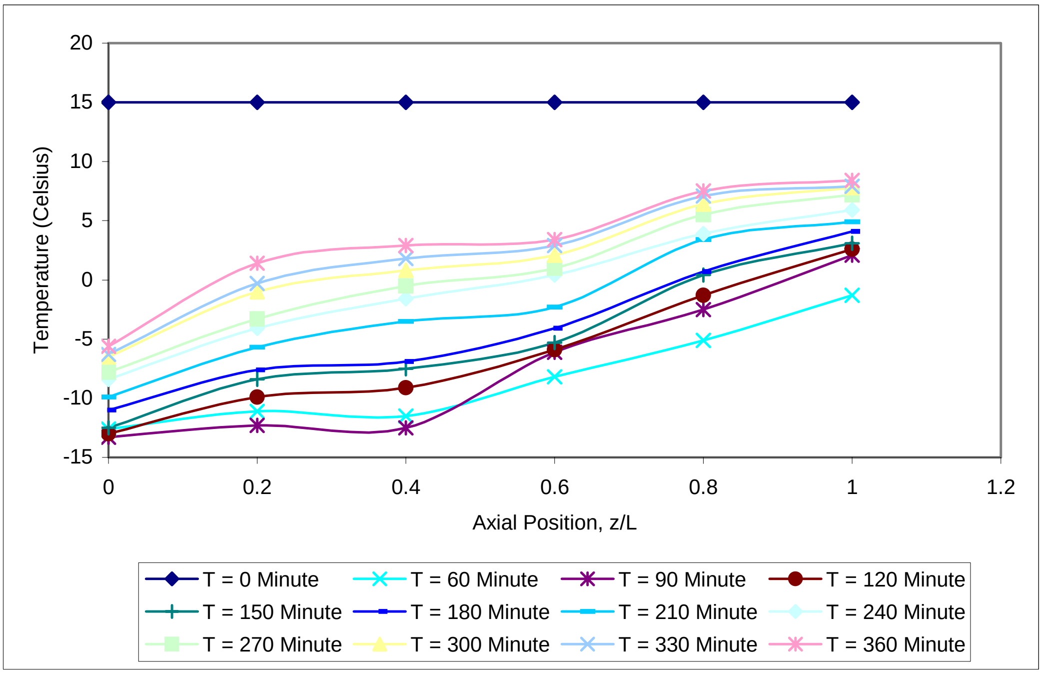
A409: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Surrounding Temperature of 20°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



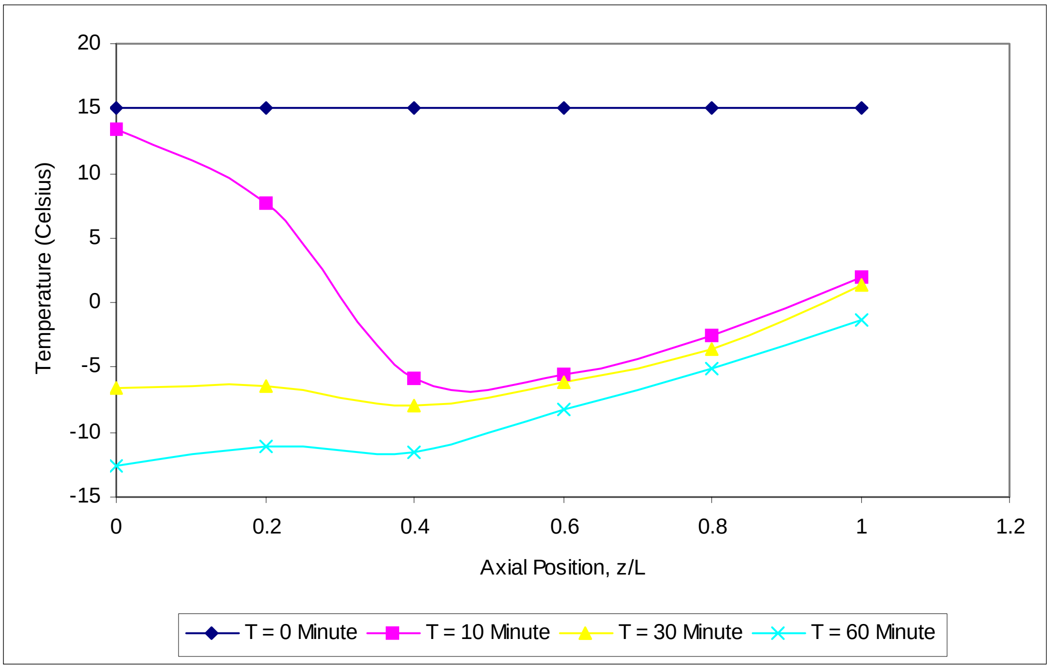
A410: Dimensionless Axial Profile of Temperature at External Wall of Surrounding Temperature of 20°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



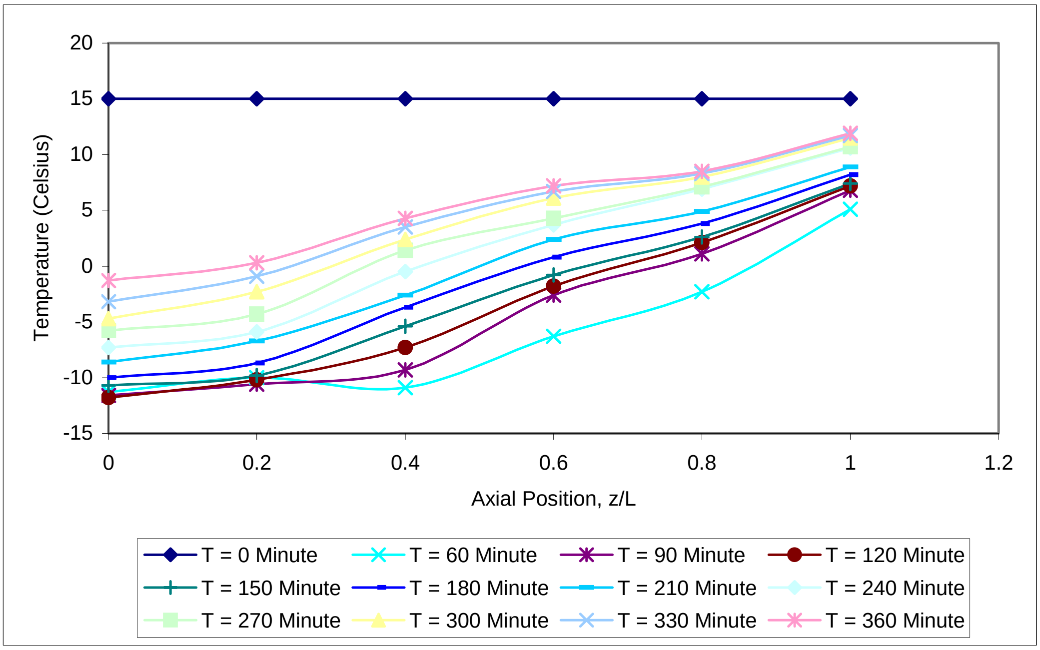
A411: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Surrounding Temperature of 20°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



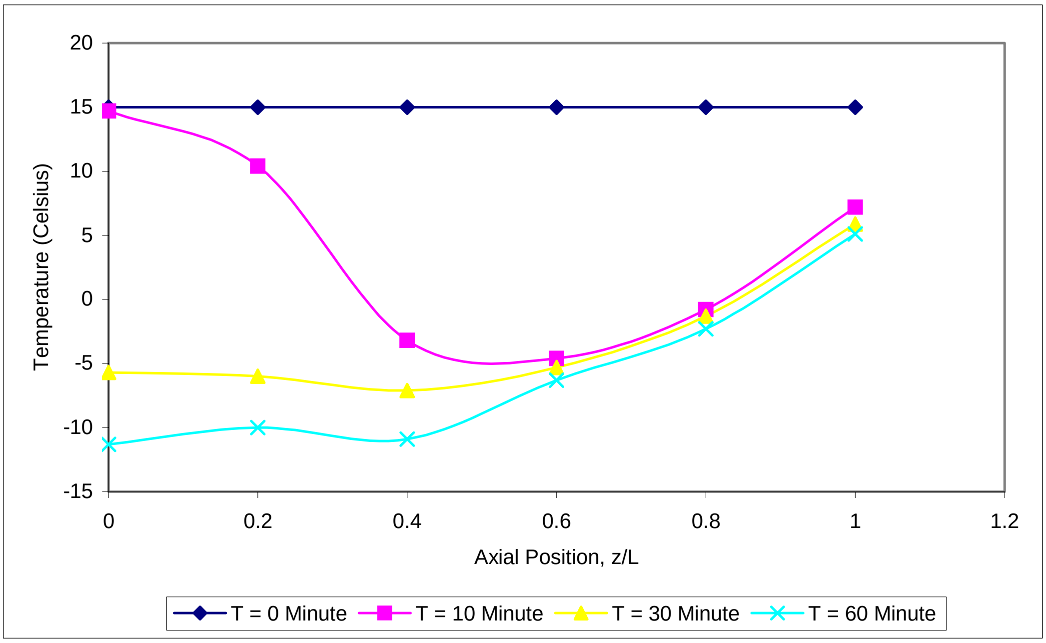
A412: Dimensionless Axial Profile of Temperature at Center of Surrounding Temperature of 15°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



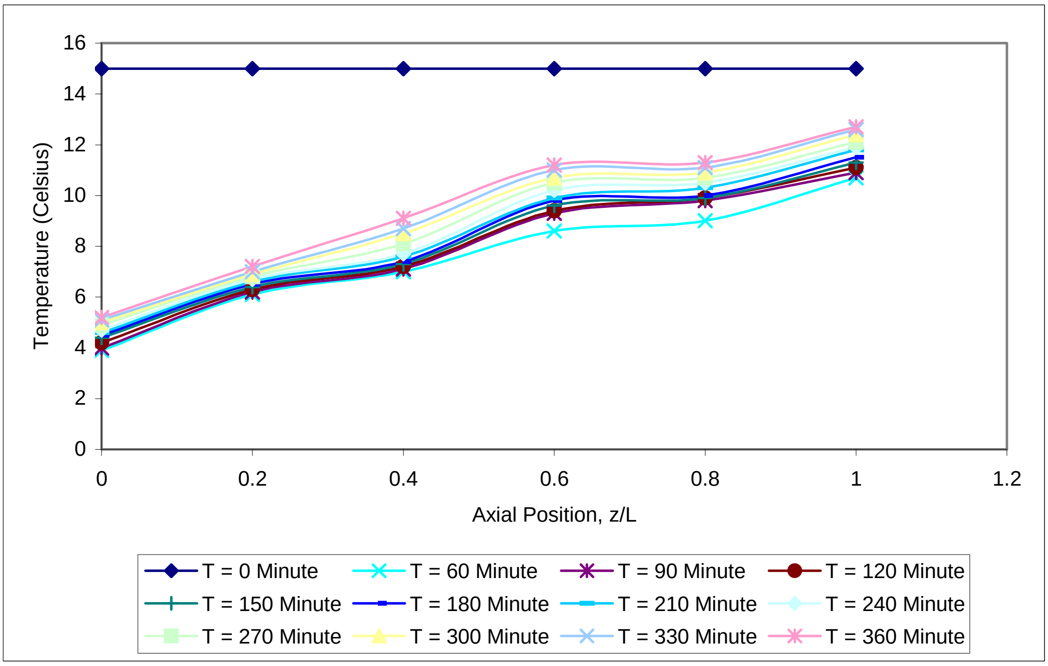
A413: Dimensionless Axial Profile of Temperature at Early Stage at Center of Surrounding Temperature of 15°C Commercial at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



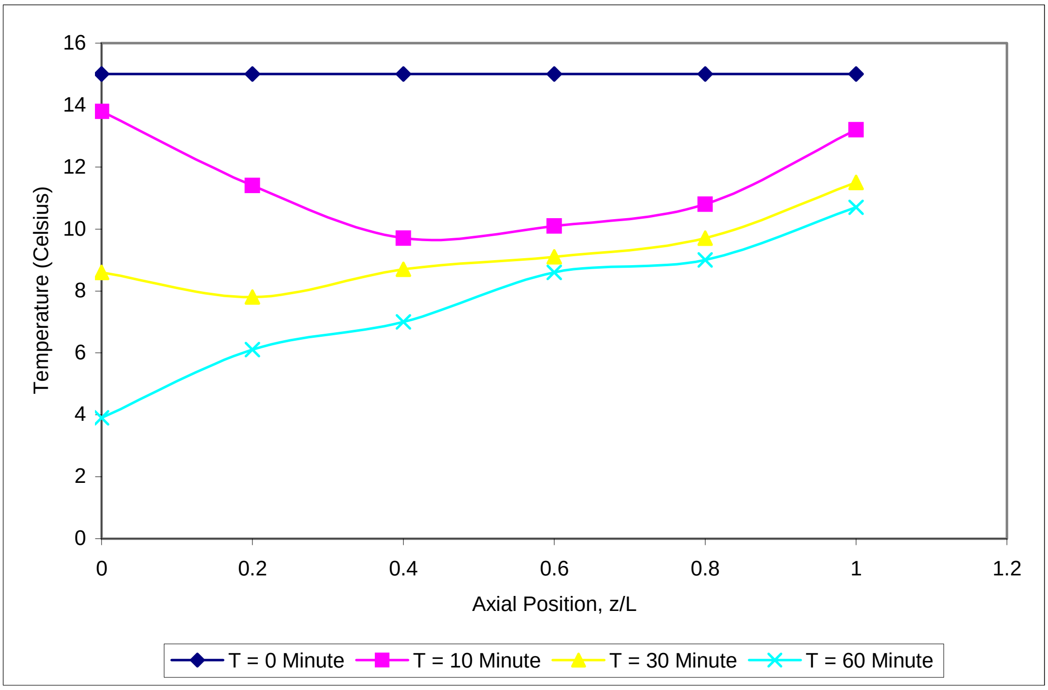
A414: Dimensionless Axial Profile of Temperature at Internal Wall of Surrounding Temperature of 15°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



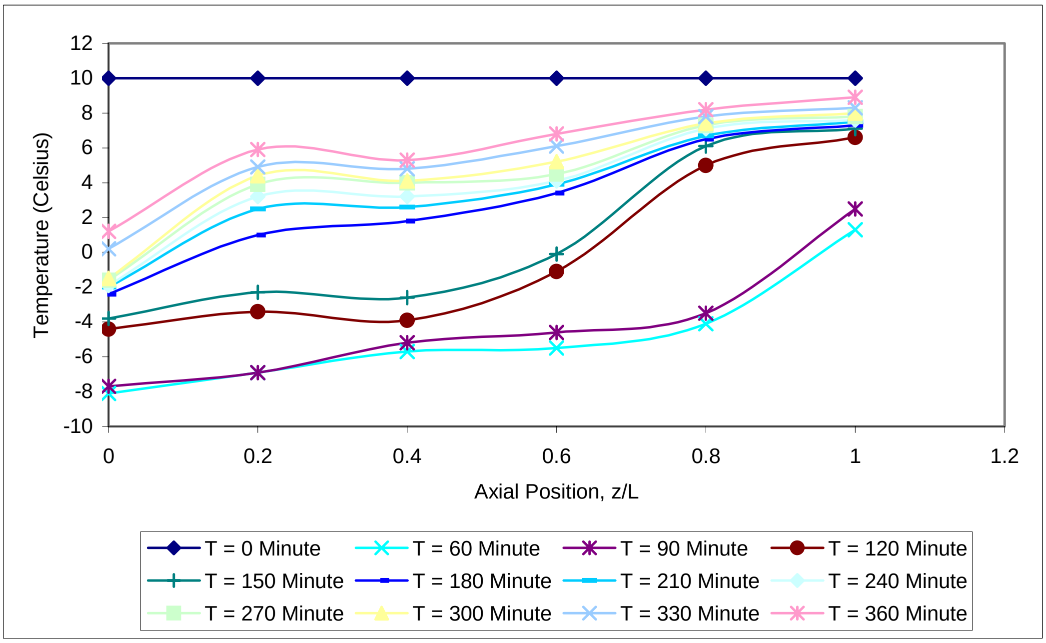
A415: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Surrounding Temperature of 15°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



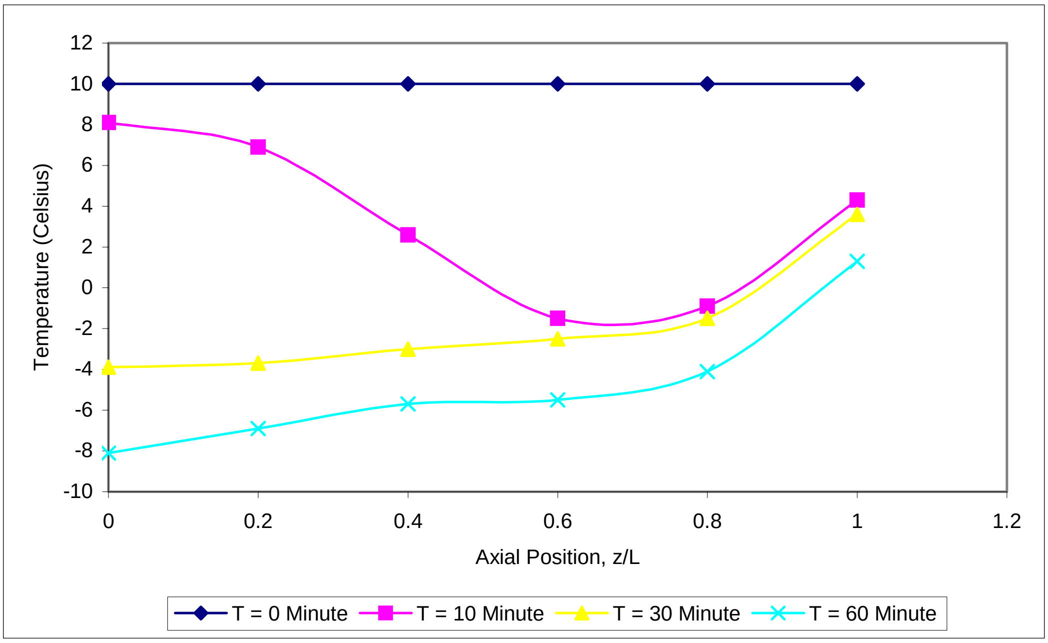
A416: Dimensionless Axial Profile of Temperature at External Wall of Surrounding Temperature of 15°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



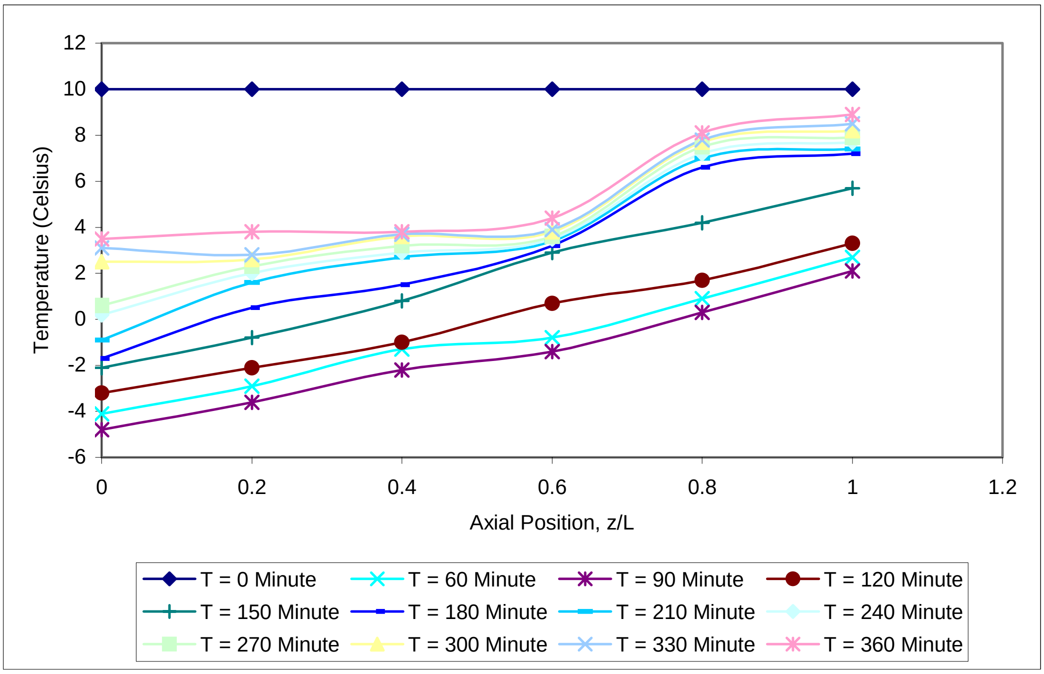
A417: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Surrounding Temperature of 15°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



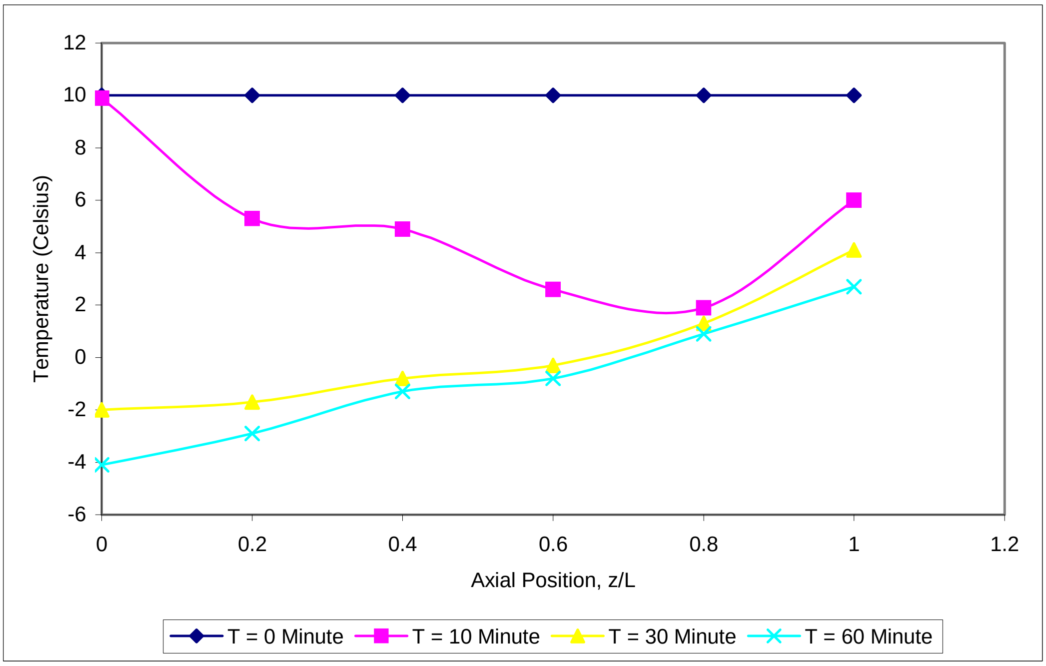
A418: Dimensionless Axial Profile of Temperature at Center of Surrounding Temperature of 10°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



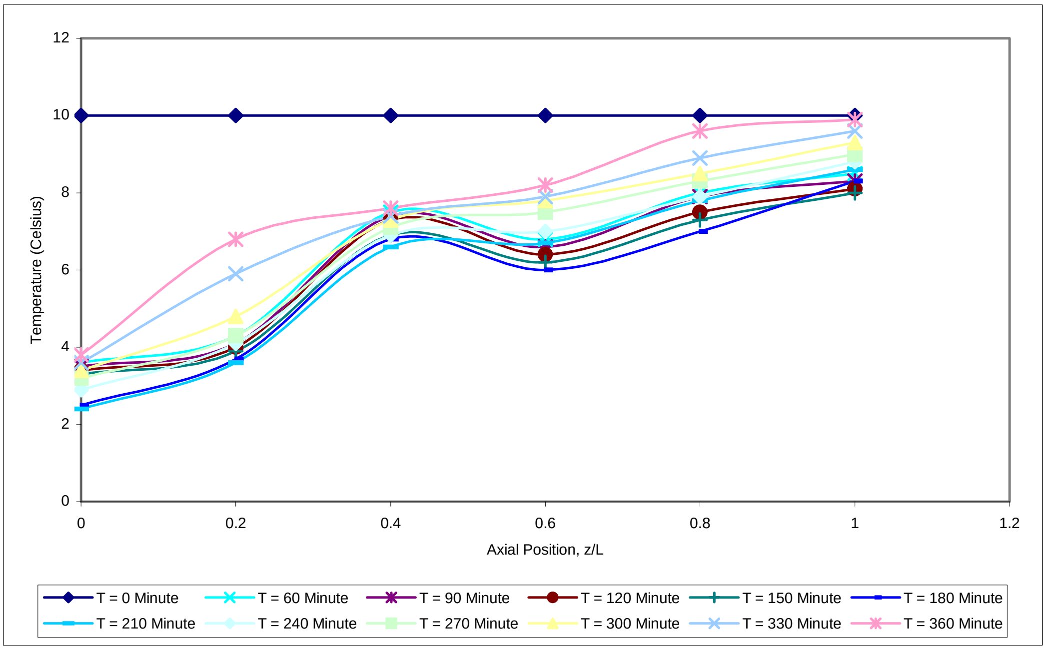
A419: Dimensionless Axial Profile of Temperature at Early Stage at Center of Surrounding Temperature of 10°C Commercial at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



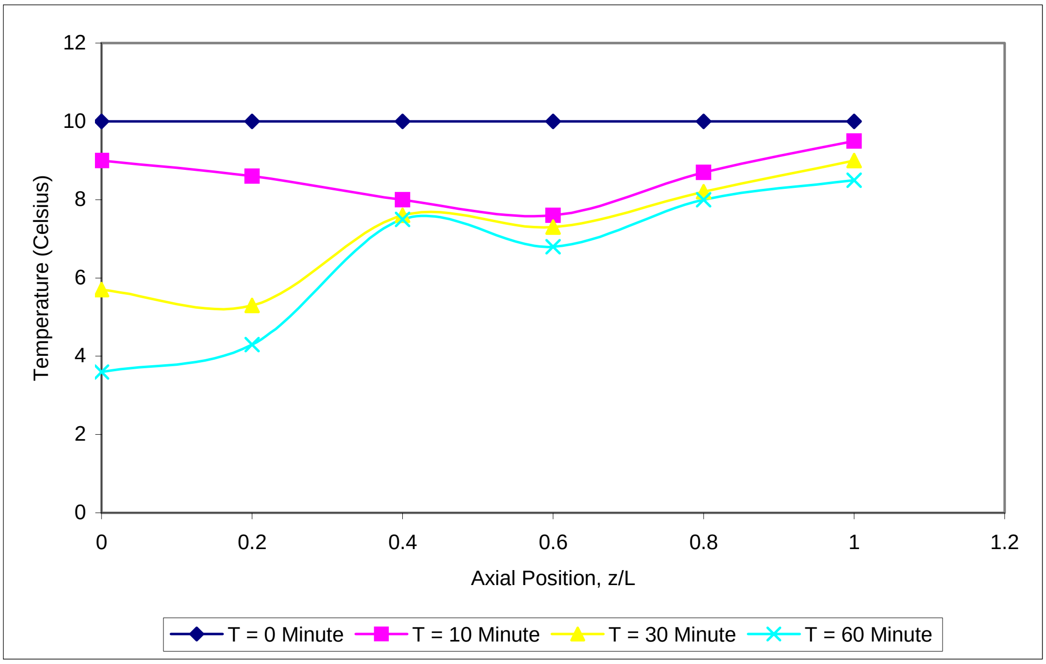
A420: Dimensionless Axial Profile of Temperature at Internal Wall of Surrounding Temperature of 10°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



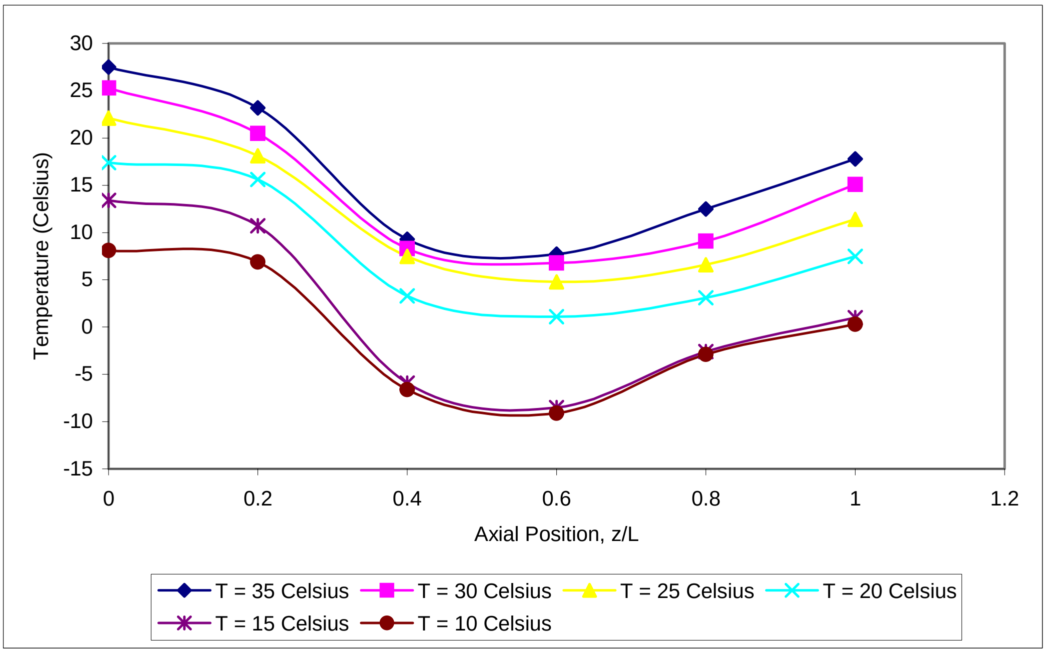
A421: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Surrounding Temperature of 10^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



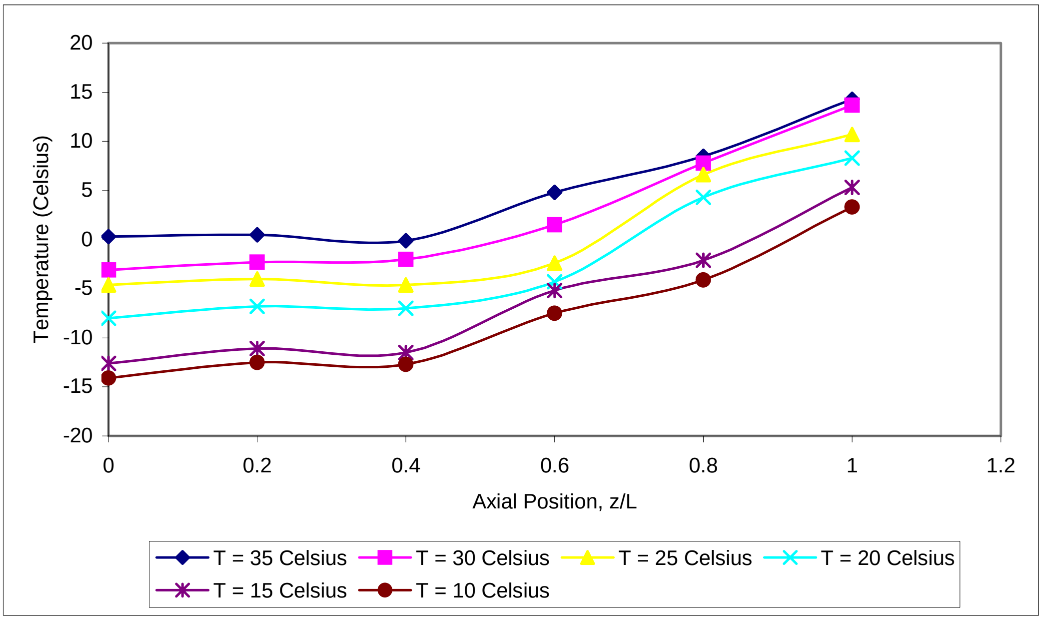
A422: Dimensionless Axial Profile of Temperature at External Wall of Surrounding Temperature of 10^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



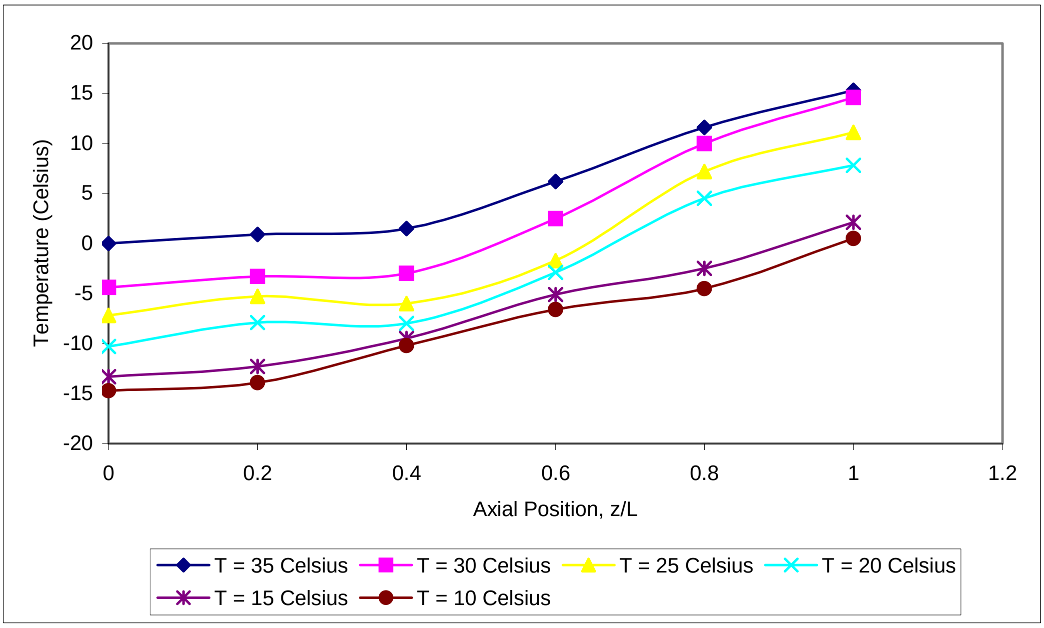
A423: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Surrounding Temperature of 10^oC at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



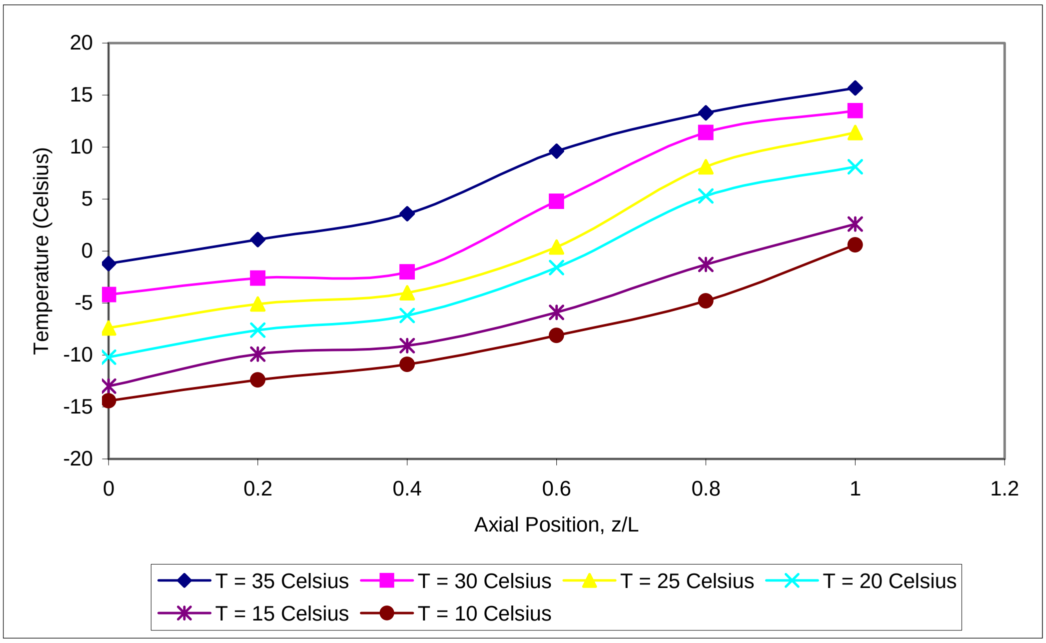
A424: Dimensionless Axial Profile of Temperature at 10 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



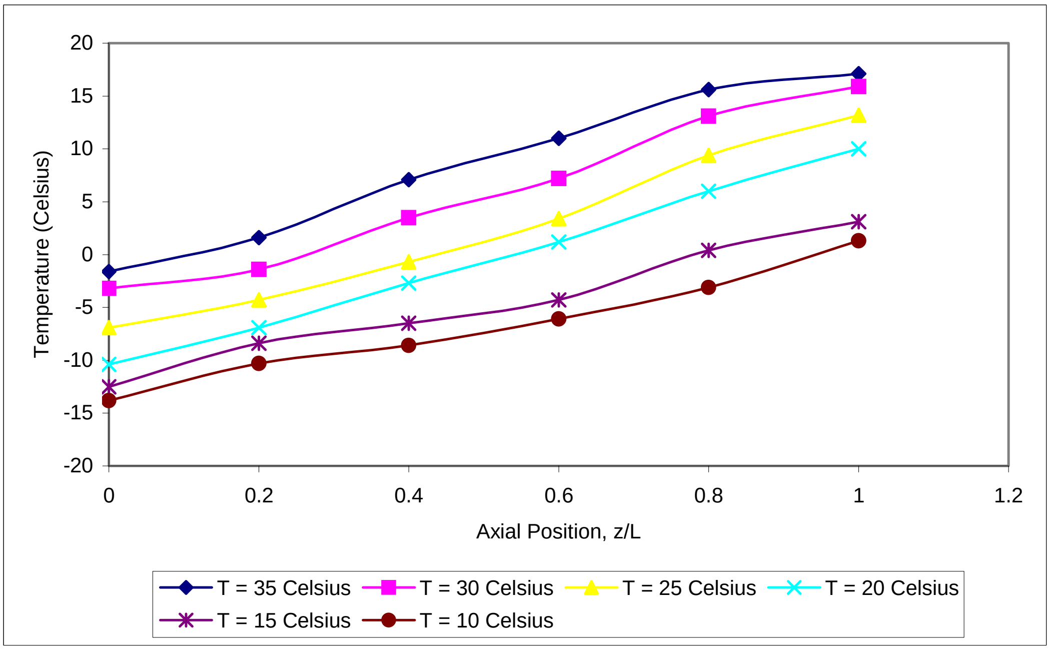
A425: Dimensionless Axial Profile of Temperature at 60 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



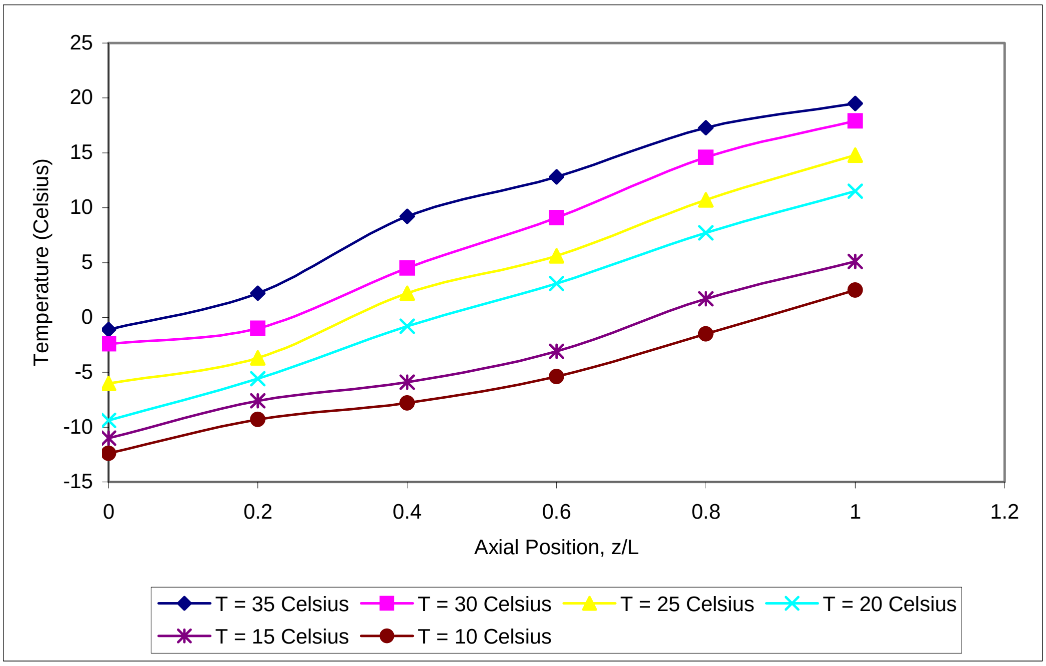
A426: Dimensionless Axial Profile of Temperature at 90 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



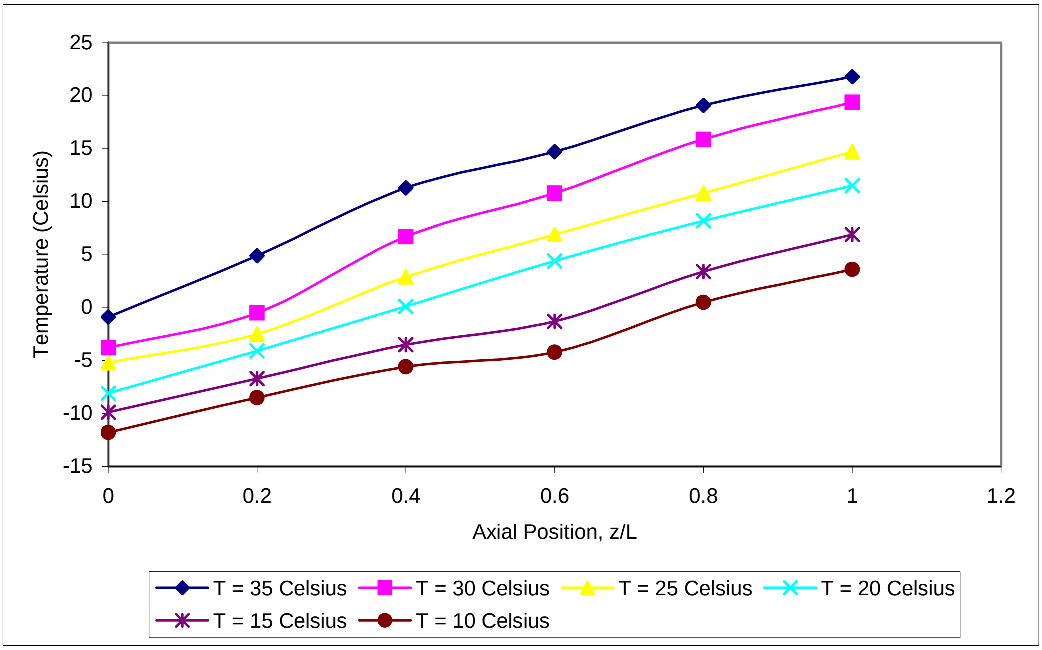
A427: Dimensionless Axial Profile of Temperature at 120 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



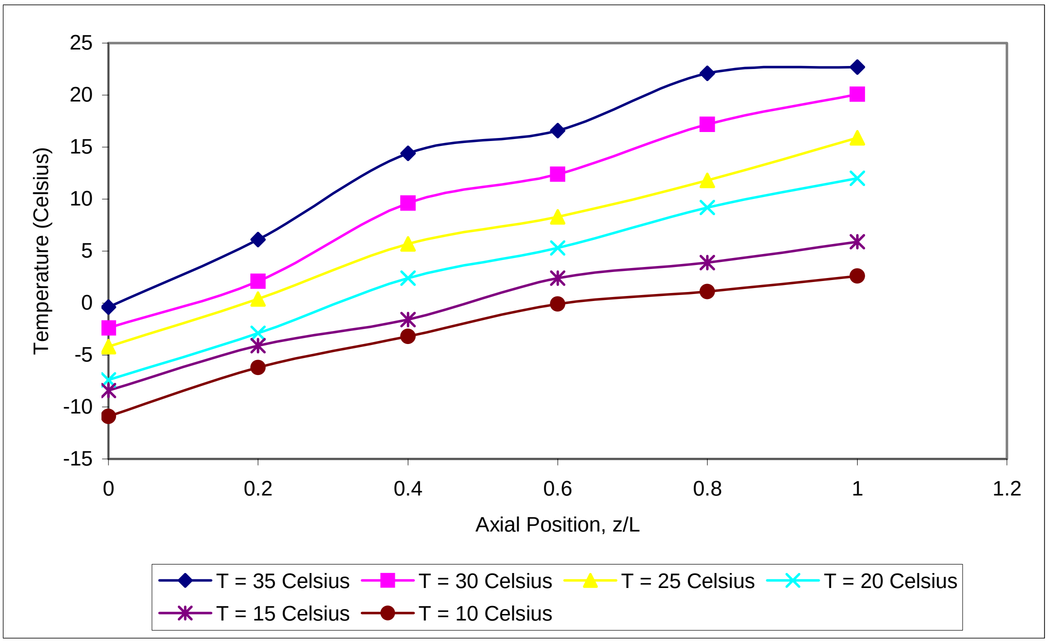
A428: Dimensionless Axial Profile of Temperature at 150 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



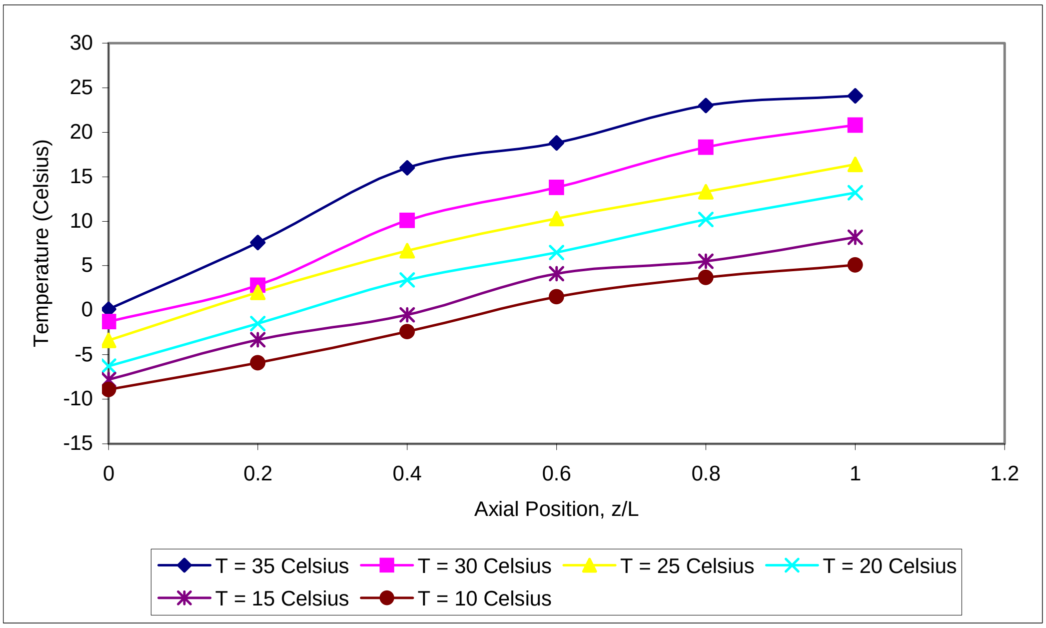
A429: Dimensionless Axial Profile of Temperature at 180 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



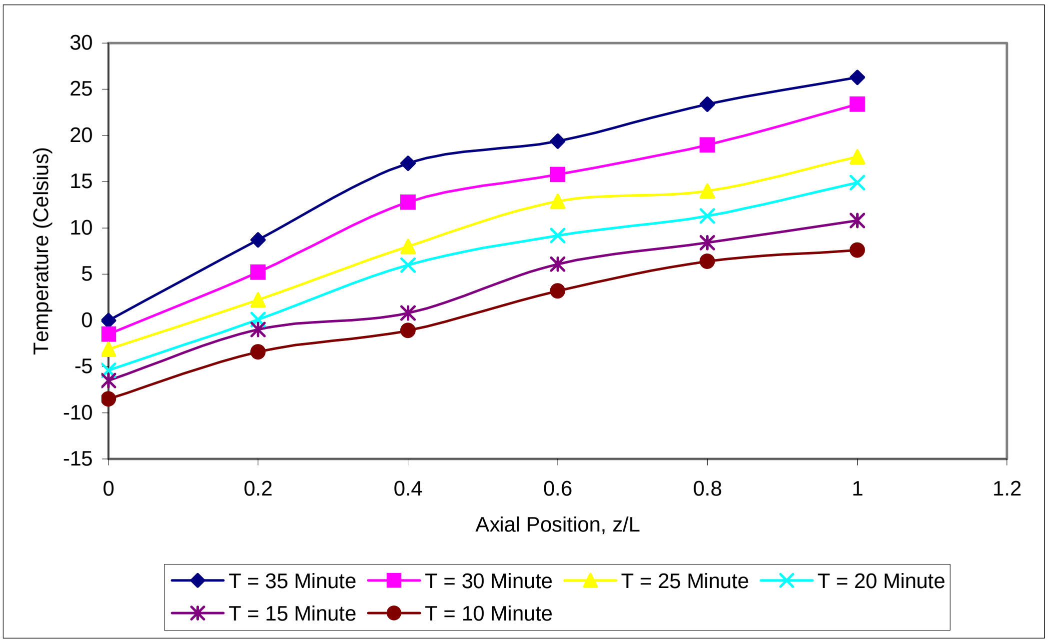
A430: Dimensionless Axial Profile of Temperature at 210 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



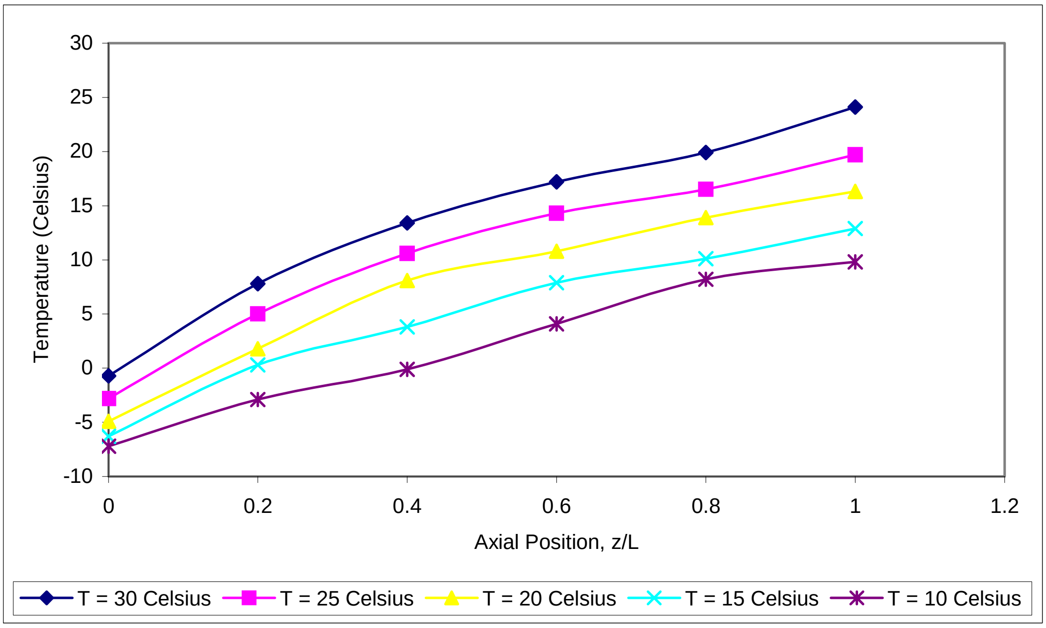
A431: Dimensionless Axial Profile of Temperature at 240 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



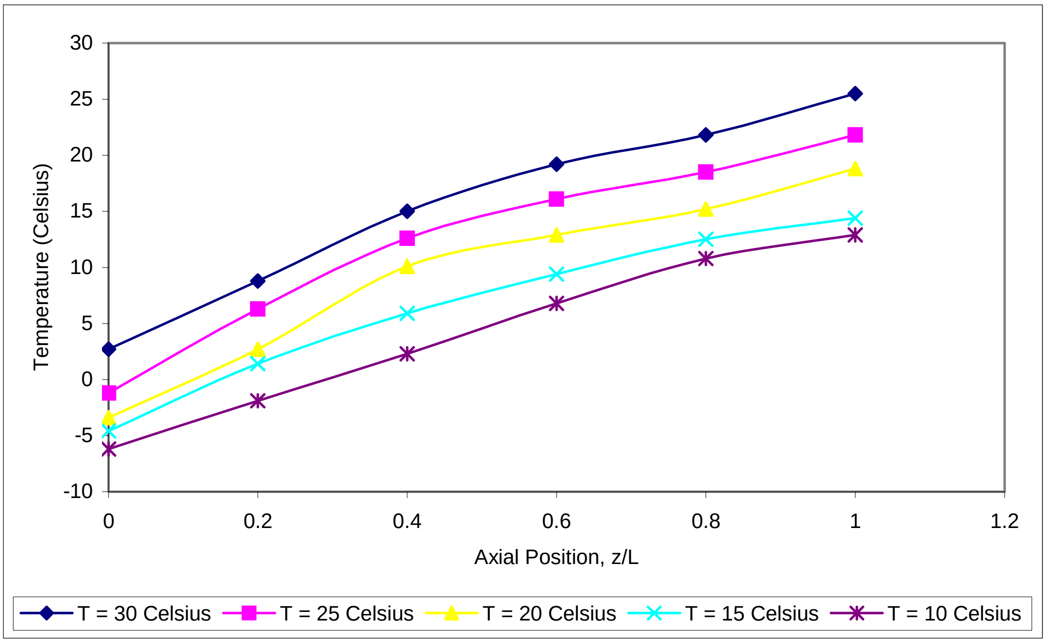
A432: Dimensionless Axial Profile of Temperature at 270 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



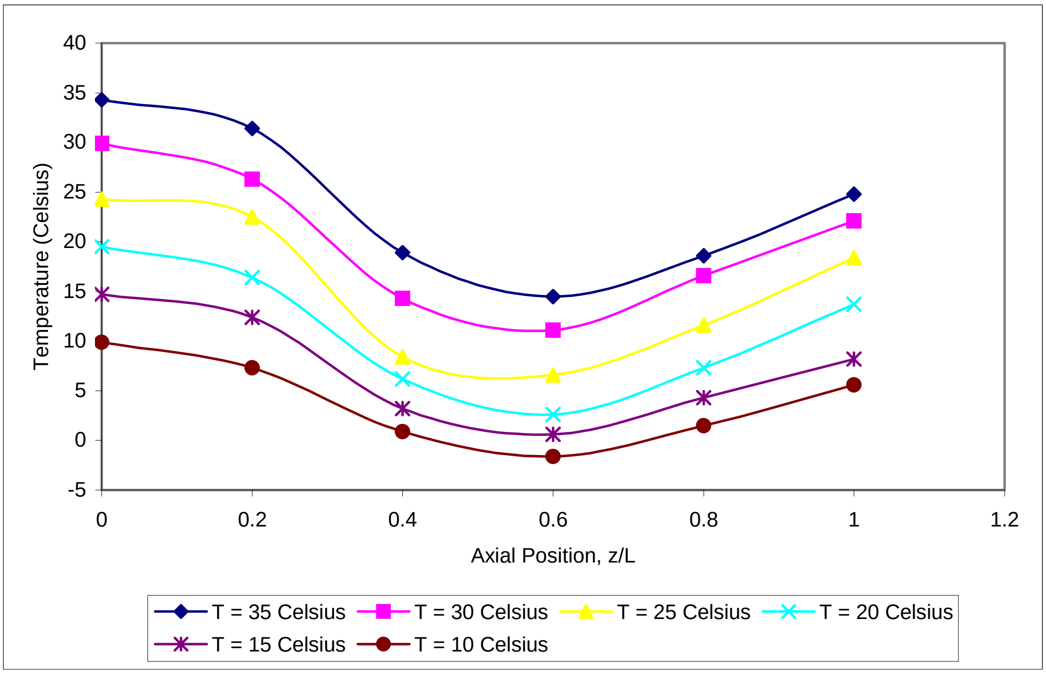
A433: Dimensionless Axial Profile of Temperature at 300 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



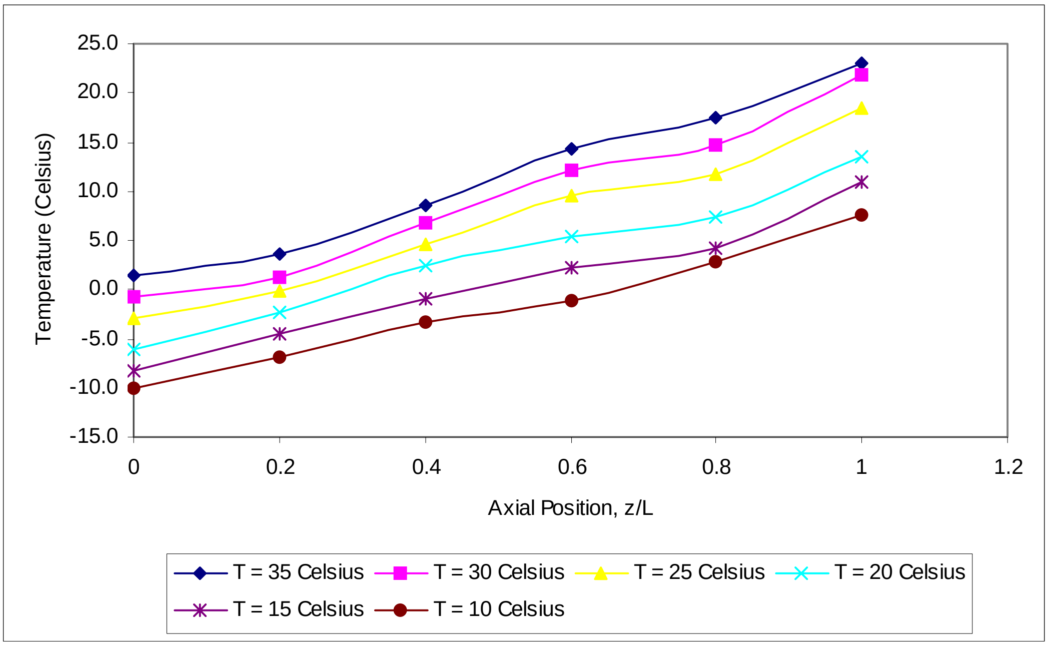
A434: Dimensionless Axial Profile of Temperature at 330 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



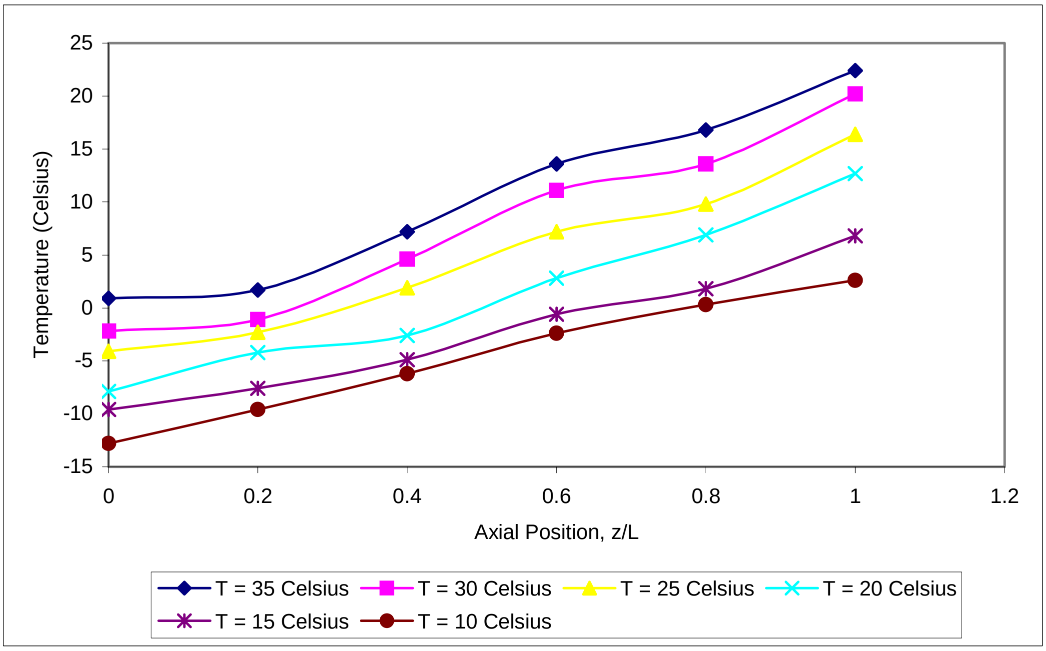
A435: Dimensionless Axial Profile of Temperature at 360 Minute at Center of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



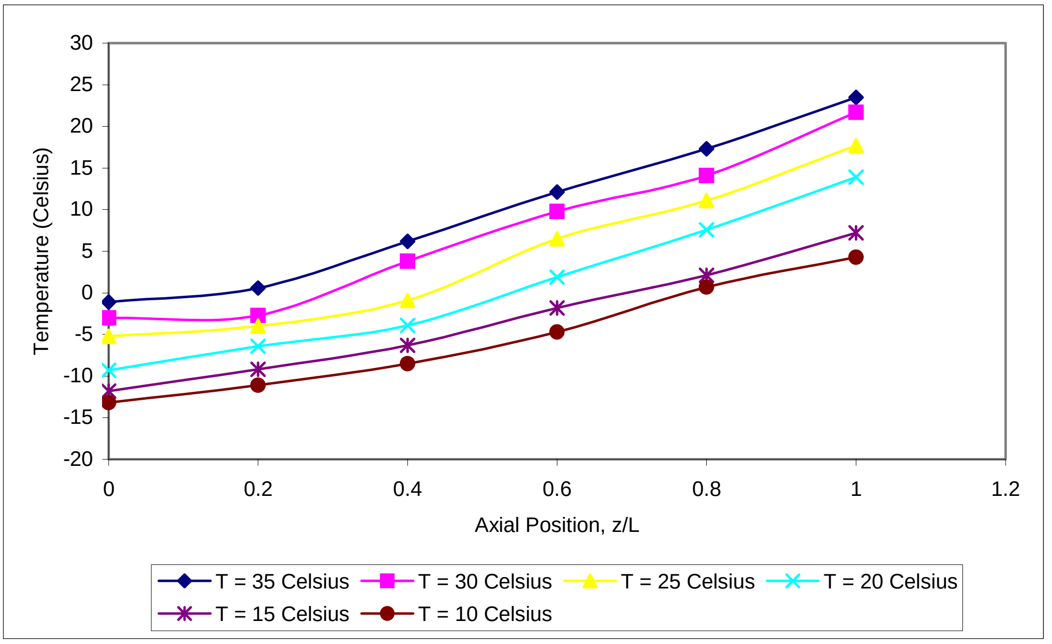
A436: Dimensionless Axial Profile of Temperature at 10 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



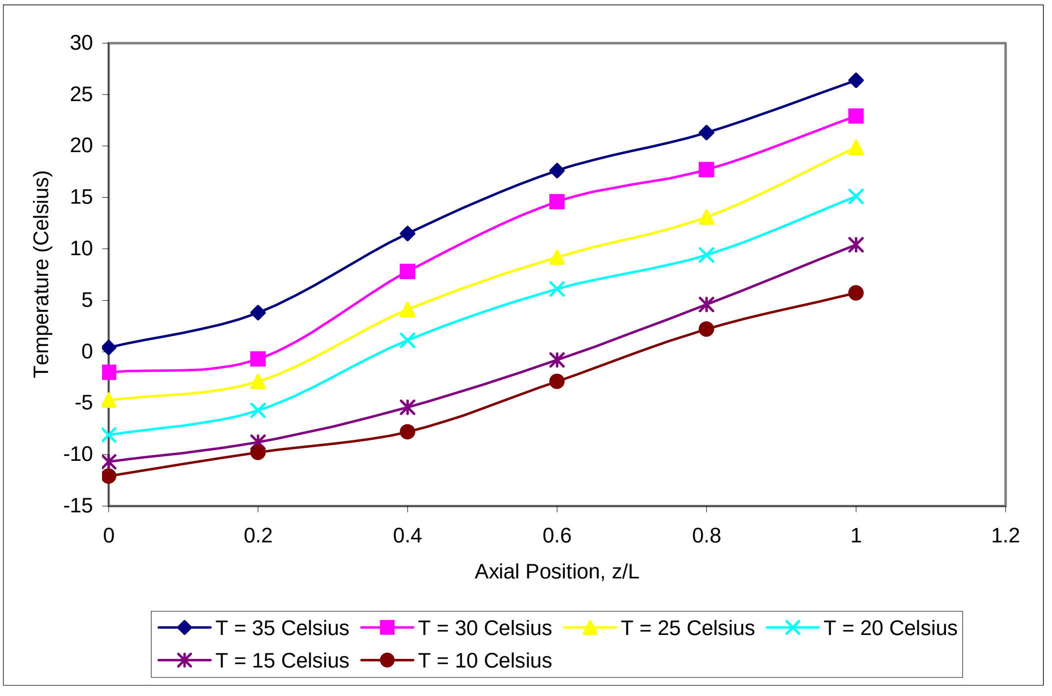
A437: Dimensionless Axial Profile of Temperature at 60 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



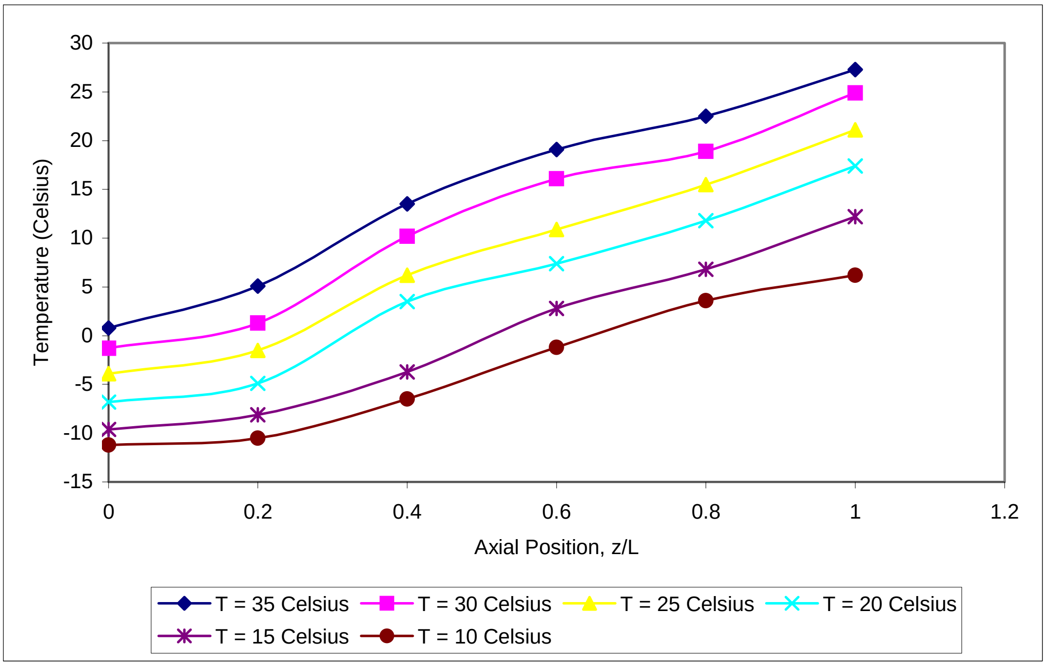
A438: Dimensionless Axial Profile of Temperature at 90 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



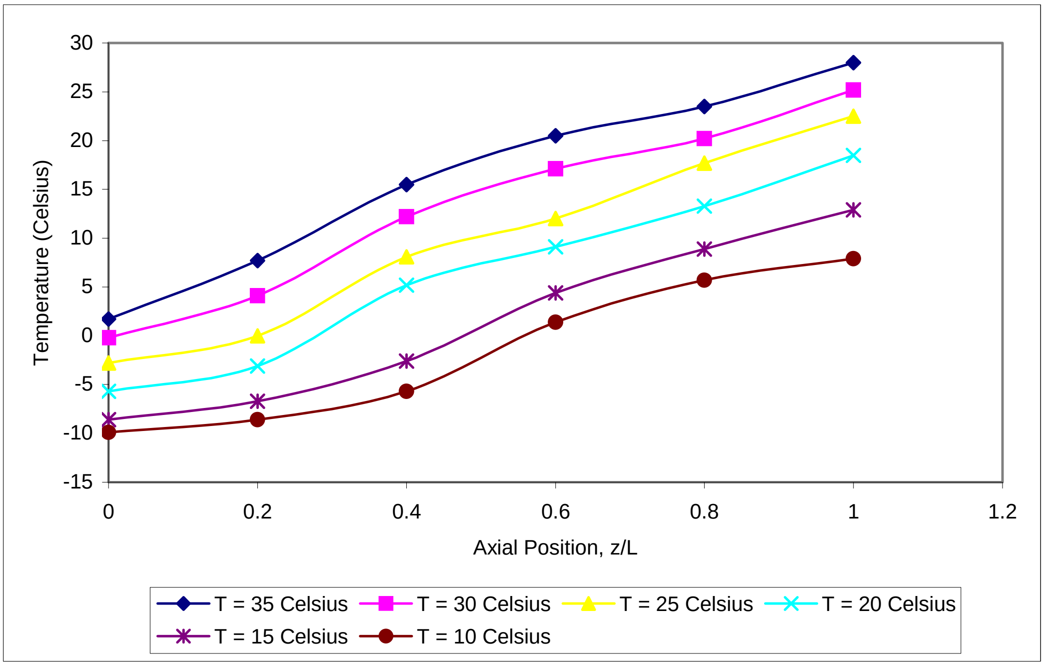
A439: Dimensionless Axial Profile of Temperature at 120 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



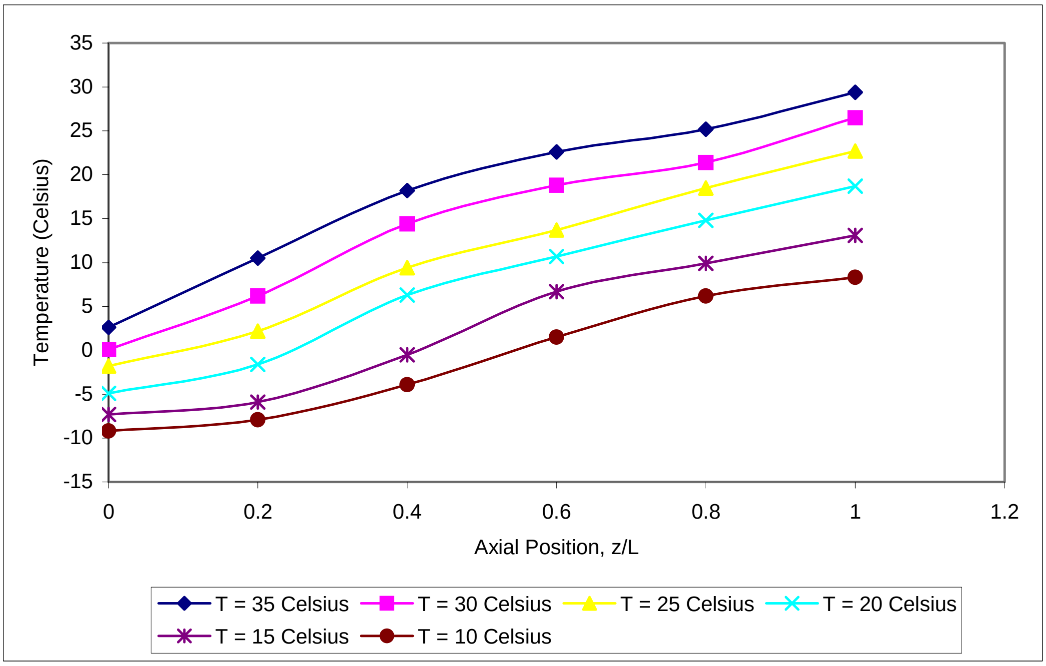
A440: Dimensionless Axial Profile of Temperature at 150 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



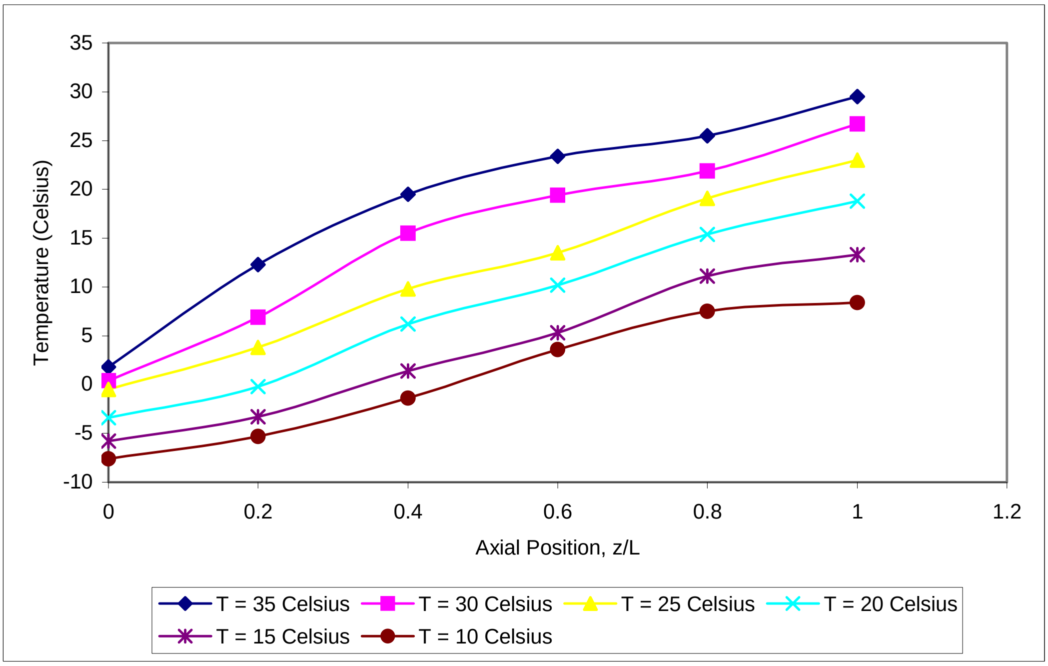
A441: Dimensionless Axial Profile of Temperature at 180 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



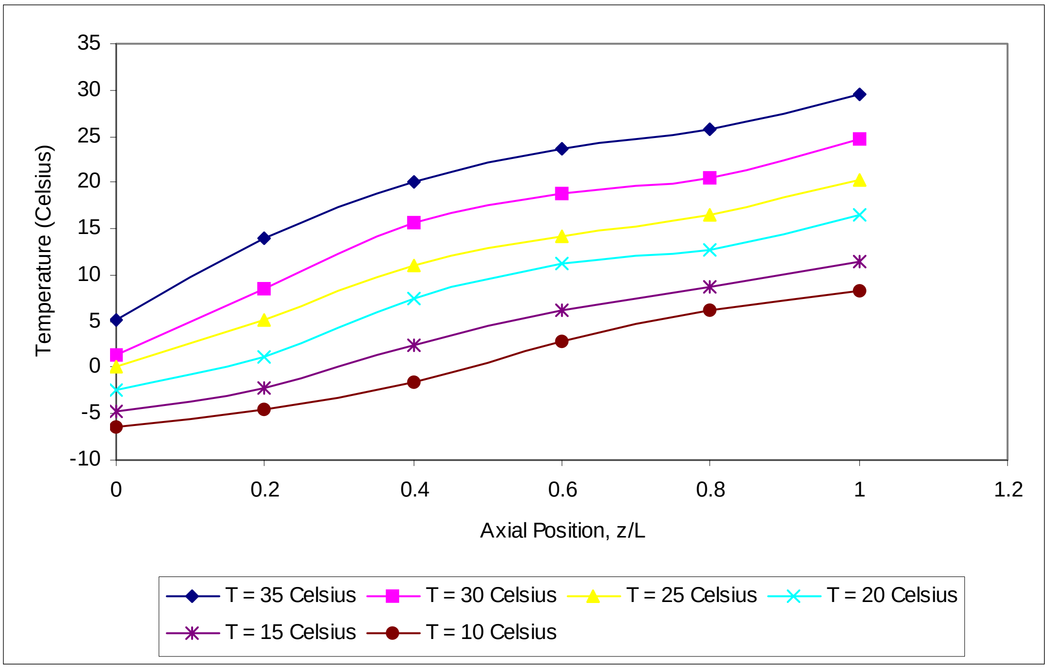
A442: Dimensionless Axial Profile of Temperature at 210 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



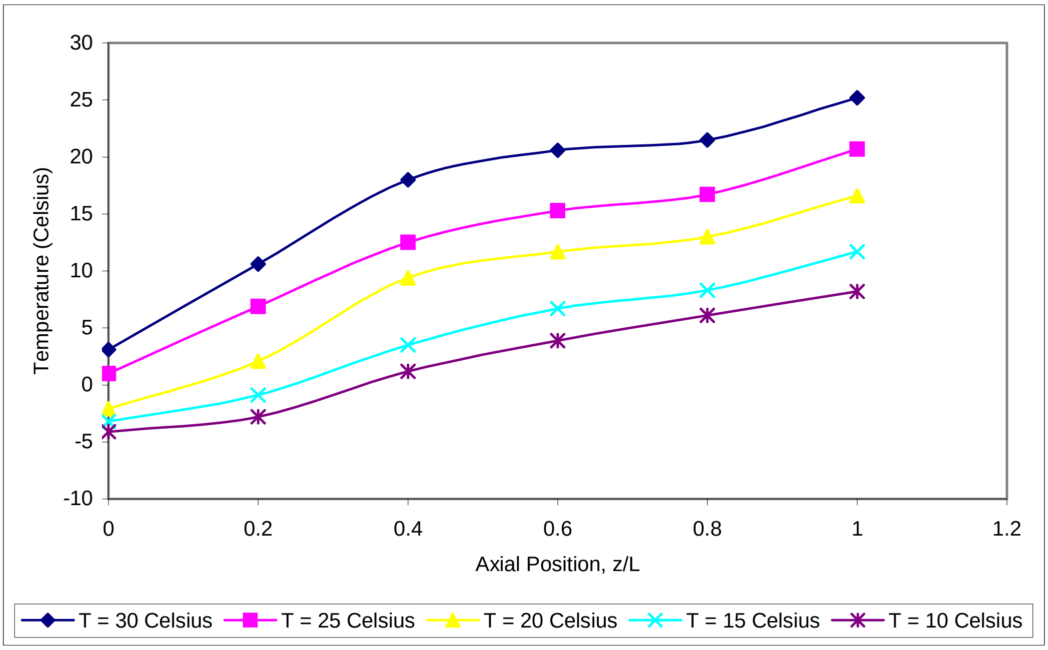
A443: Dimensionless Axial Profile of Temperature at 240 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



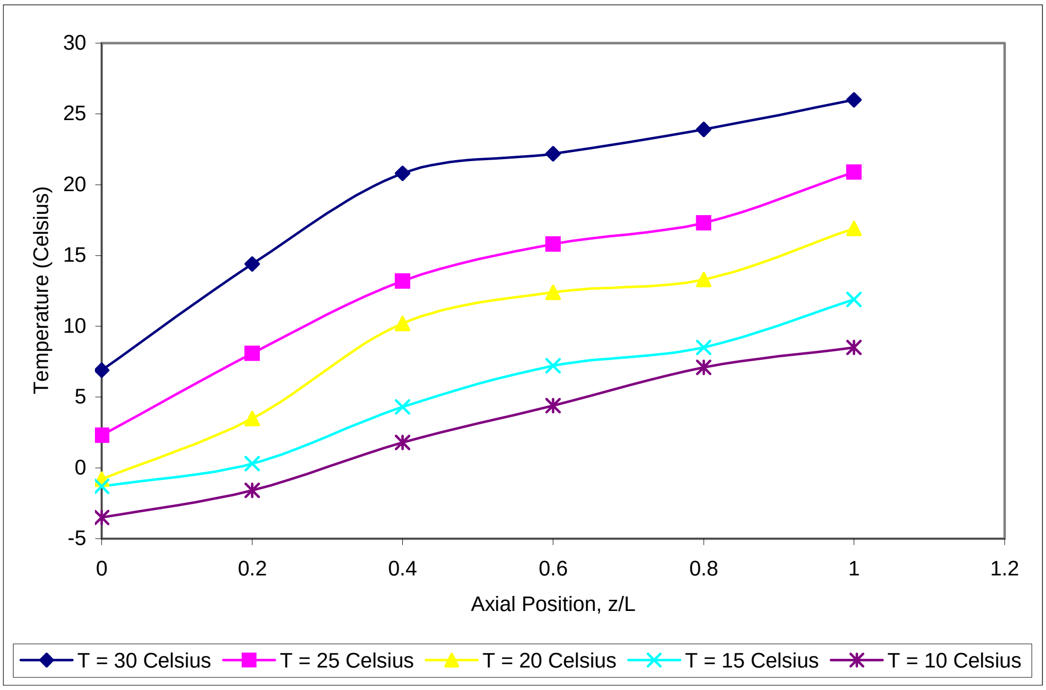
A444: Dimensionless Axial Profile of Temperature at 270 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



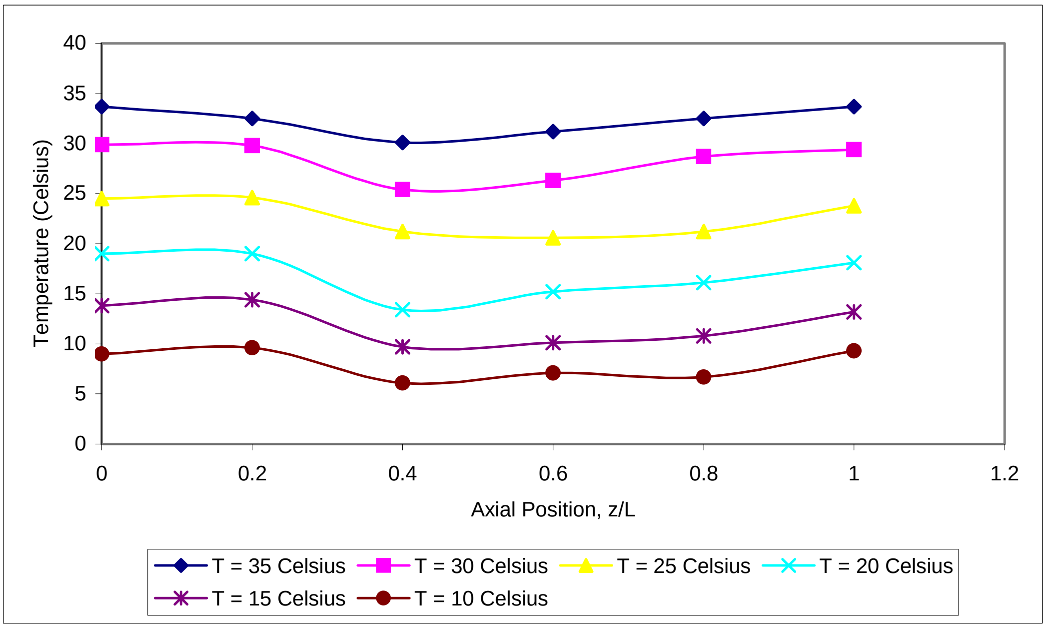
A445: Dimensionless Axial Profile of Temperature at 300 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



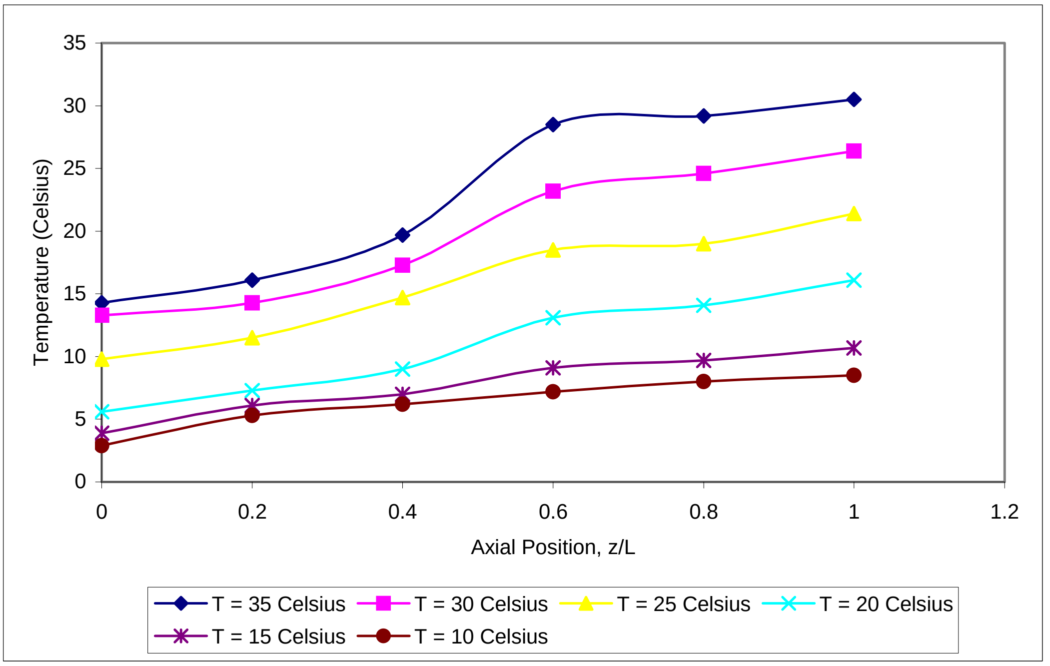
A446: Dimensionless Axial Profile of Temperature at 330 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



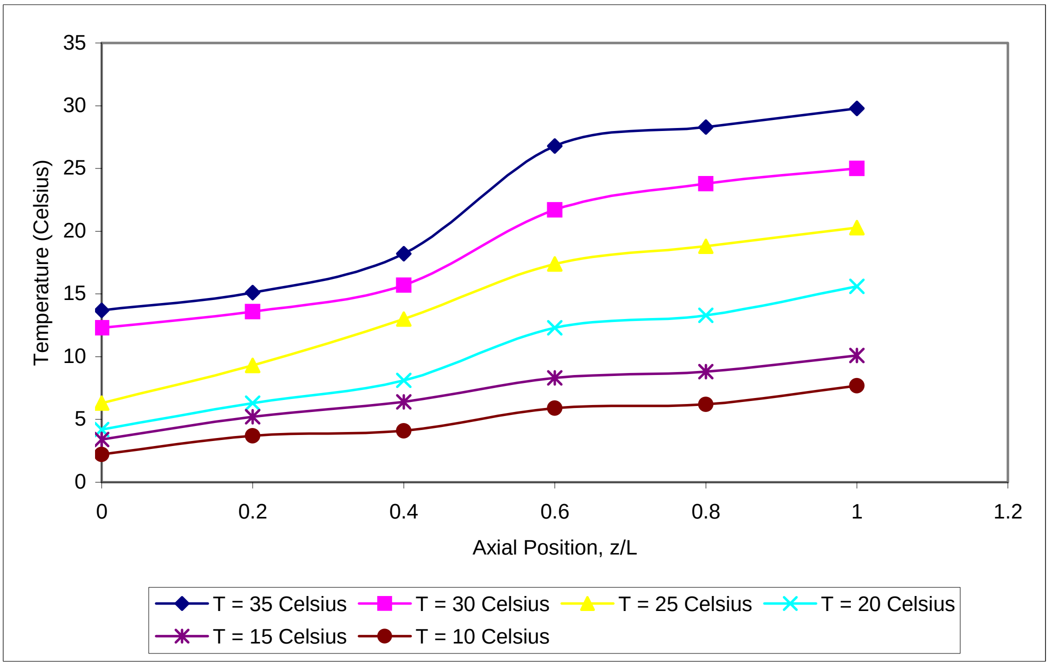
A447: Dimensionless Axial Profile of Temperature at 360 Minute at Internal Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



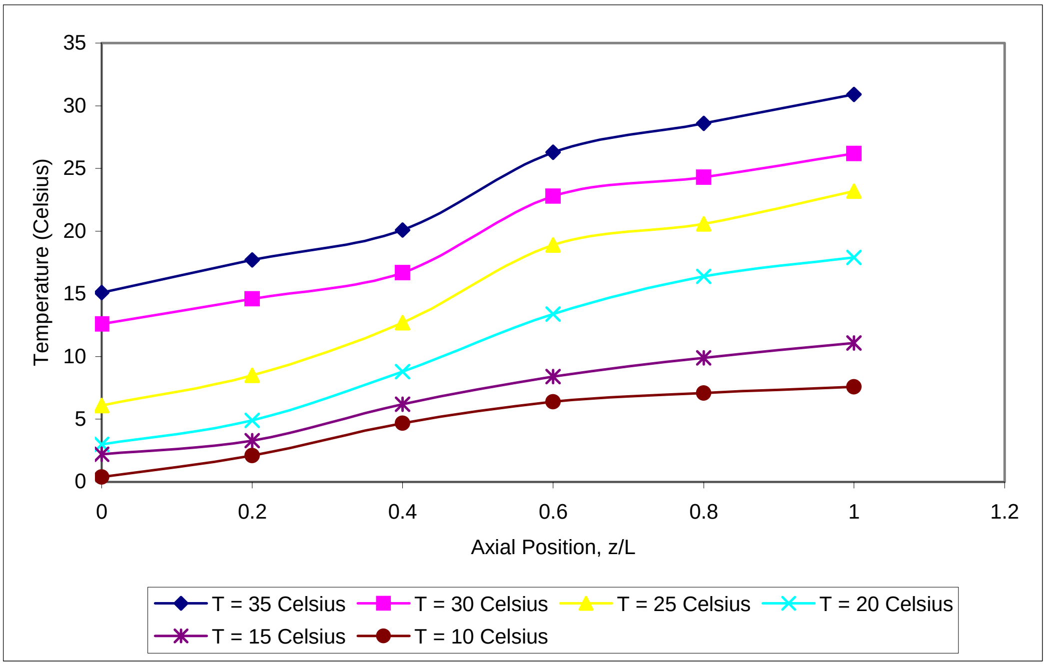
A448: Dimensionless Axial Profile of Temperature at 10 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



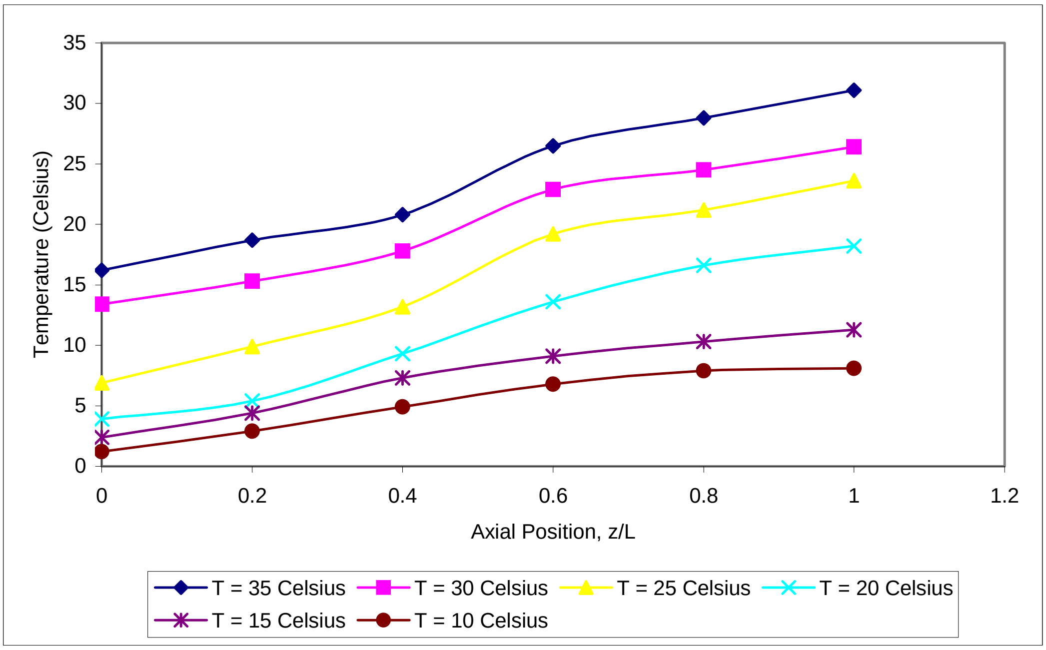
A449: Dimensionless Axial Profile of Temperature at 60 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



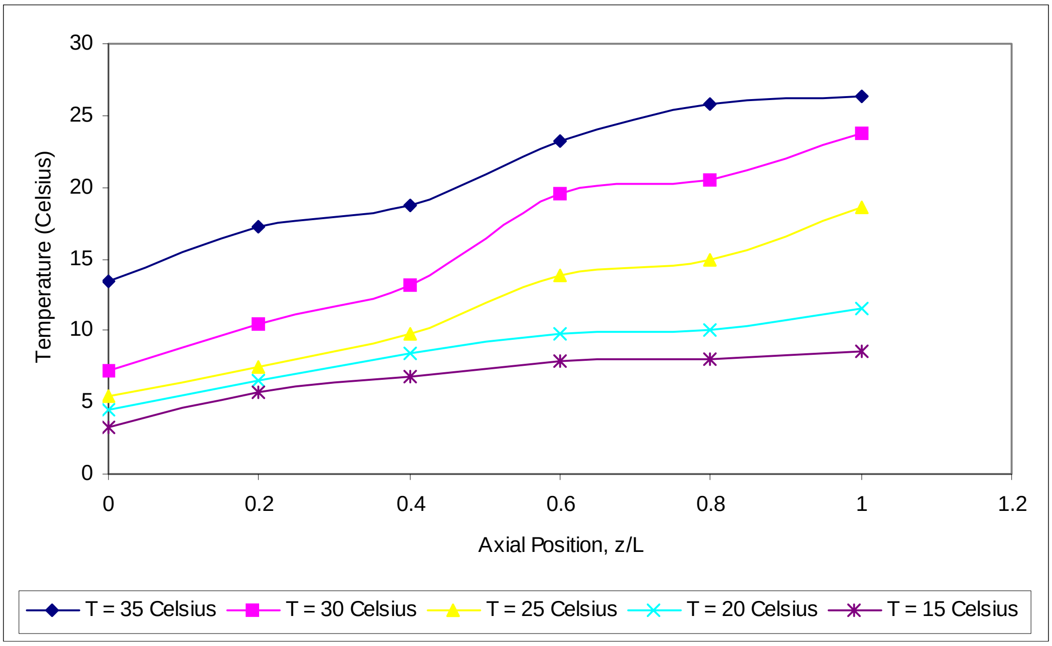
A450: Dimensionless Axial Profile of Temperature at 90 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



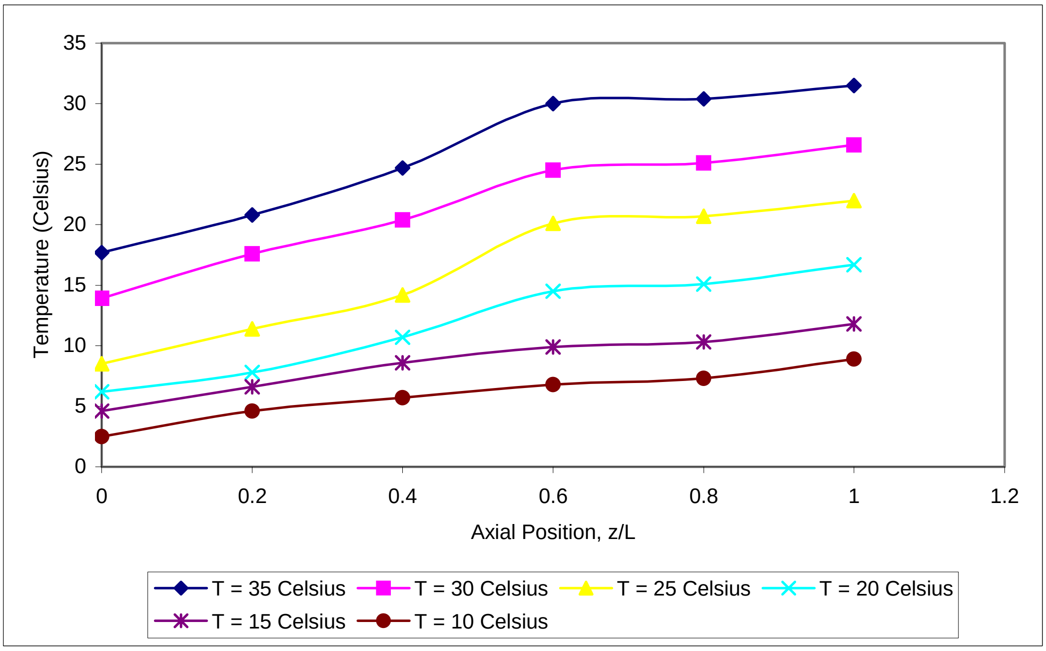
A451: Dimensionless Axial Profile of Temperature at 120 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



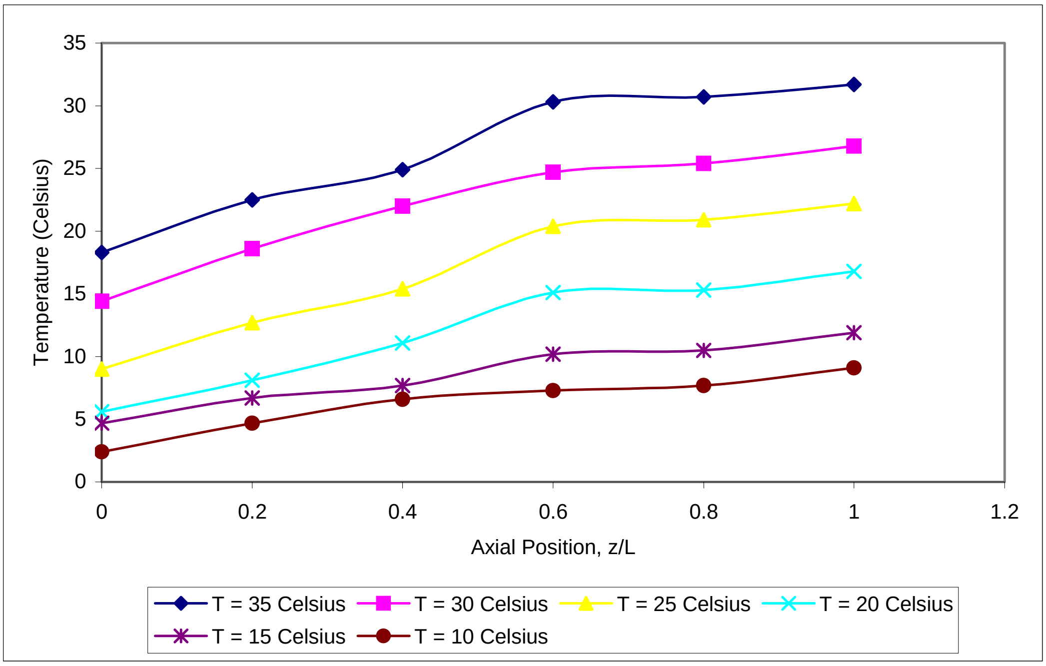
A452: Dimensionless Axial Profile of Temperature at 150 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



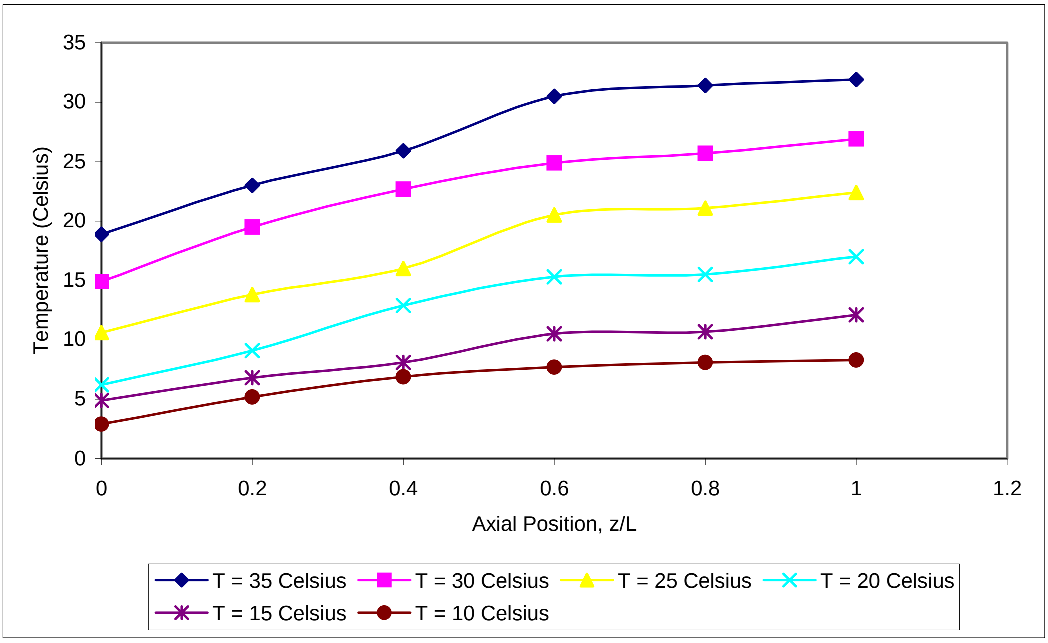
A453: Dimensionless Axial Profile of Temperature at 180 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



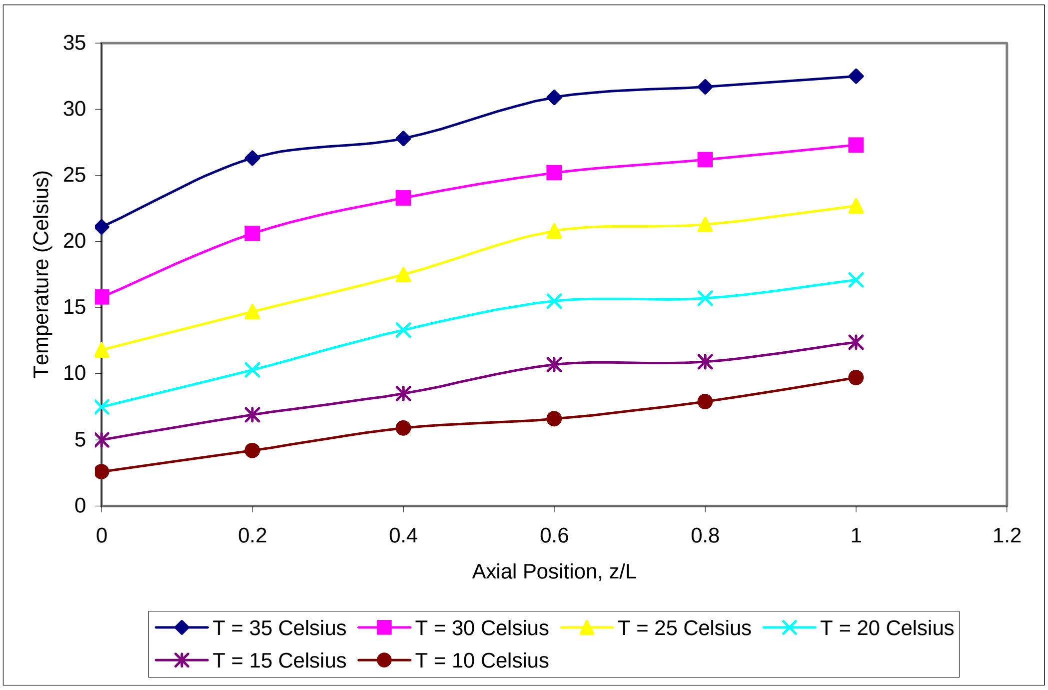
A454: Dimensionless Axial Profile of Temperature at 210 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



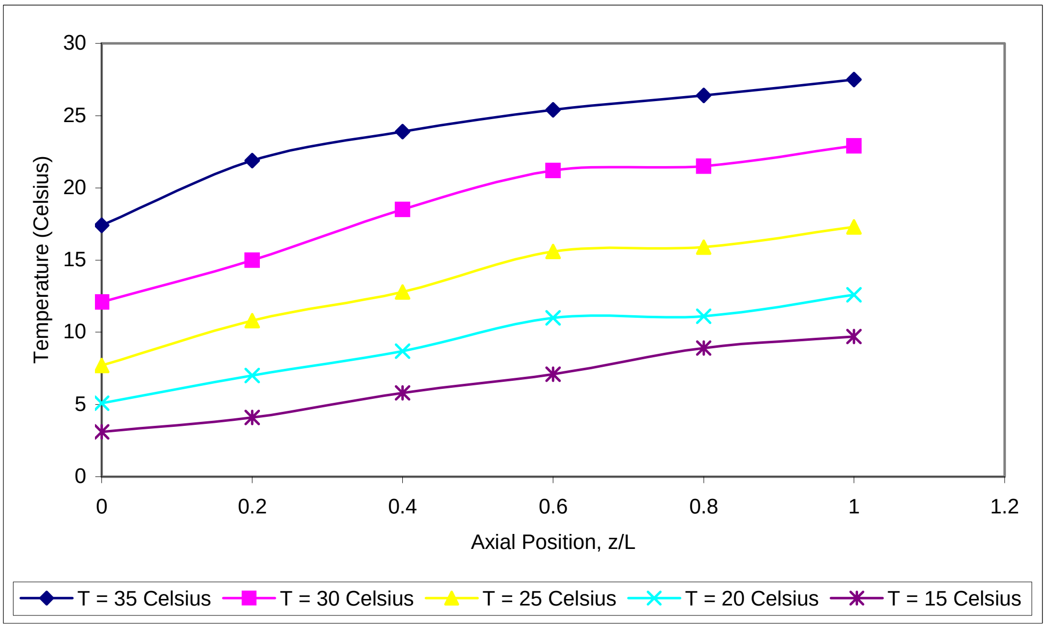
A455: Dimensionless Axial Profile of Temperature at 240 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



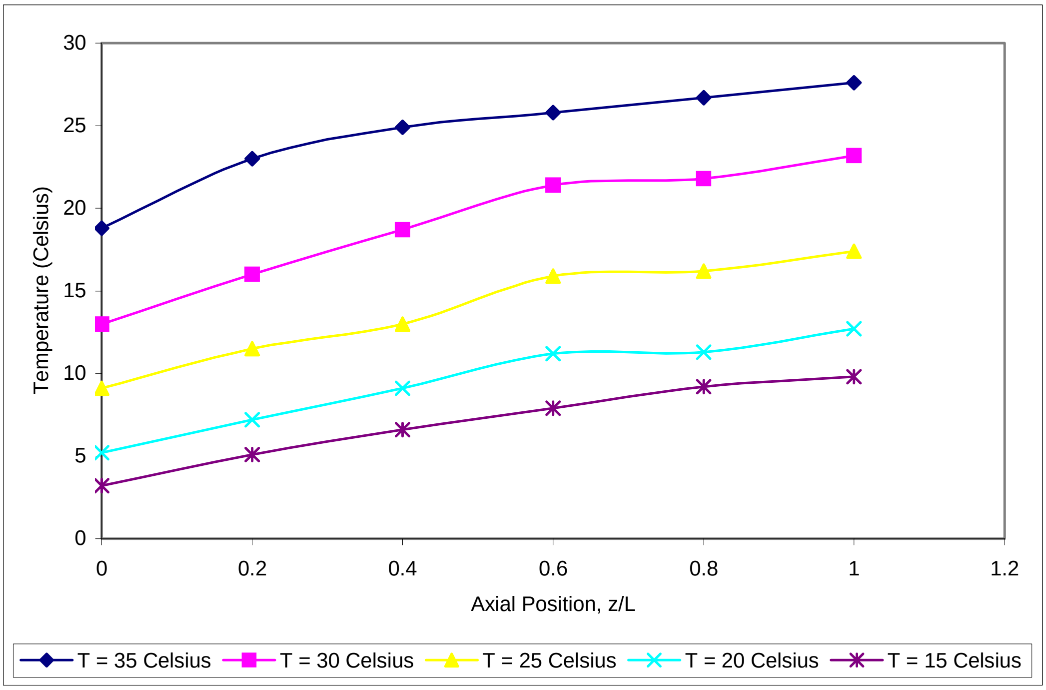
A456: Dimensionless Axial Profile of Temperature at 270 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



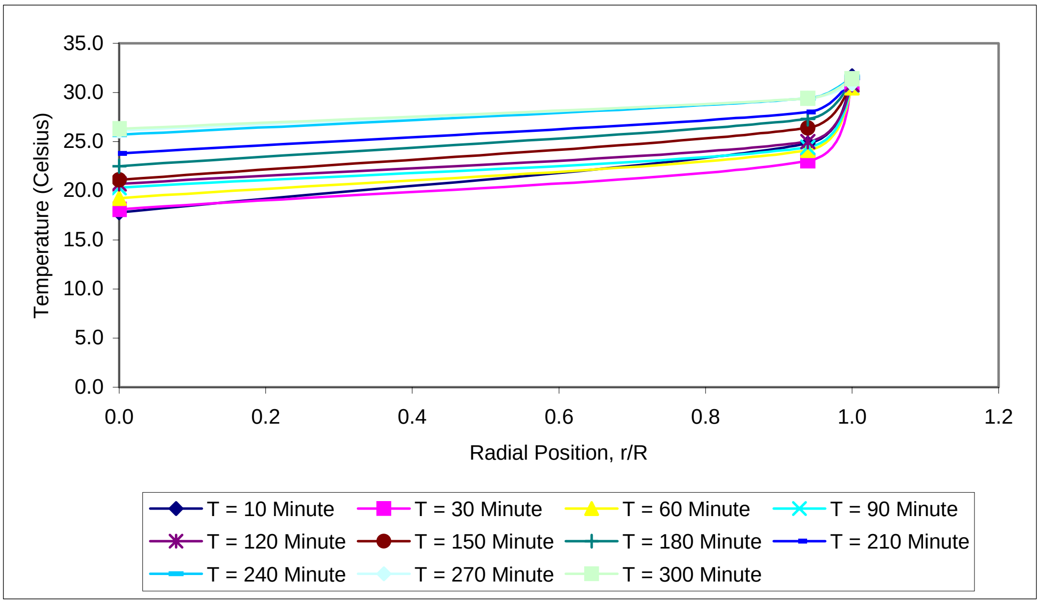
A457: Dimensionless Axial Profile of Temperature at 300 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



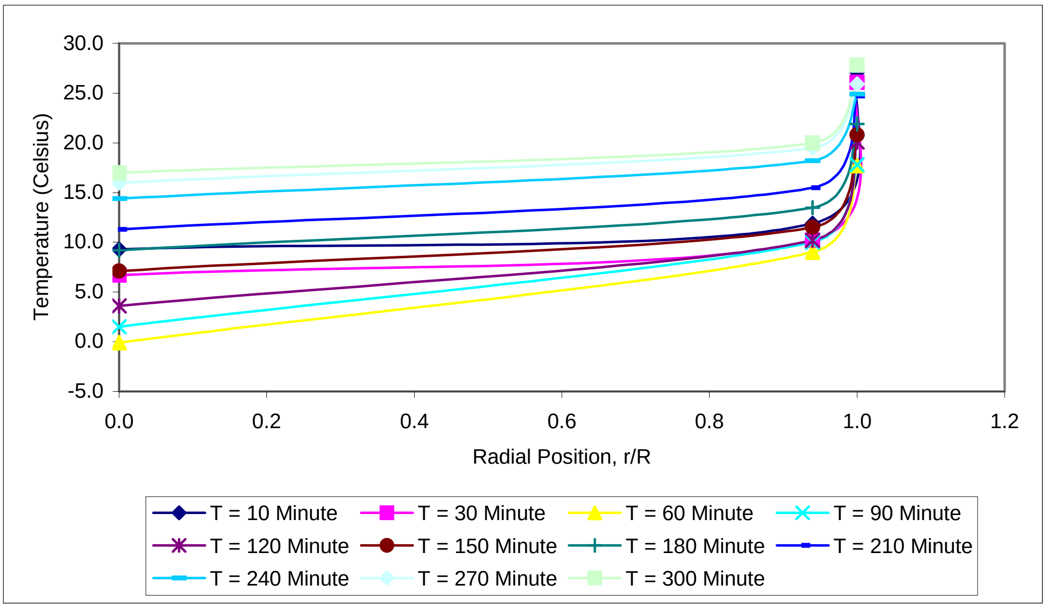
A458: Dimensionless Axial Profile of Temperature at 330 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



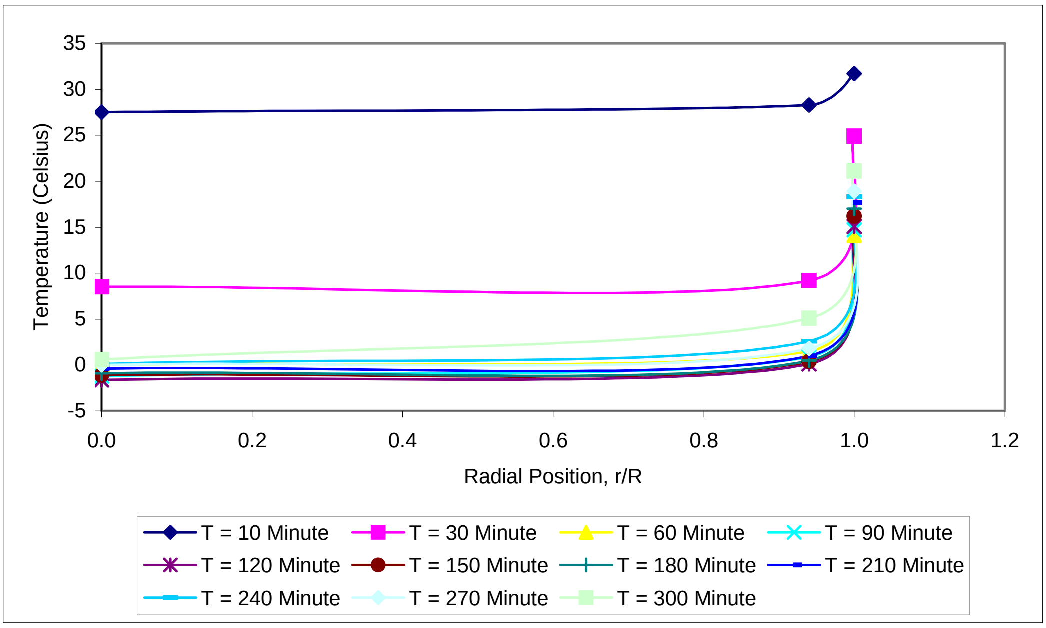
A459: Dimensionless Axial Profile of Temperature at 360 Minute at External Wall of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



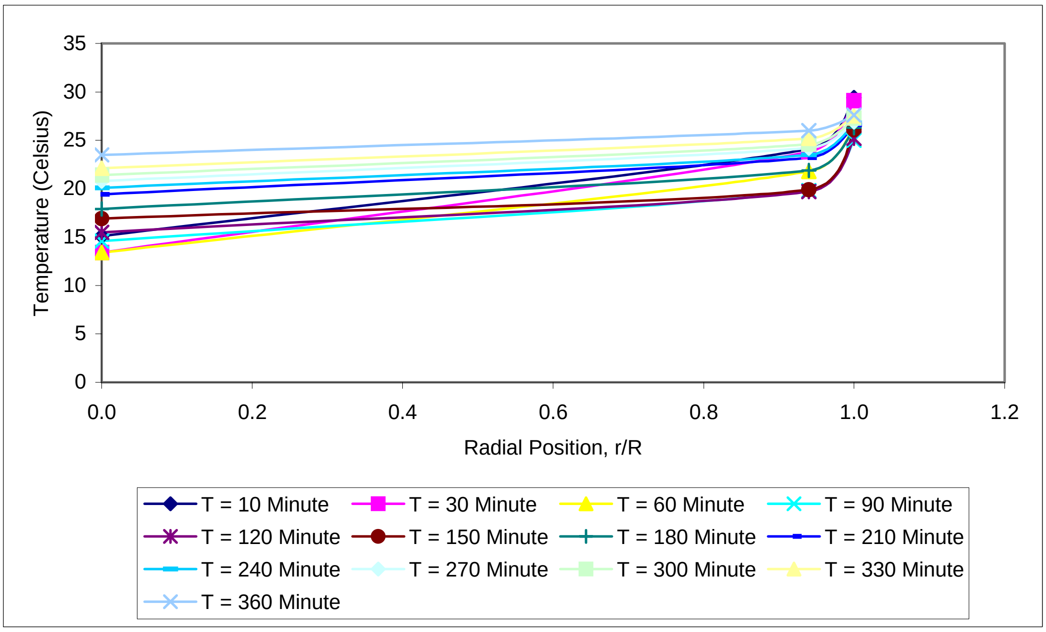
A460: Dimensionless Radial Profile of Temperature at Level 1 of Surrounding Temperature of 35^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



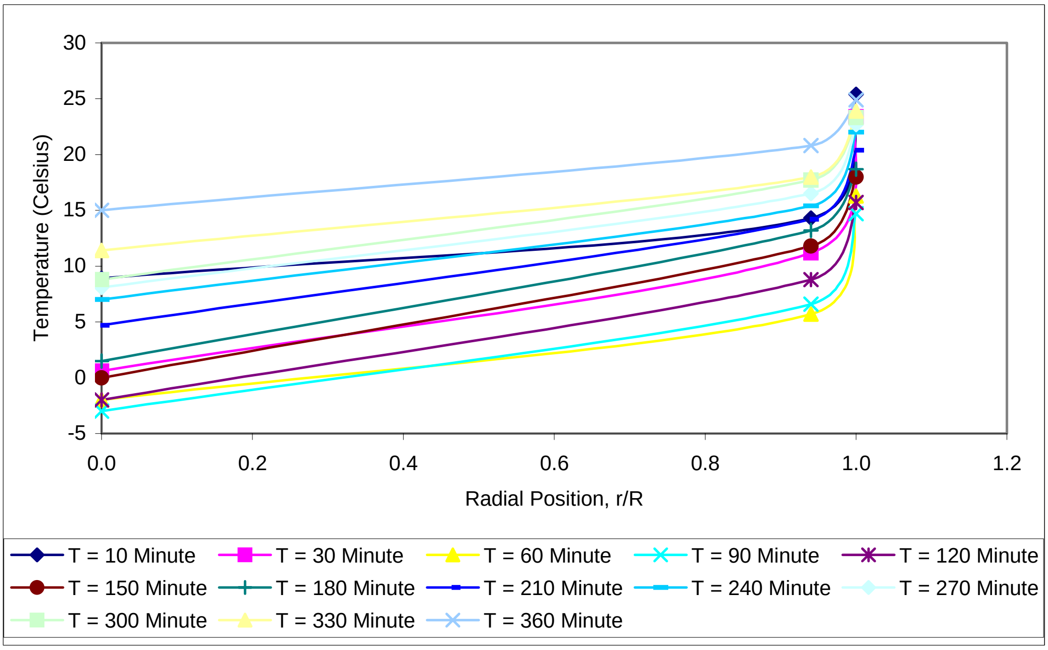
A461: Dimensionless Radial Profile of Temperature at Level 4 of Surrounding Temperature of 35°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



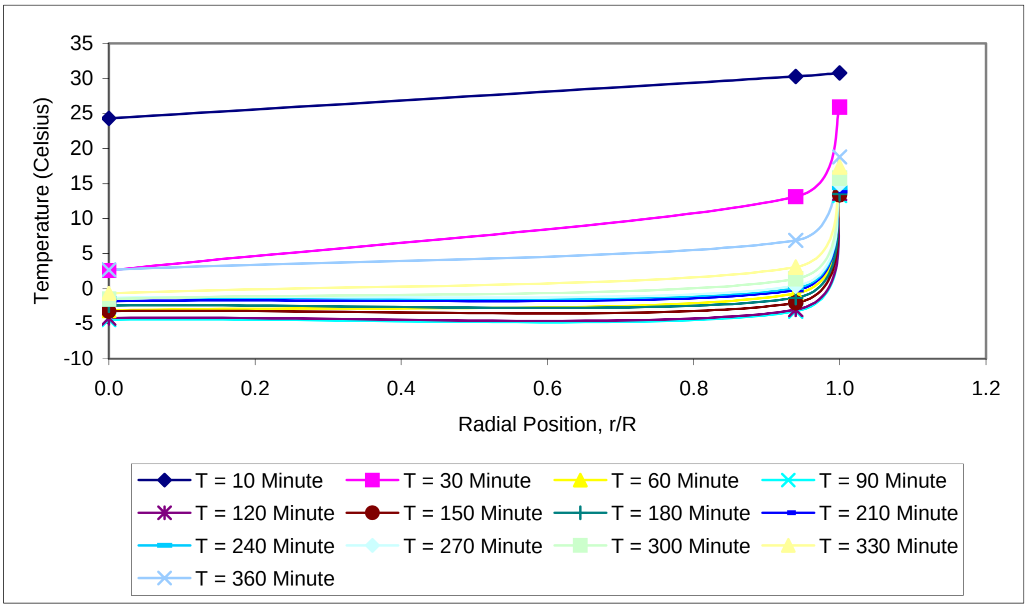
A462: Dimensionless Radial Profile of Temperature at Level 6 of Surrounding Temperature of 35°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



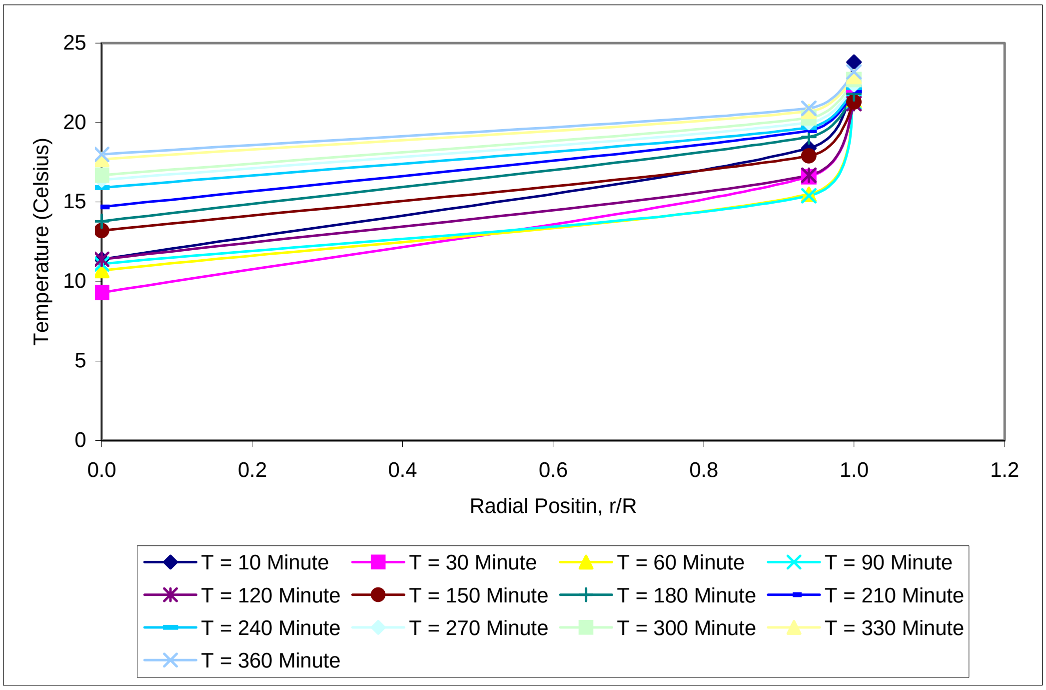
A463: Dimensionless Radial Profile of Temperature at Level 1 of Surrounding Temperature of 30^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



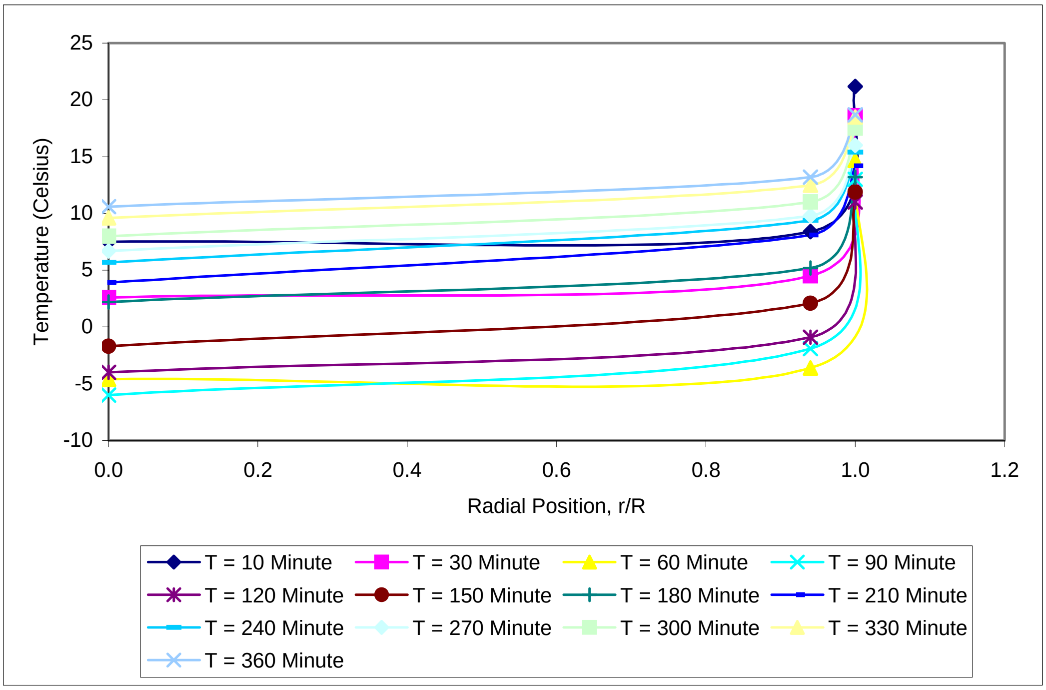
A464: Dimensionless Radial Profile of Temperature at Level 4 of Surrounding Temperature of 30^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



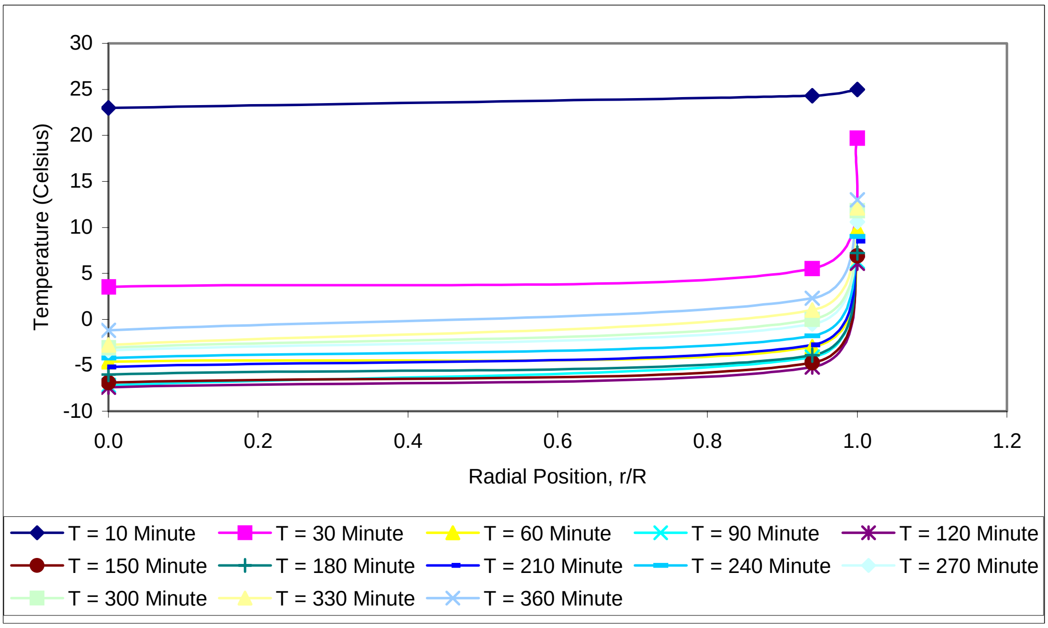
A465: Dimensionless Radial Profile of Temperature at Level 6 of Surrounding Temperature of 30°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



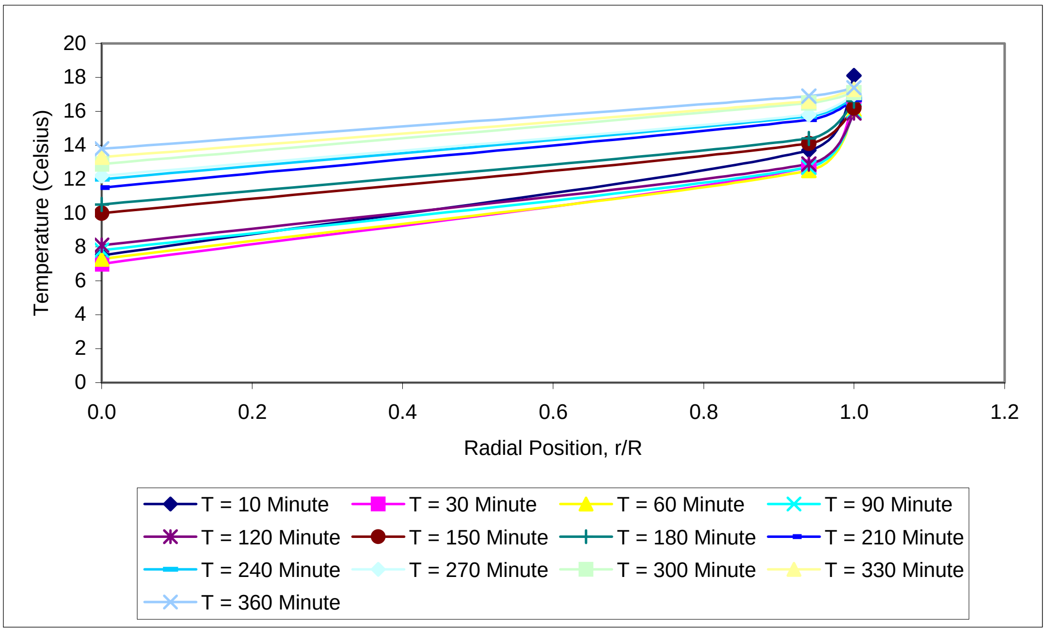
A466: Dimensionless Radial Profile of Temperature at Level 1 of Surrounding Temperature of 25°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



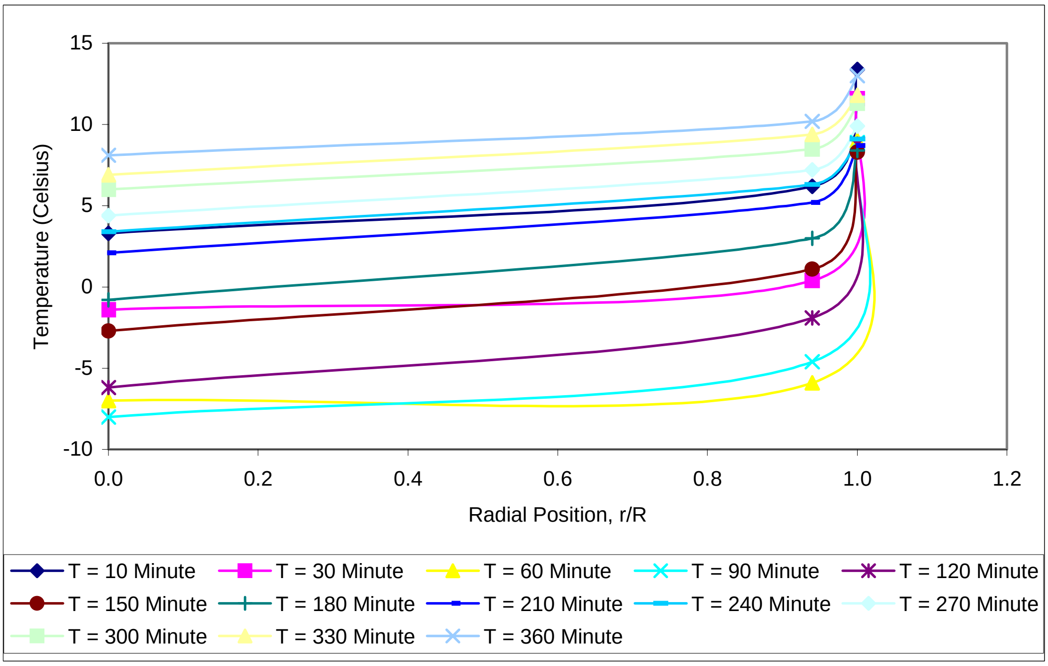
A467: Dimensionless Radial Profile of Temperature at Level 4 of Surrounding Temperature of 25^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



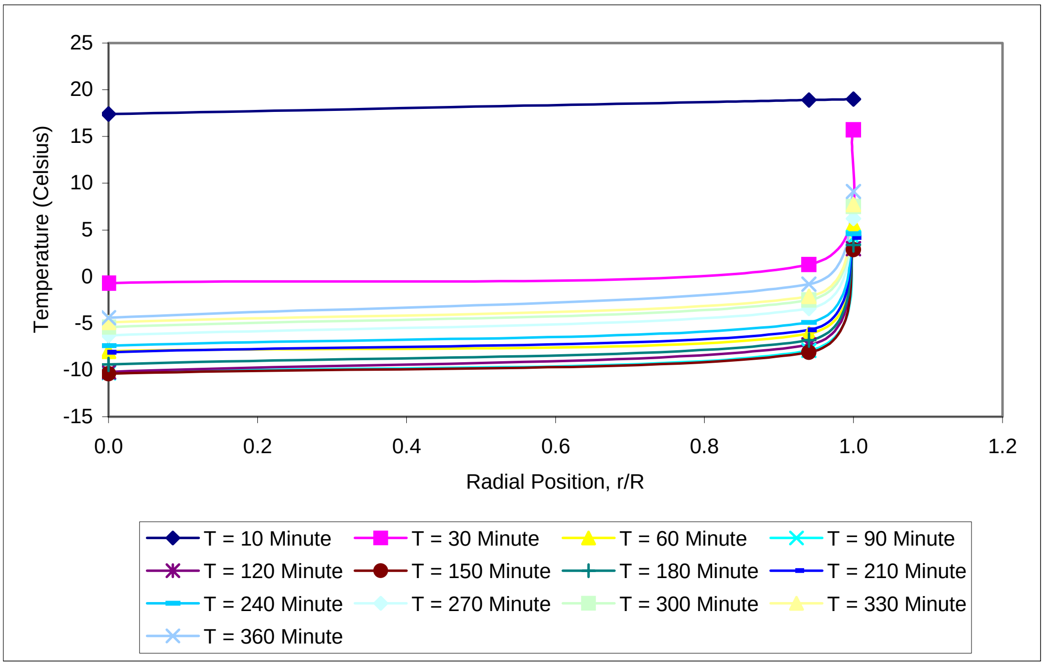
A468: Dimensionless Radial Profile of Temperature at Level 6 of Surrounding Temperature of 25^{o}C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



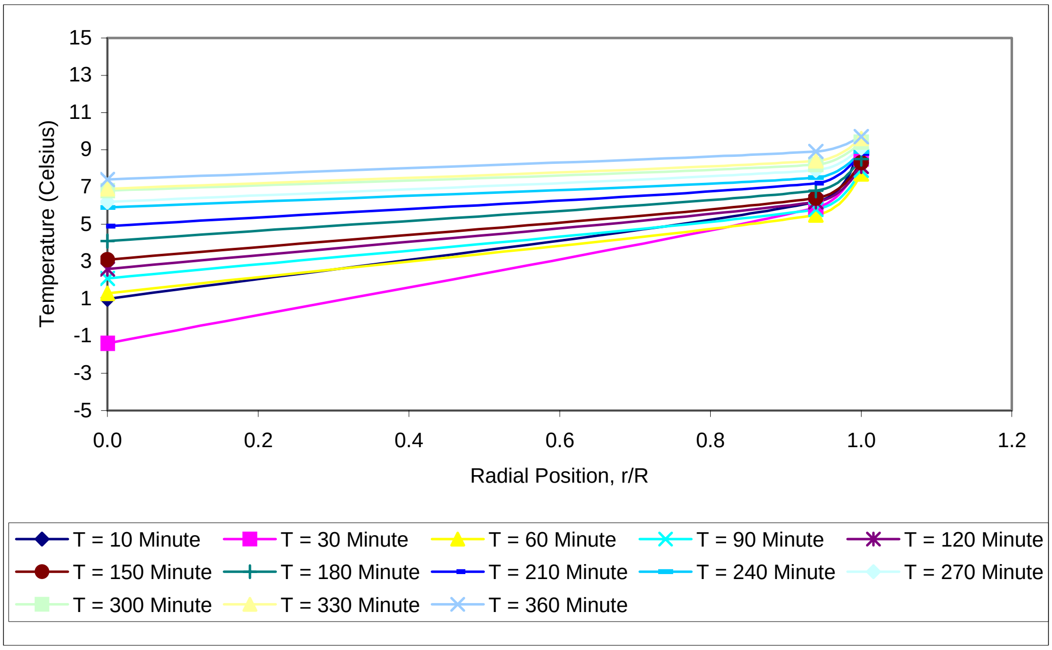
A469: Dimensionless Radial Profile of Temperature at Level 1 of Surrounding Temperature of 20°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



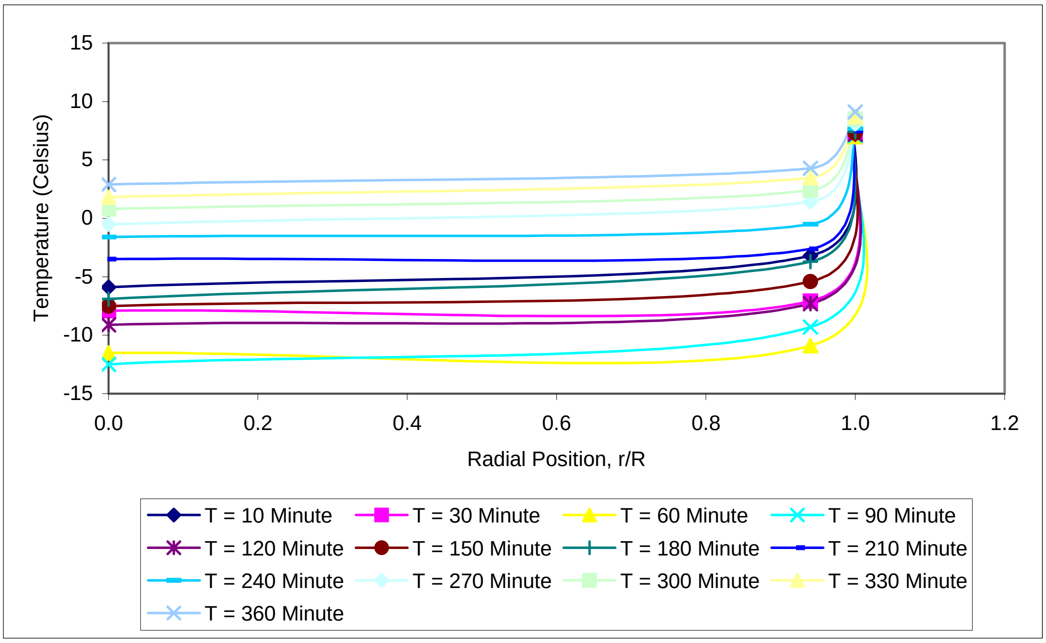
A470: Dimensionless Radial Profile of Temperature at Level 4 of Surrounding Temperature of 20°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



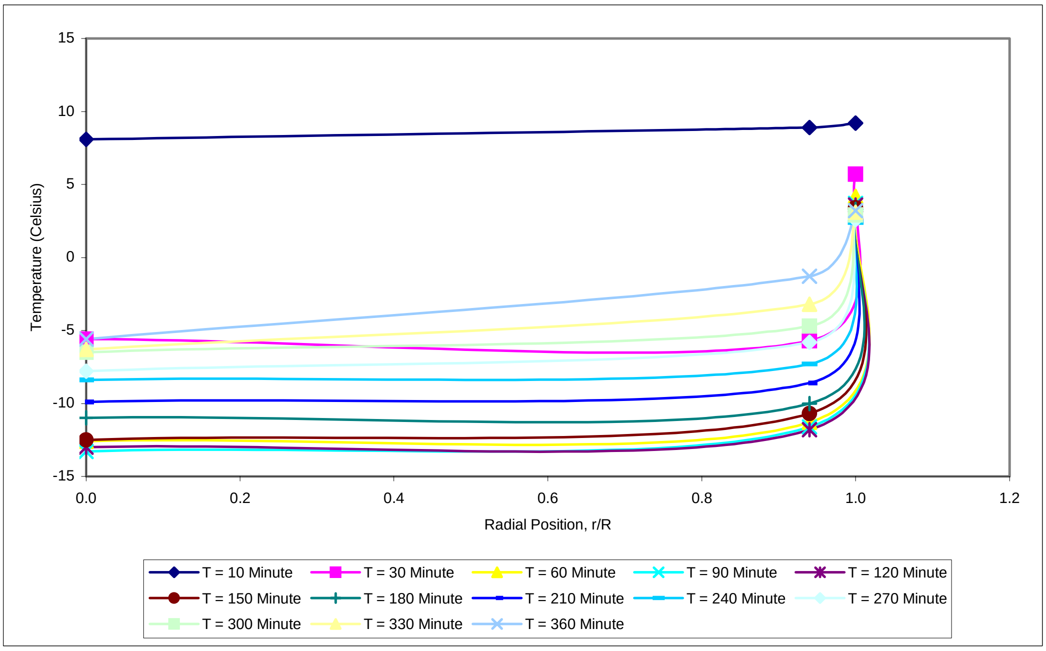
A471: Dimensionless Radial Profile of Temperature at Level 6 of Surrounding Temperature of 20°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



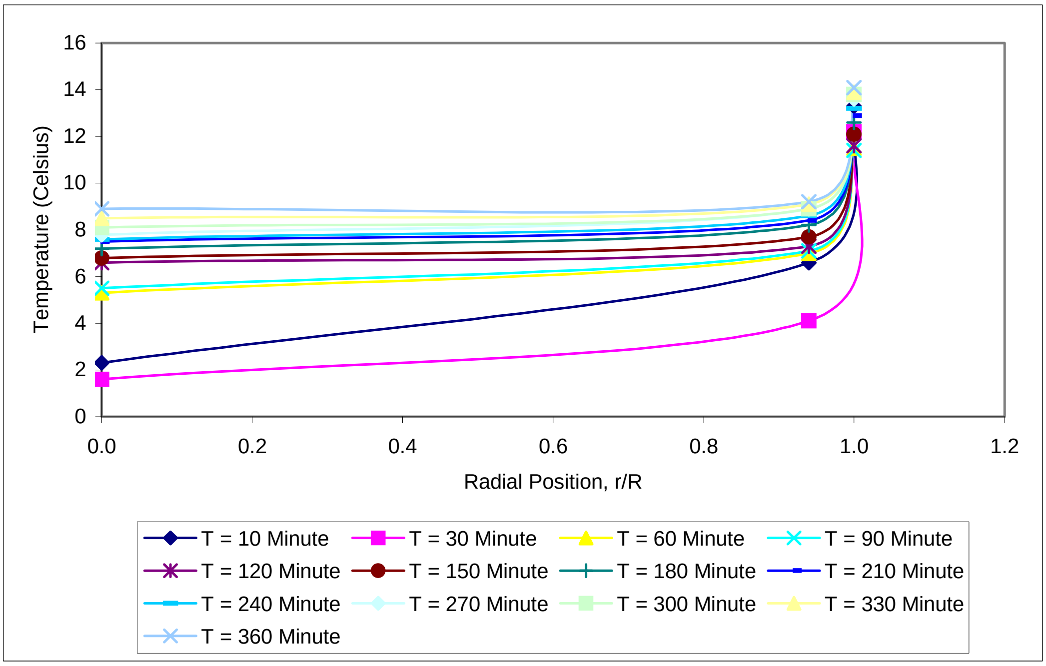
A472: Dimensionless Radial Profile of Temperature at Level 1 of Surrounding Temperature of 15°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



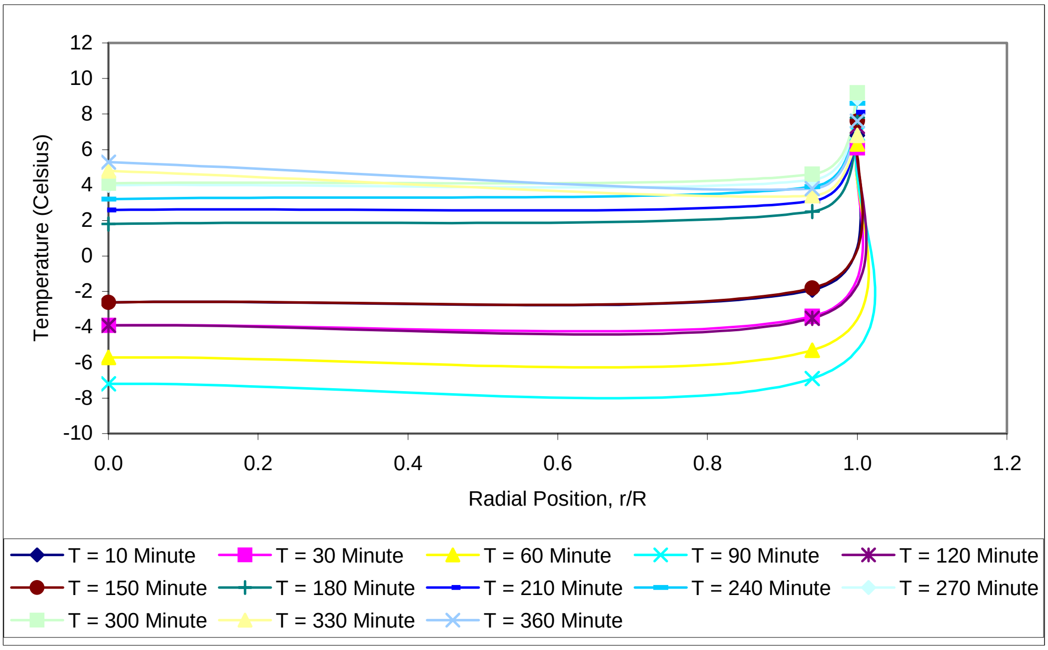
A473: Dimensionless Radial Profile of Temperature at Level 4 of Surrounding Temperature of 15°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



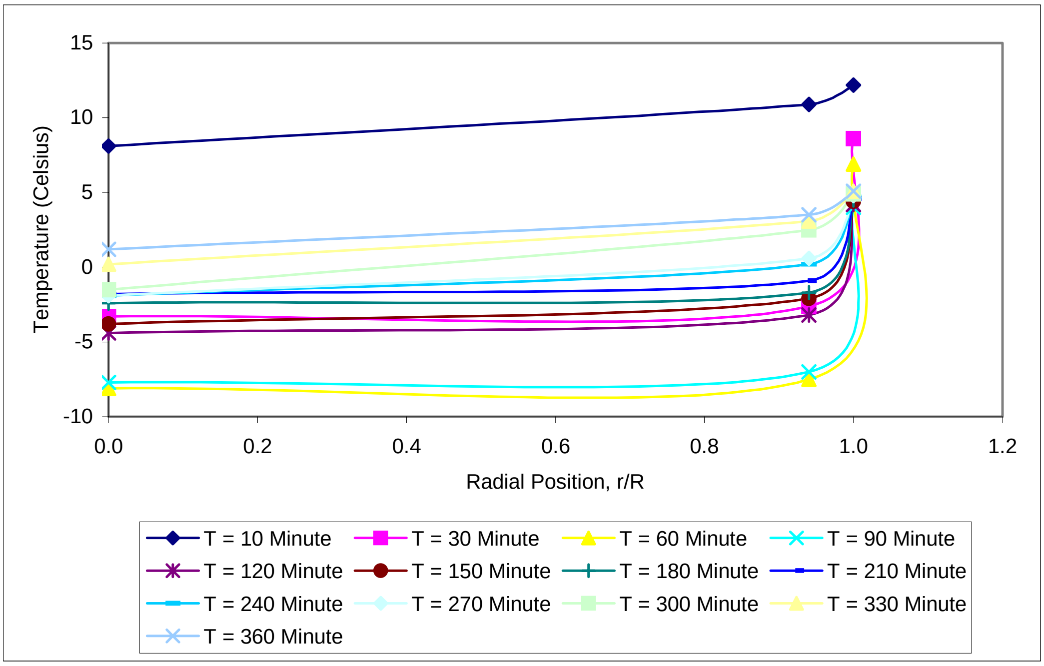
A474: Dimensionless Radial Profile of Temperature at Level 6 of Surrounding Temperature of 15°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



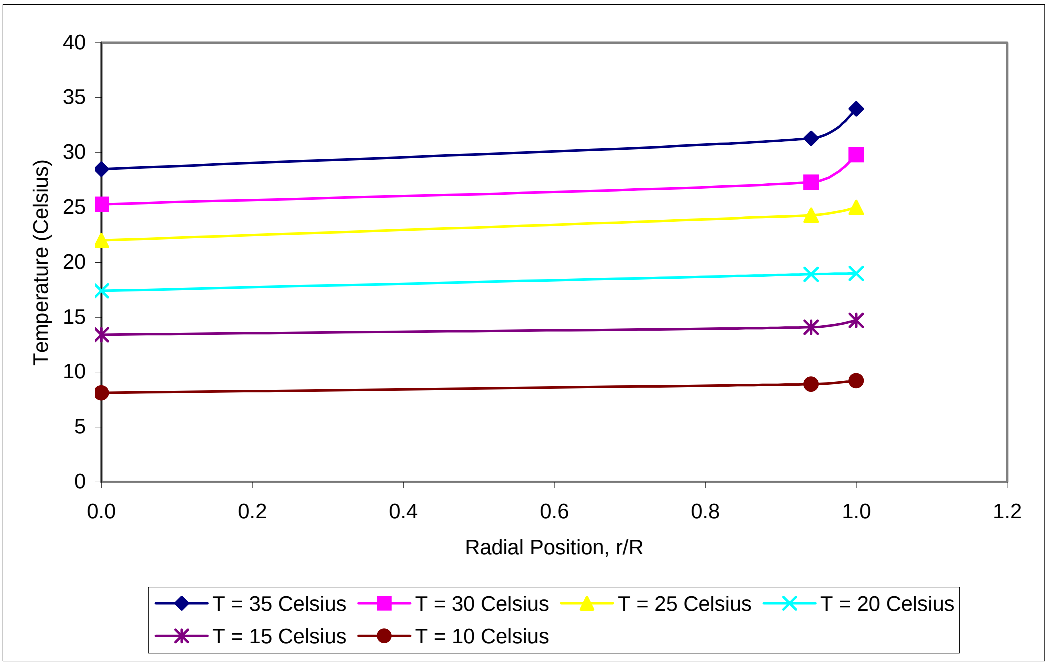
A475: Dimensionless Radial Profile of Temperature at Level 1 of Surrounding Temperature of 10°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



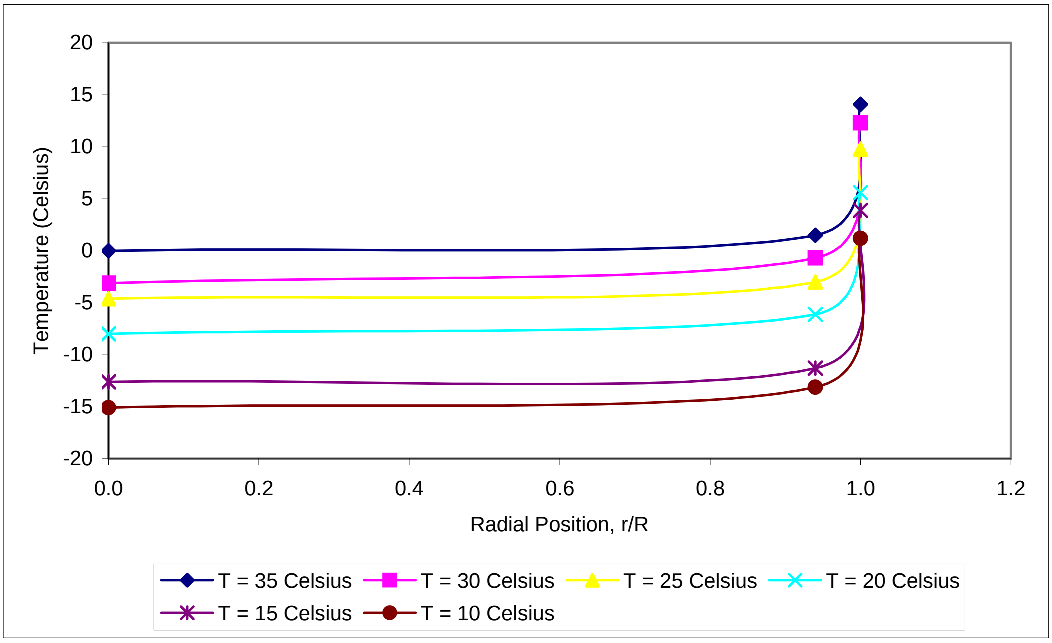
A476: Dimensionless Radial Profile of Temperature at Level 4 of Surrounding Temperature of 10°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



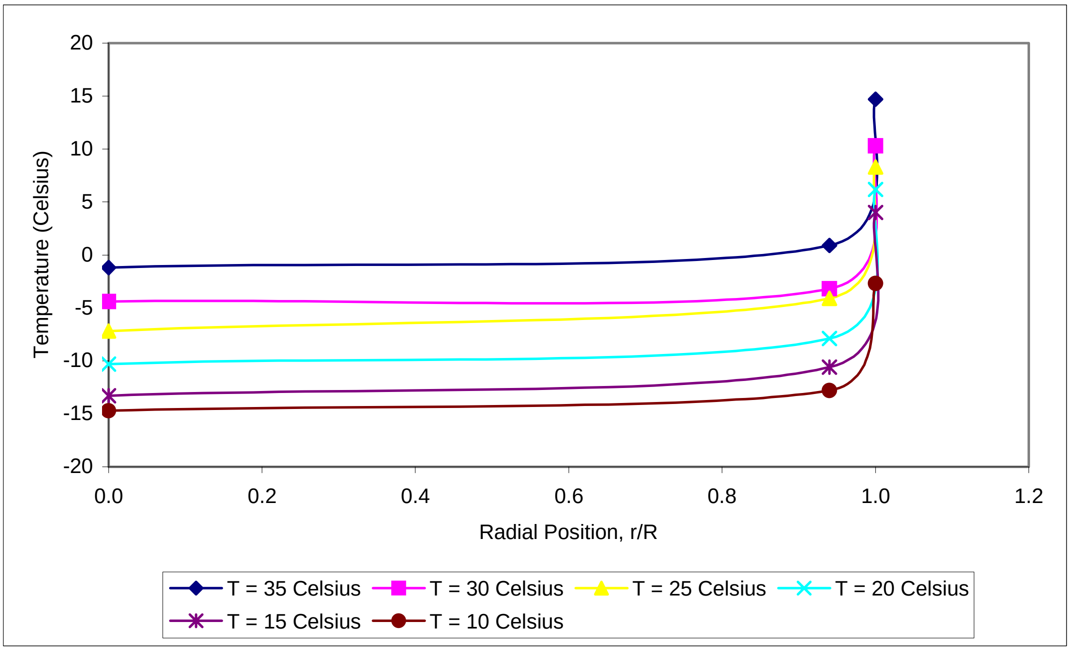
A477: Dimensionless Radial Profile of Temperature at Level 6 of Surrounding Temperature of 10°C at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



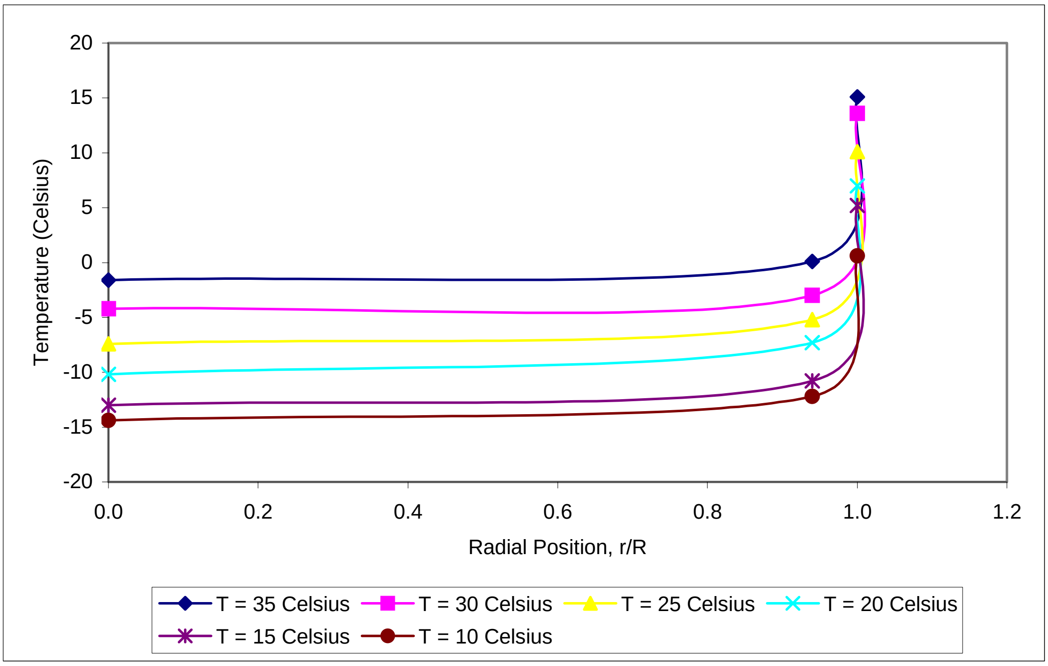
A478: Dimensionless Radial Profile of Temperature at Level 6 at 10 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



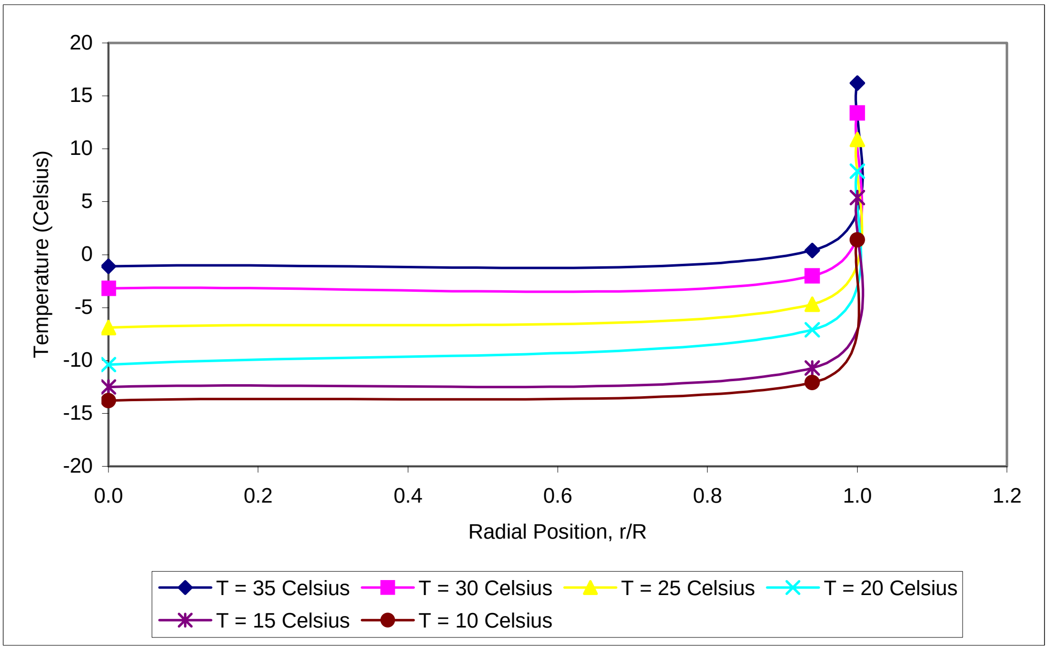
A479: Dimensionless Radial Profile of Temperature at Level 6 at 60 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



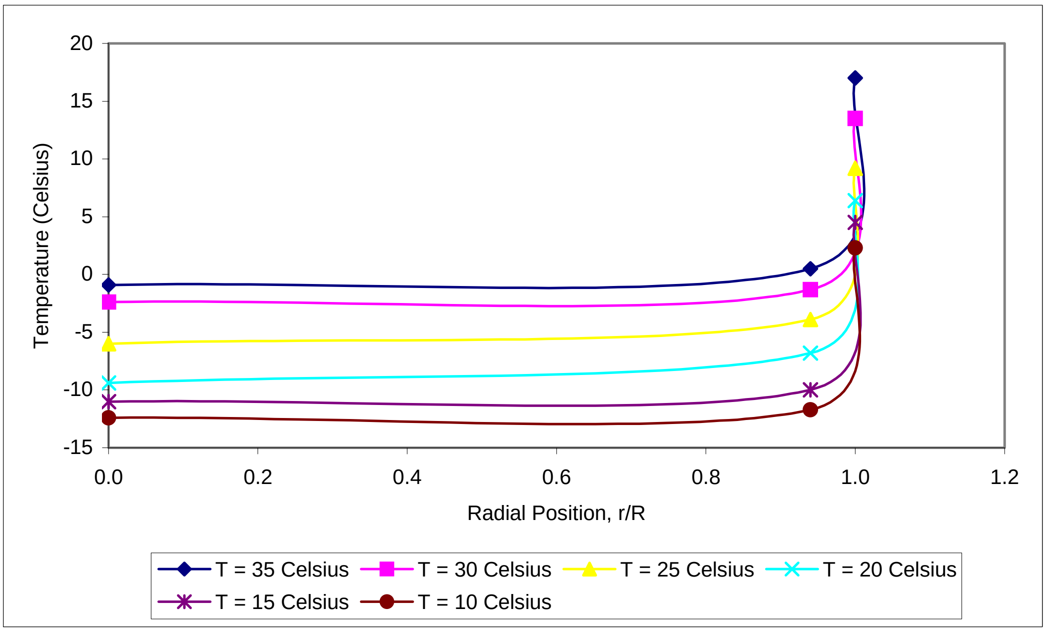
A480: Dimensionless Radial Profile of Temperature at Level 6 at 90 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



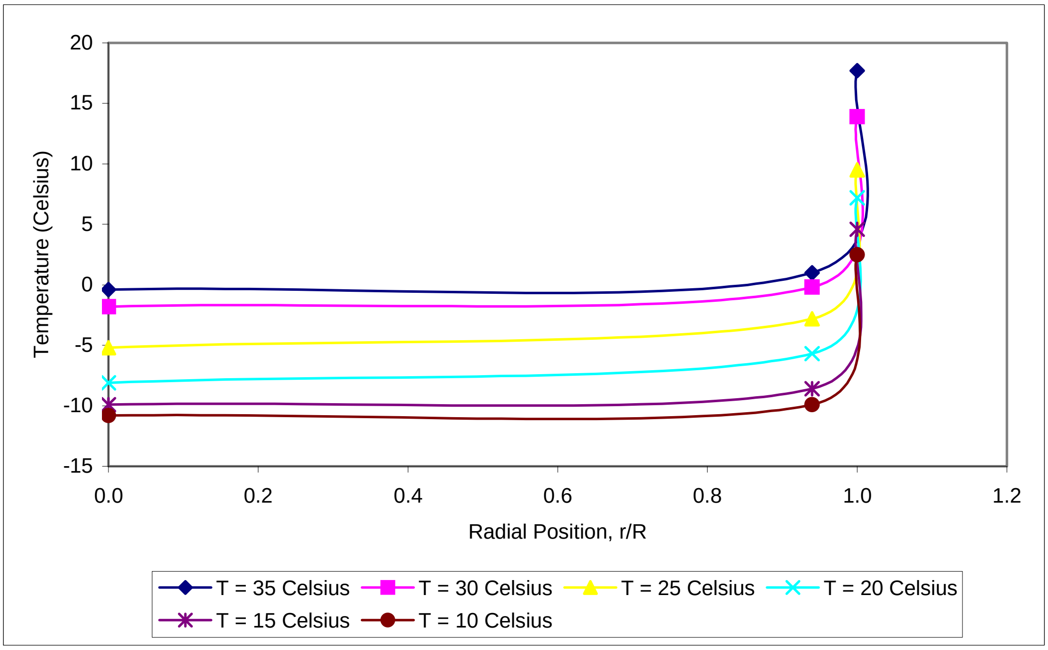
A481: Dimensionless Radial Profile of Temperature at Level 6 at 120 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



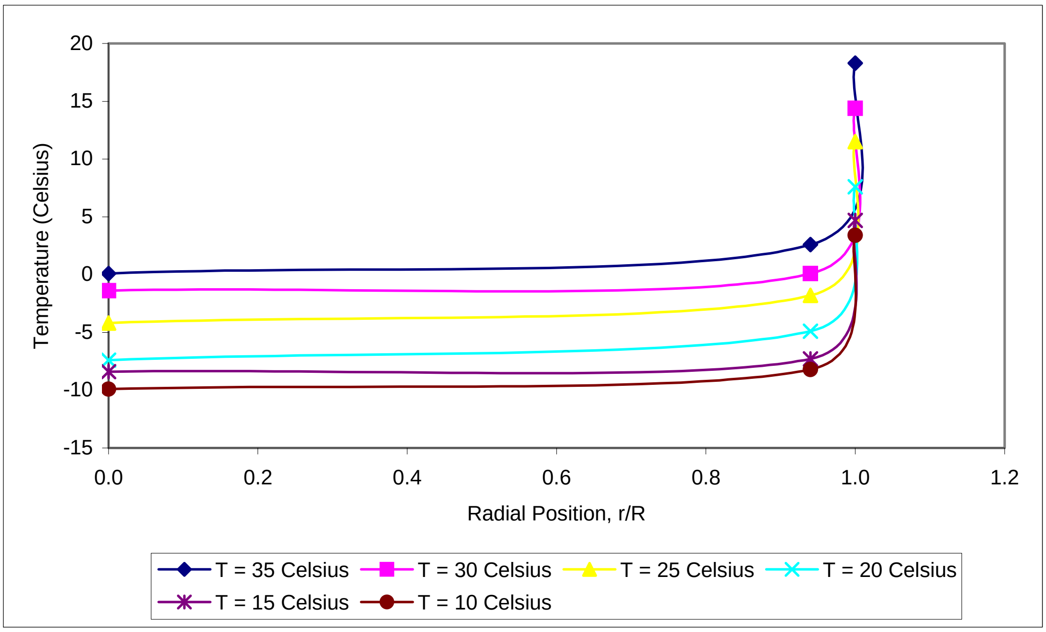
A482: Dimensionless Radial Profile of Temperature at Level 6 at 150 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



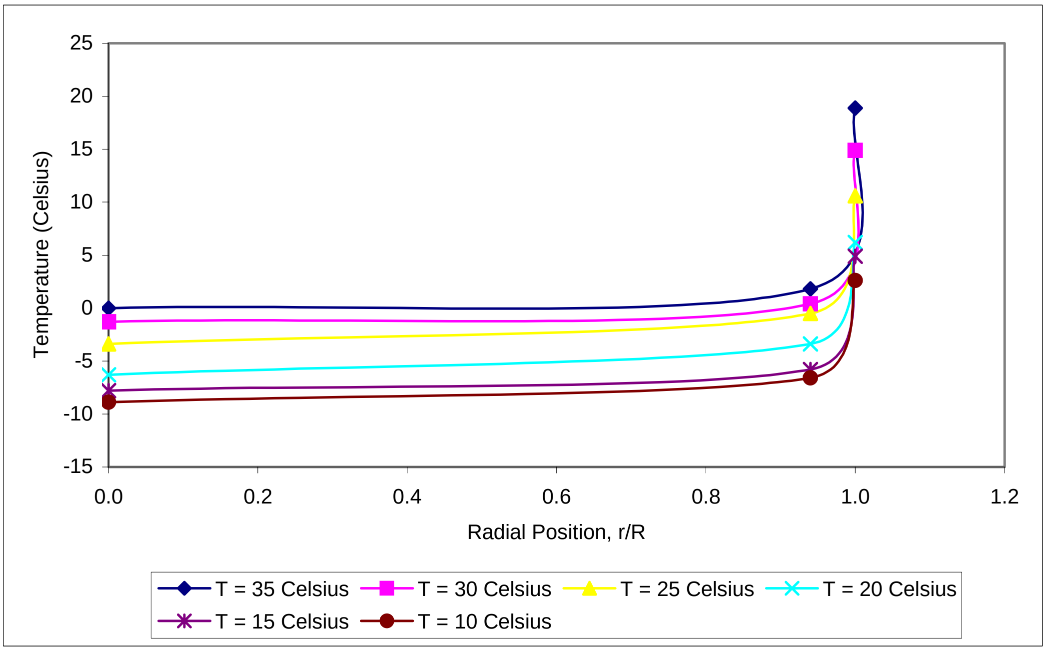
A483: Dimensionless Radial Profile of Temperature at Level 6 at 180 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



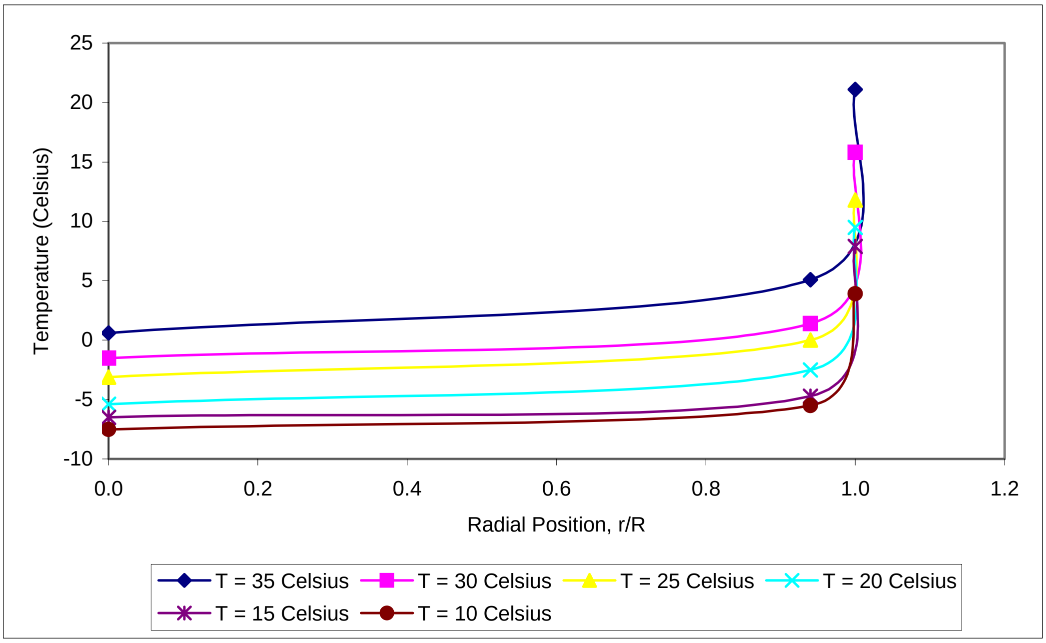
A484: Dimensionless Radial Profile of Temperature at Level 6 at 210 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



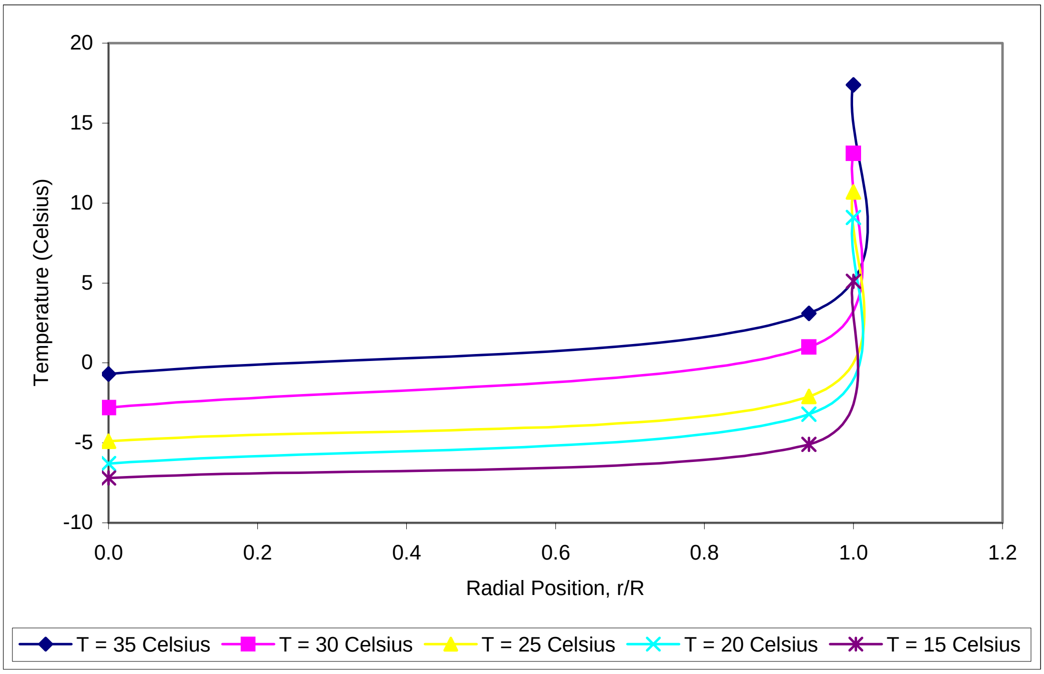
A485: Dimensionless Radial Profile of Temperature at Level 6 at 240 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



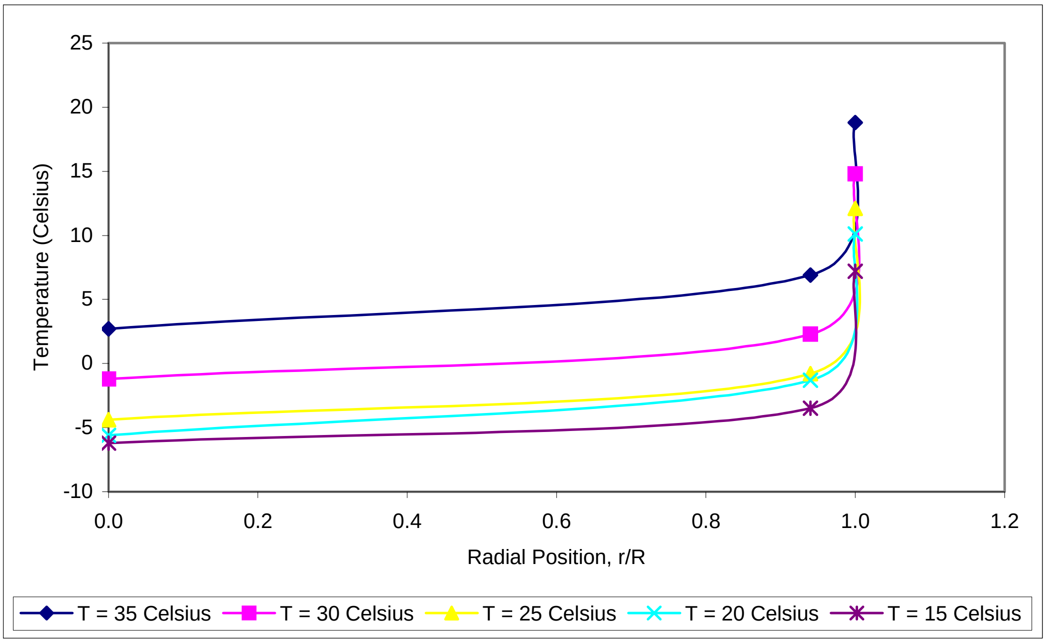
A486: Dimensionless Radial Profile of Temperature at Level 6 at 270 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



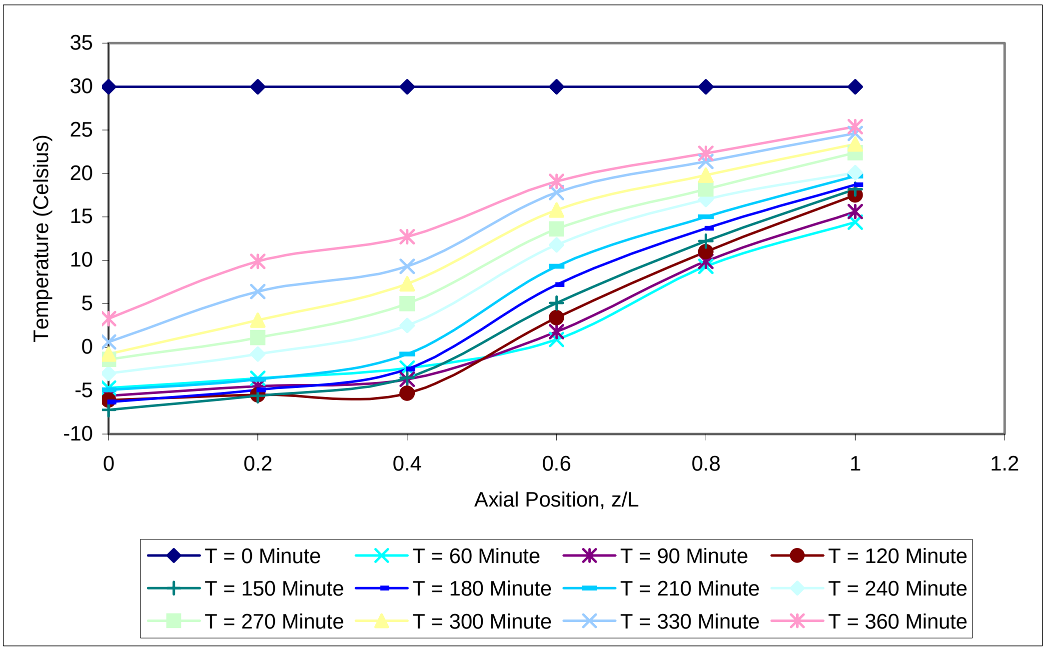
A487: Dimensionless Radial Profile of Temperature at Level 6 at 300 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



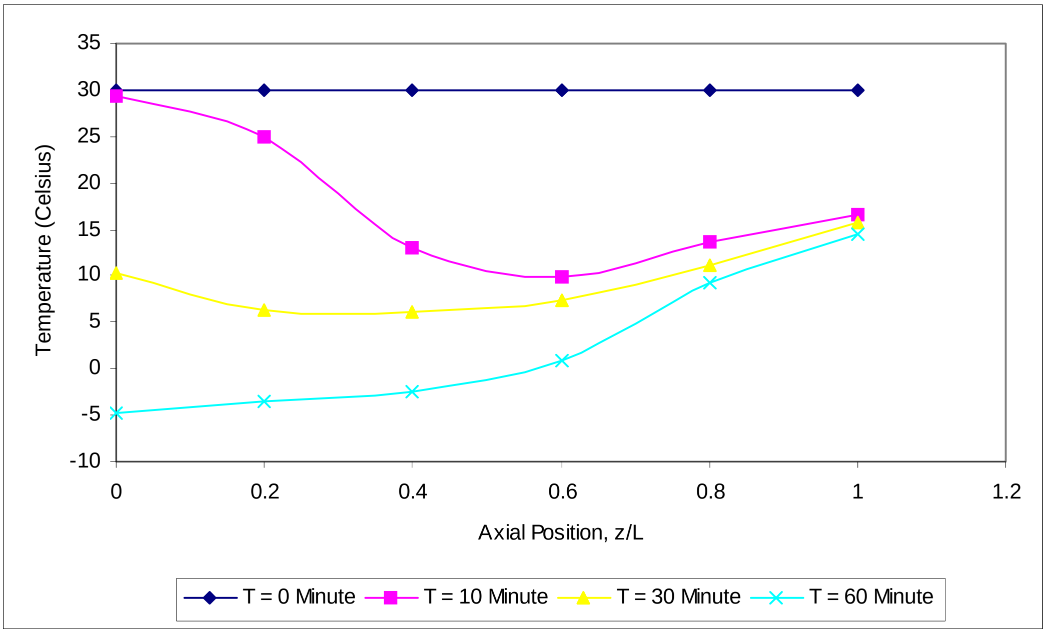
A488: Dimensionless Radial Profile of Temperature at Level 6 at 330 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



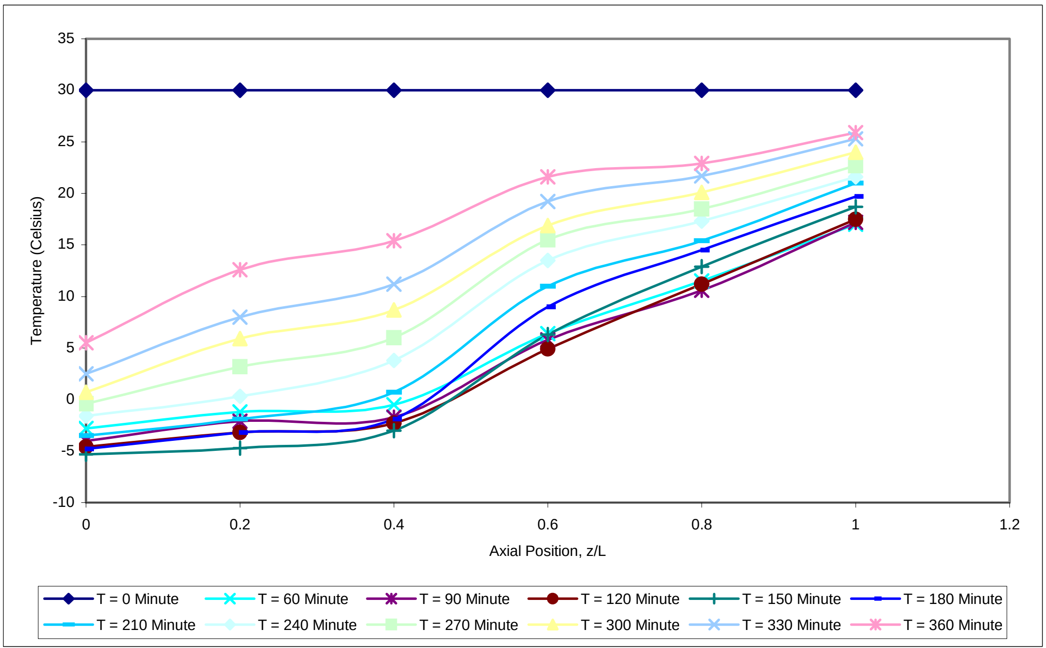
A489: Dimensionless Radial Profile of Temperature at Level 6 at 360 Minute of Various Surrounding Temperature at Flow rate of 48 liter/minute, Composition of 4060 and Weight of 6 kg



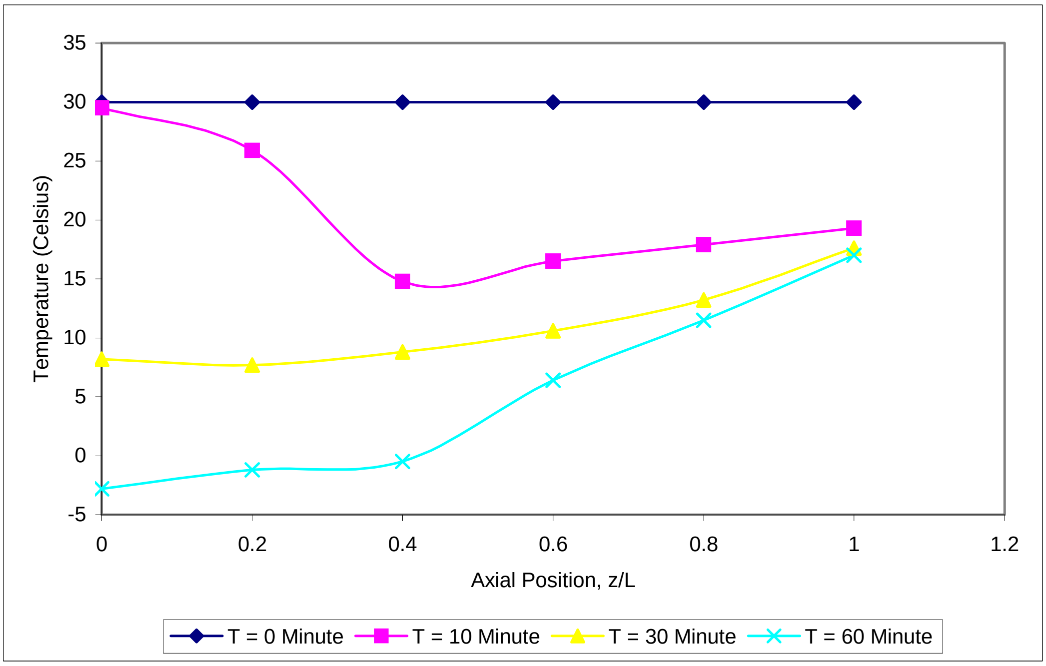
A490: Dimensionless Axial Profile of Temperature at Center of Weight of 7 kg at Surrounding Temperature of 30^{o}C, Flow rate of 48 liter/minute and Composition of 4060



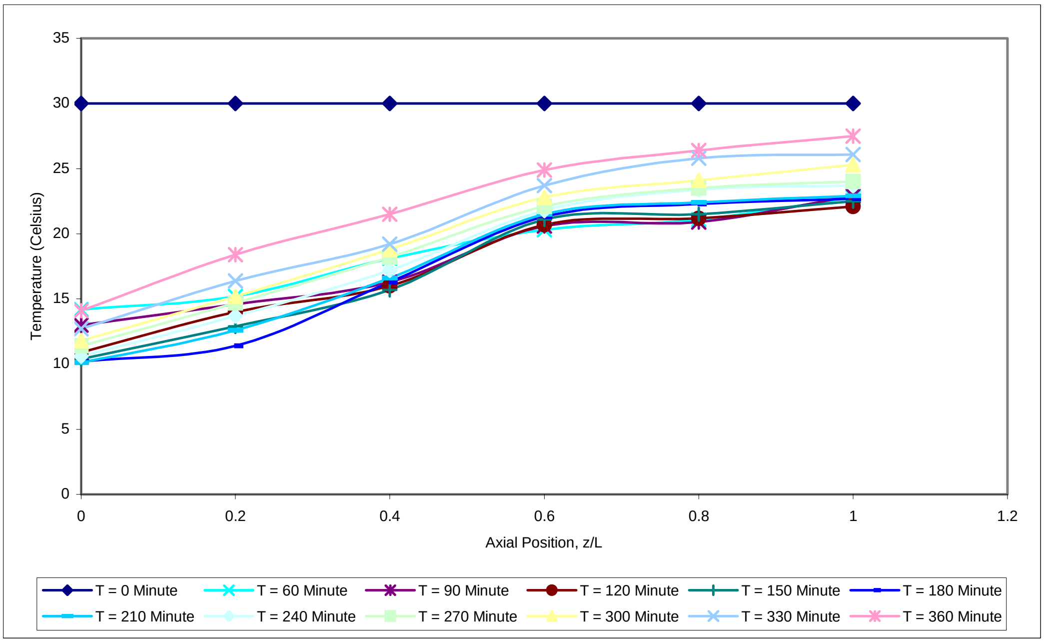
A491: Dimensionless Axial Profile of Temperature at Early Stage at Center of Weight of 7 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



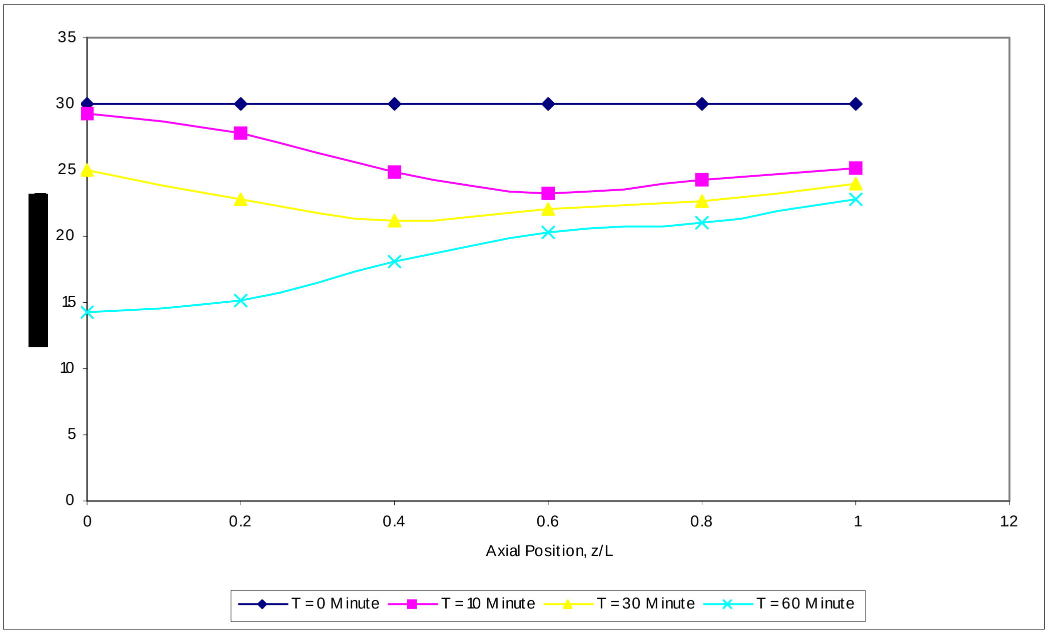
A492: Dimensionless Axial Profile of Temperature at Internal Wall of Weight of 7 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



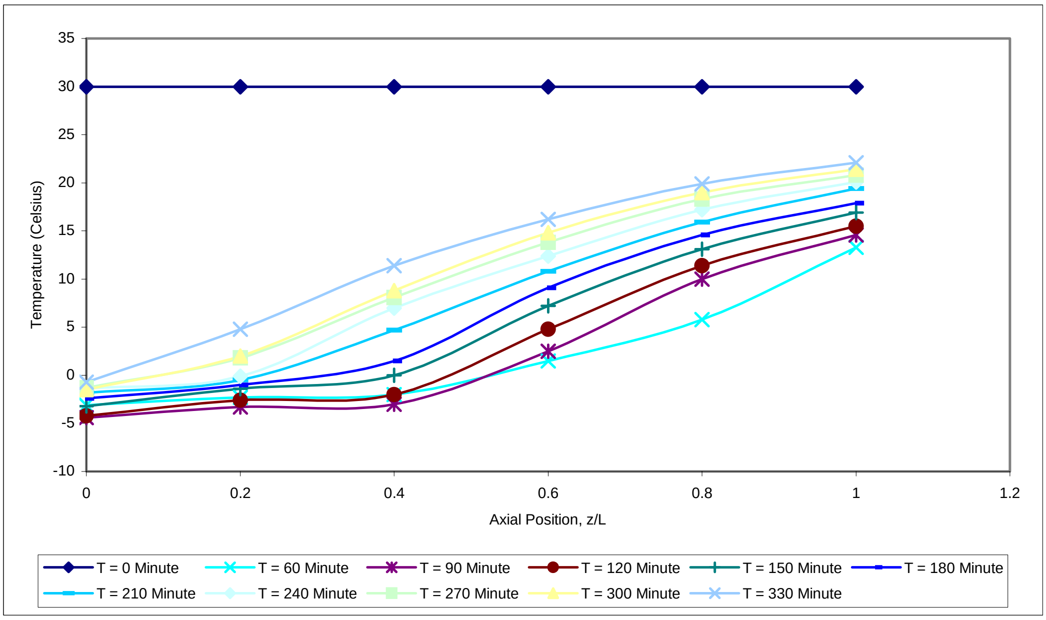
A493: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Weight of 7 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



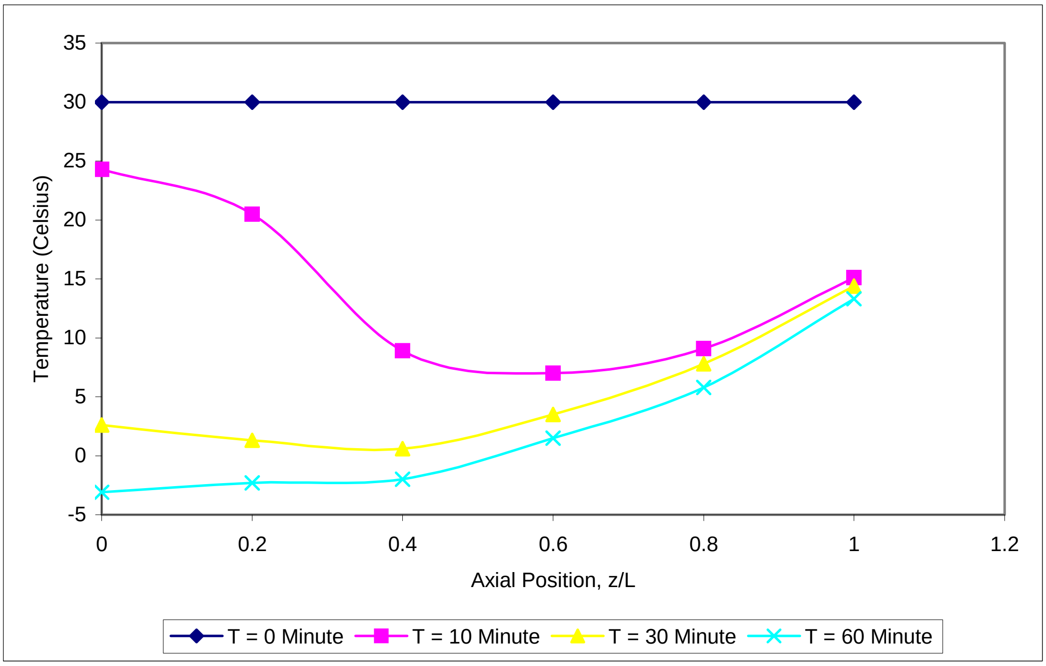
A494: Dimensionless Axial Profile of Temperature at External Wall of Weight of 7 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



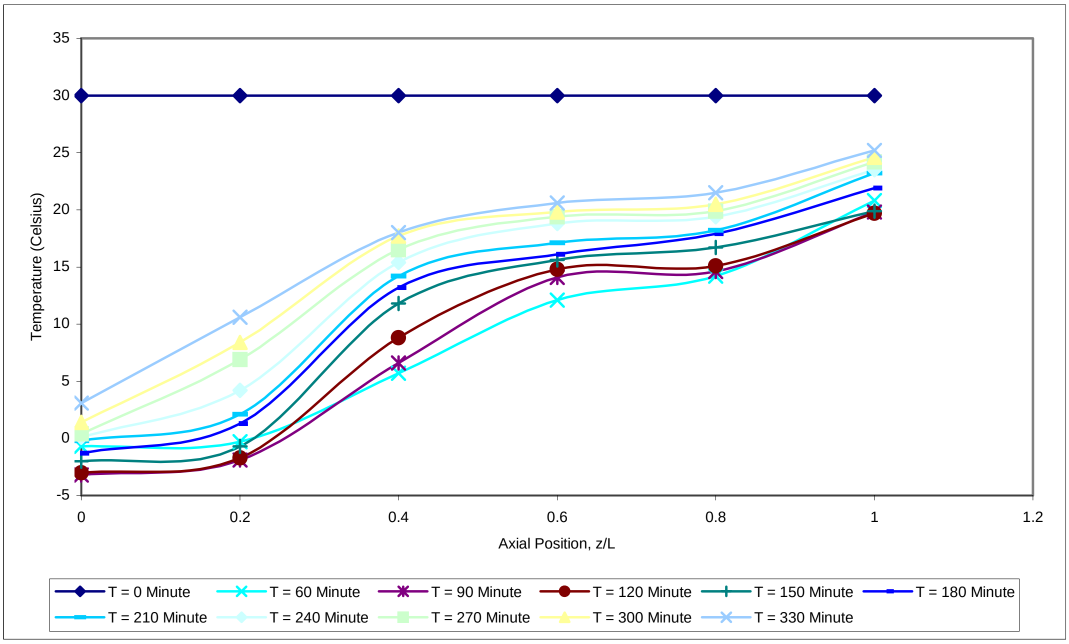
A495: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Weight of 7 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C



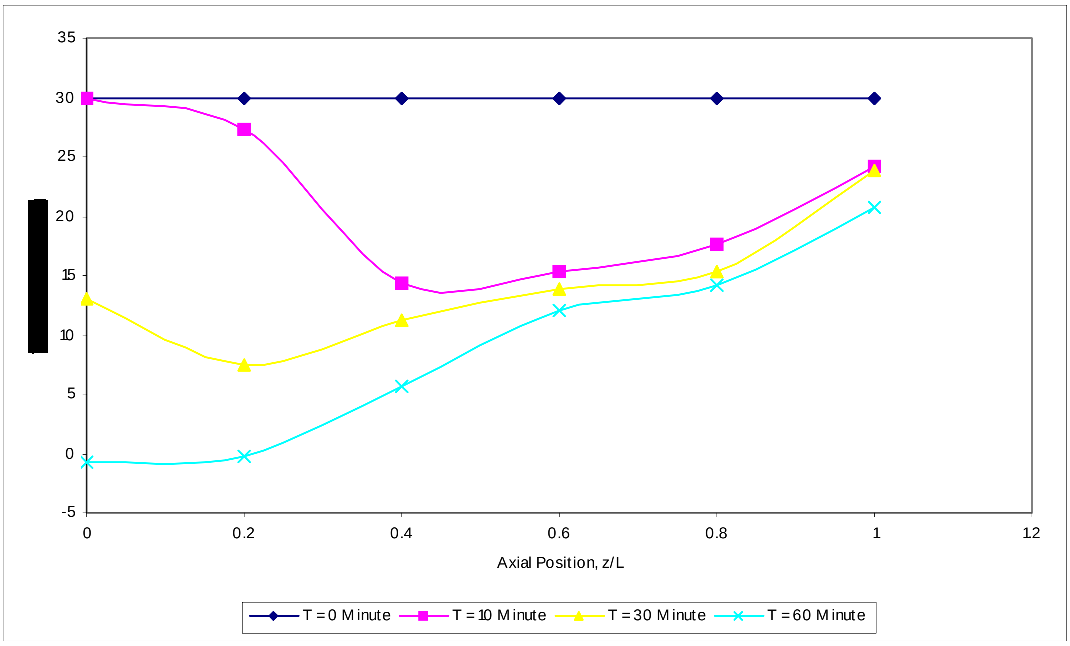
A496: Dimensionless Axial Profile of Temperature Center of Weight of 6 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C



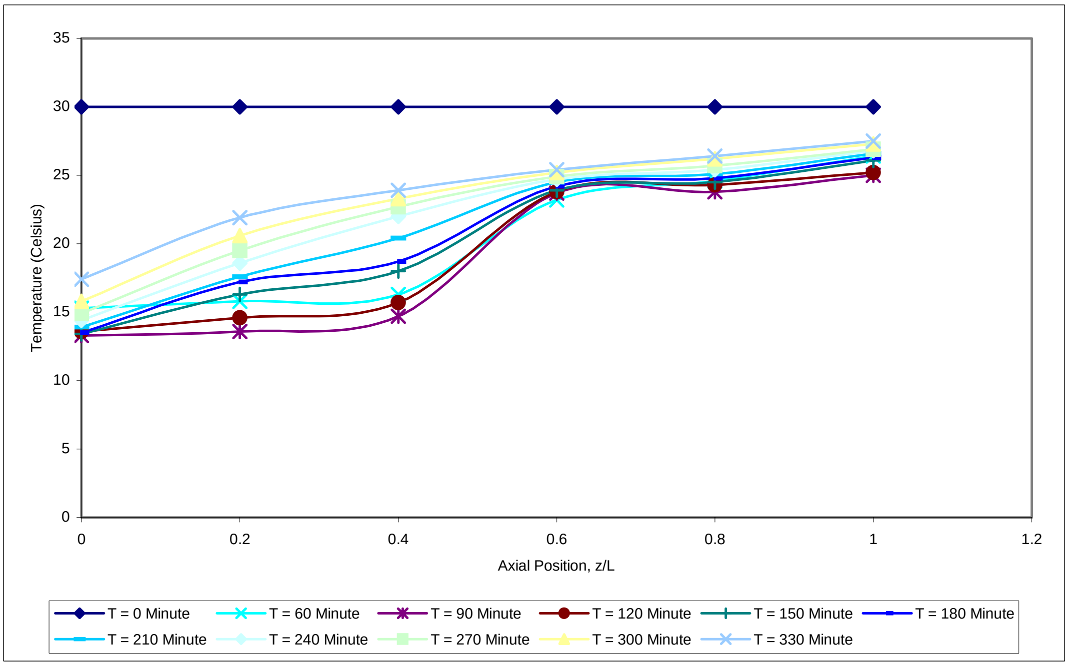
A497: Dimensionless Axial Profile of Temperature at Early Stage at Center of Weight of 6 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



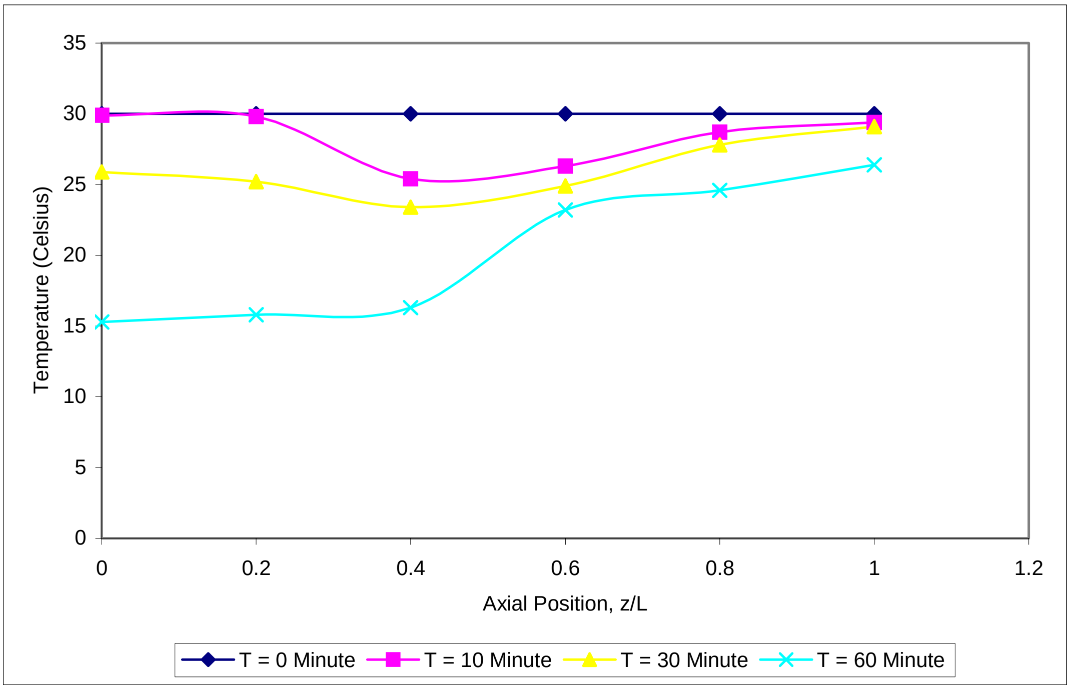
A498: Dimensionless Axial Profile of Temperature at Internal Wall of Weight of 6 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



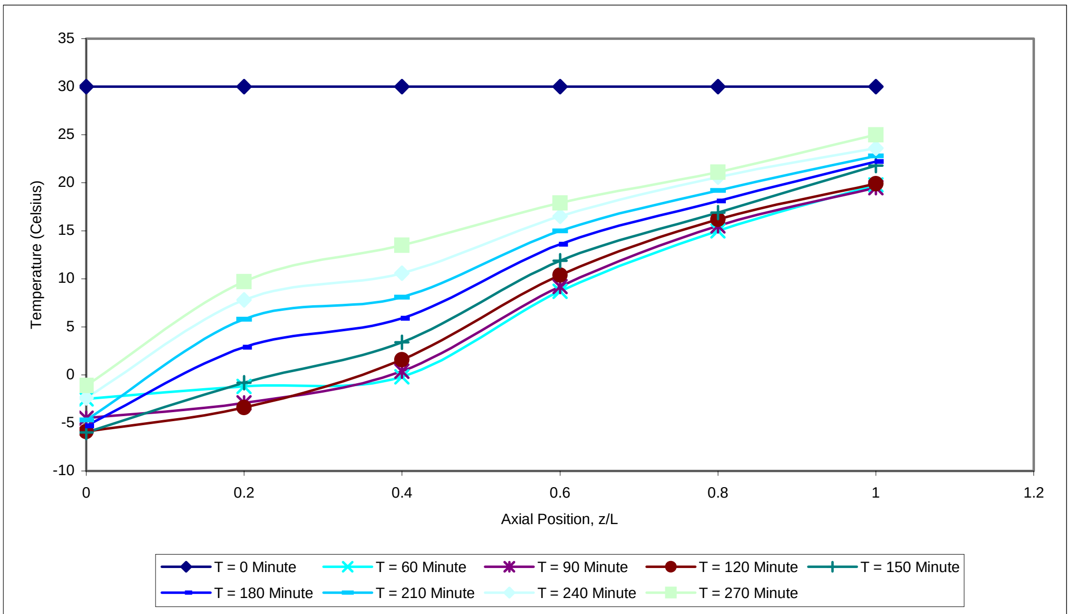
A499: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Weight of 6 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



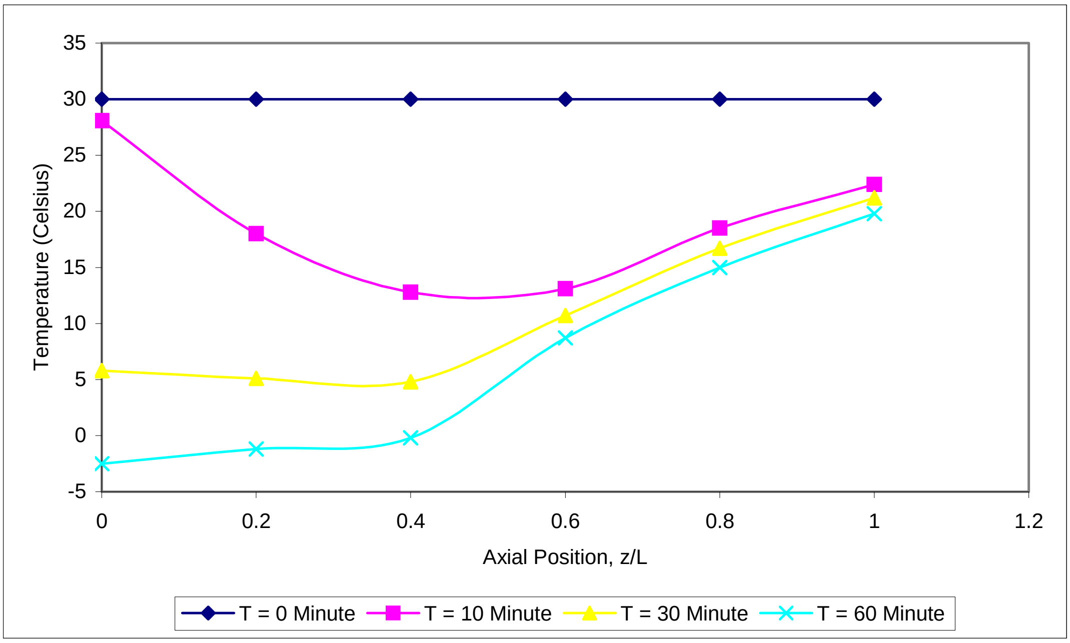
A500: Dimensionless Axial Profile of Temperature at External Wall of Weight of 6 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



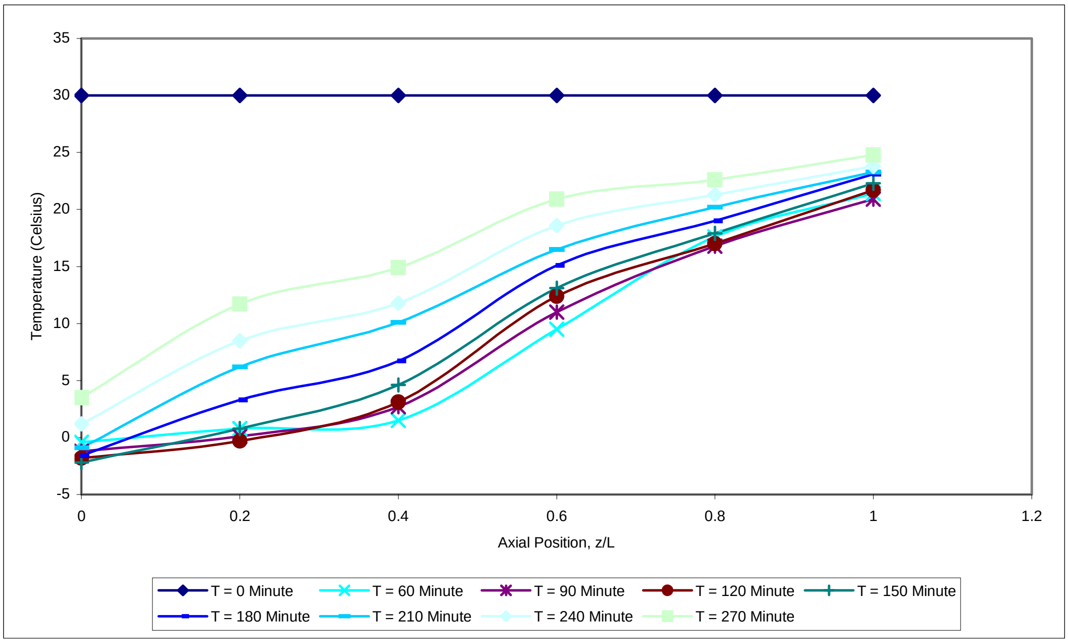
A501: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Weight of 6 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



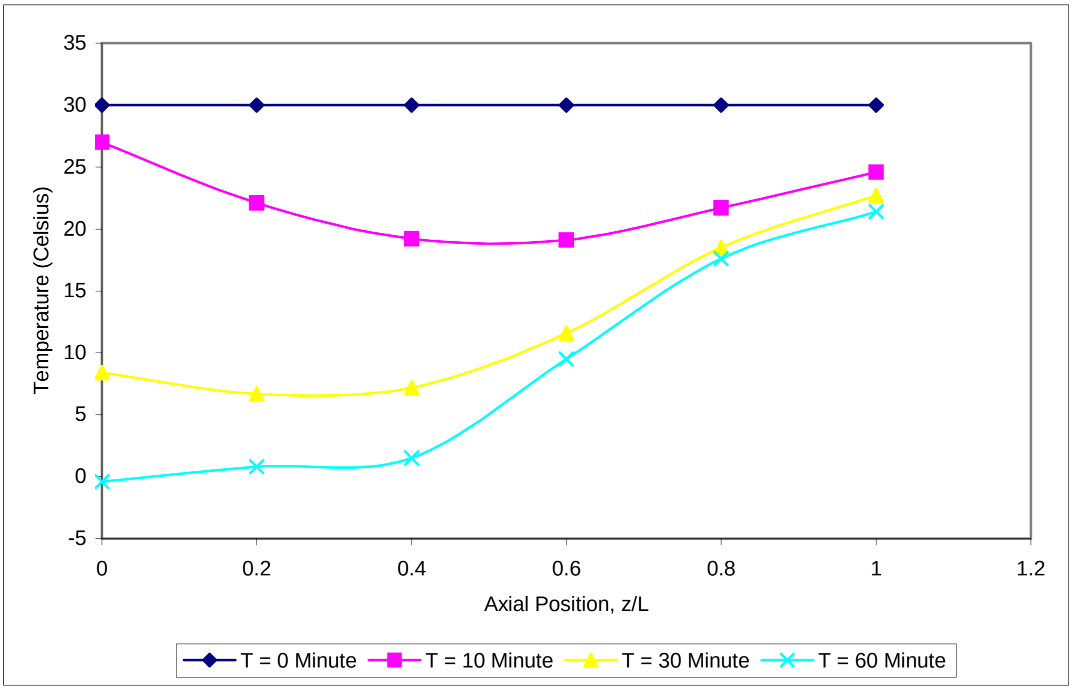
A502: Dimensionless Axial Profile of Temperature Center of Weight of 5 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



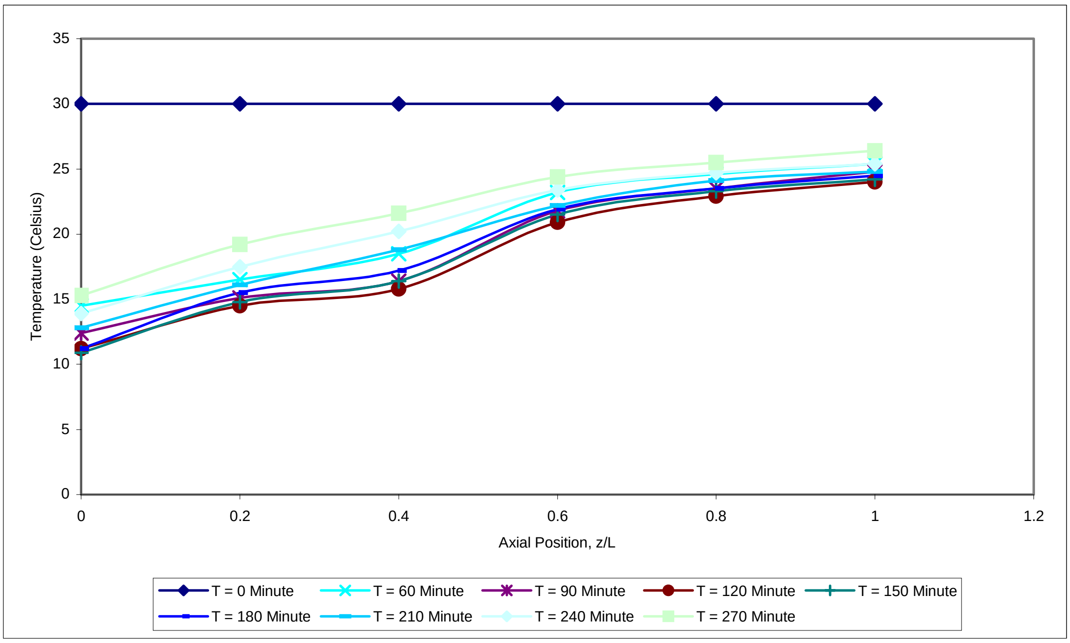
A503: Dimensionless Axial Profile of Temperature at Early Stage at Center of Weight of 5 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C



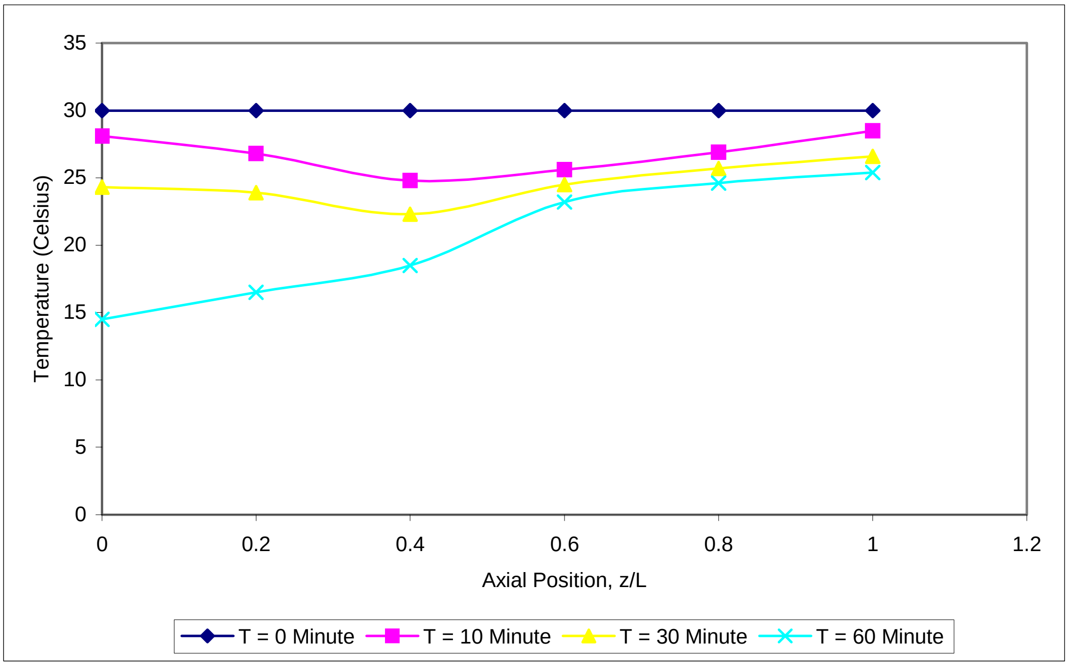
A504: Dimensionless Axial Profile of Temperature at Internal Wall of Weight of 5 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30°C



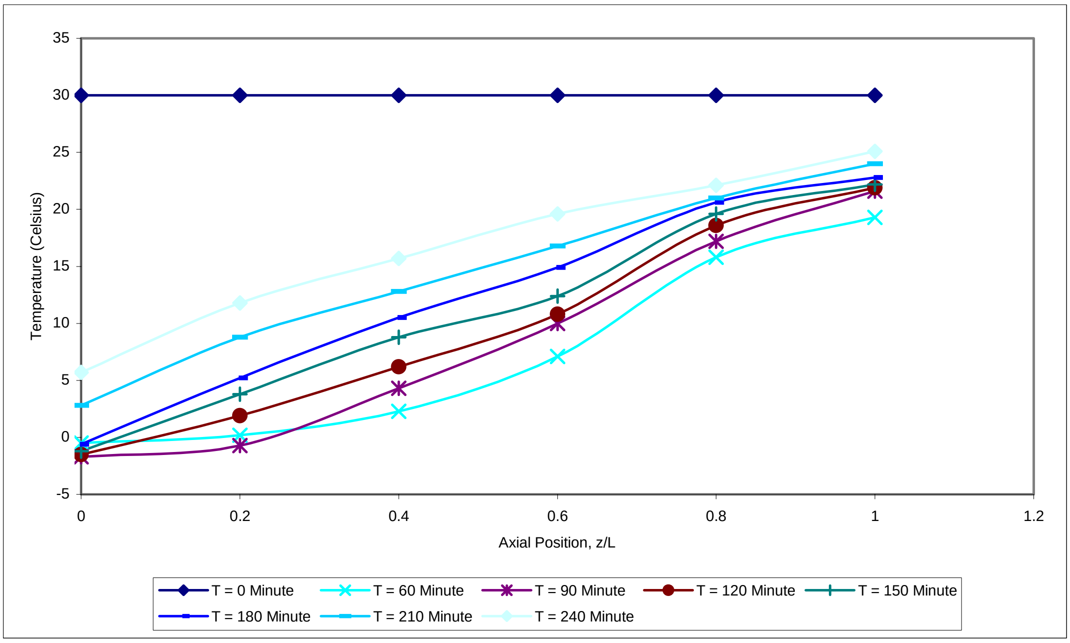
A505: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Weight of 5 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



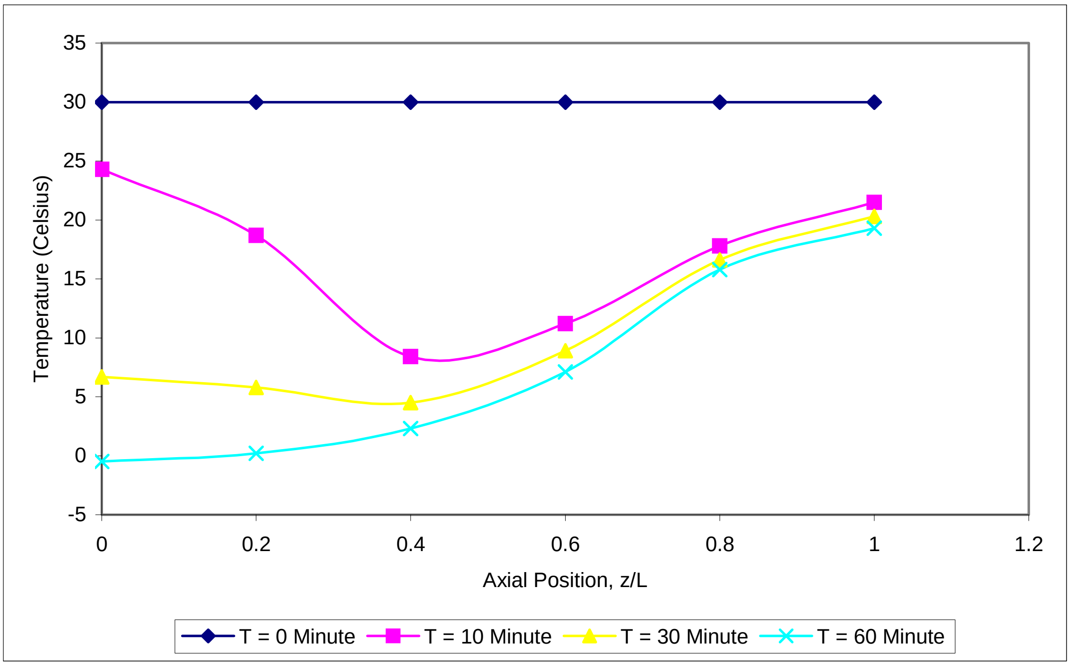
A506: Dimensionless Axial Profile of Temperature at External Wall of Weight of 5 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



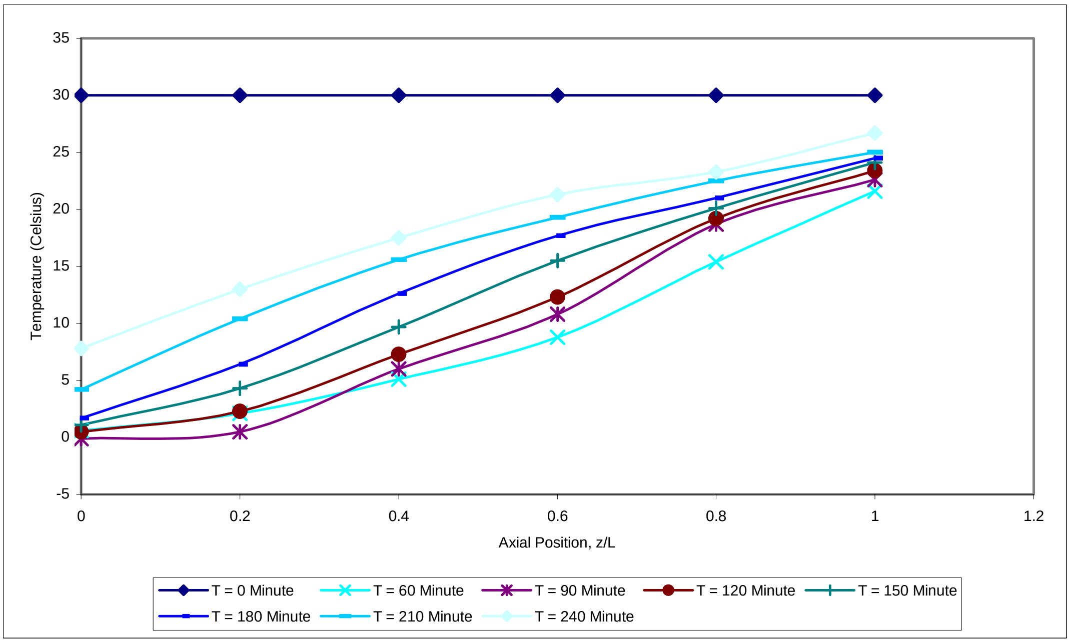
A507: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Weight of 5 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C



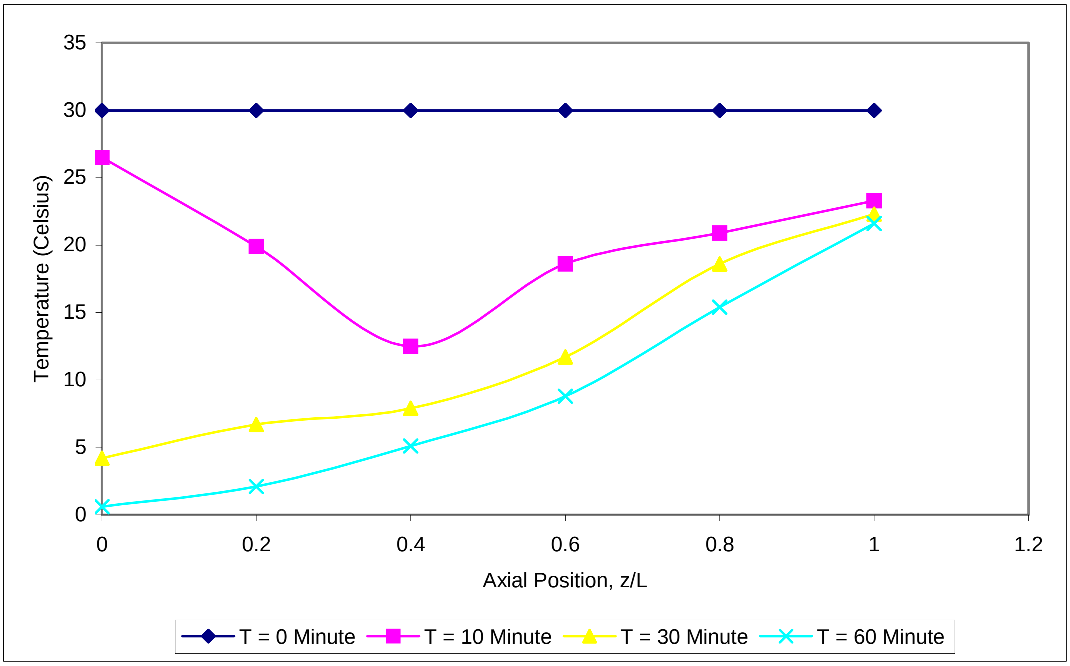
A508: Dimensionless Axial Profile of Temperature Center of Weight of 4 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C



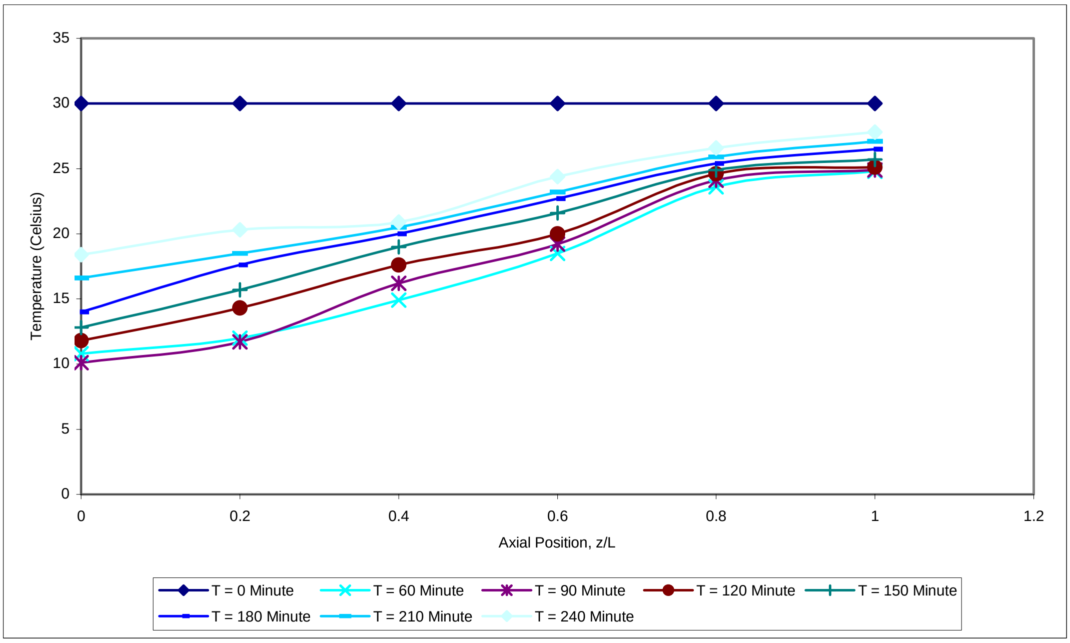
A509: Dimensionless Axial Profile of Temperature at Early Stage at Center of Weight of 4 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C



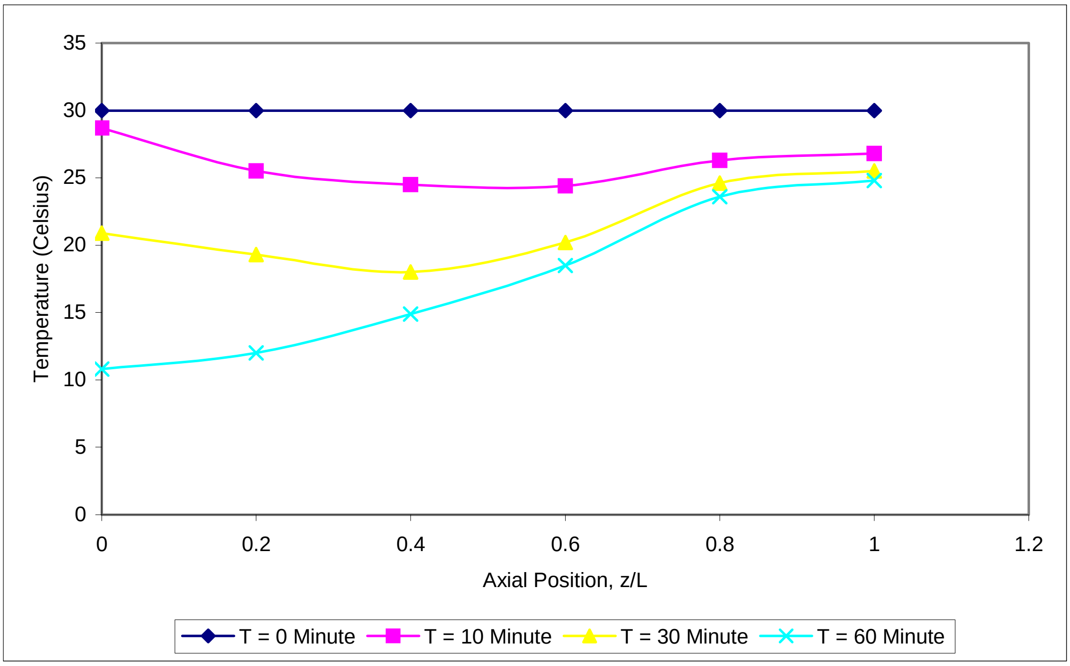
A510: Dimensionless Axial Profile of Temperature at Internal Wall of Weight of 4 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30°C



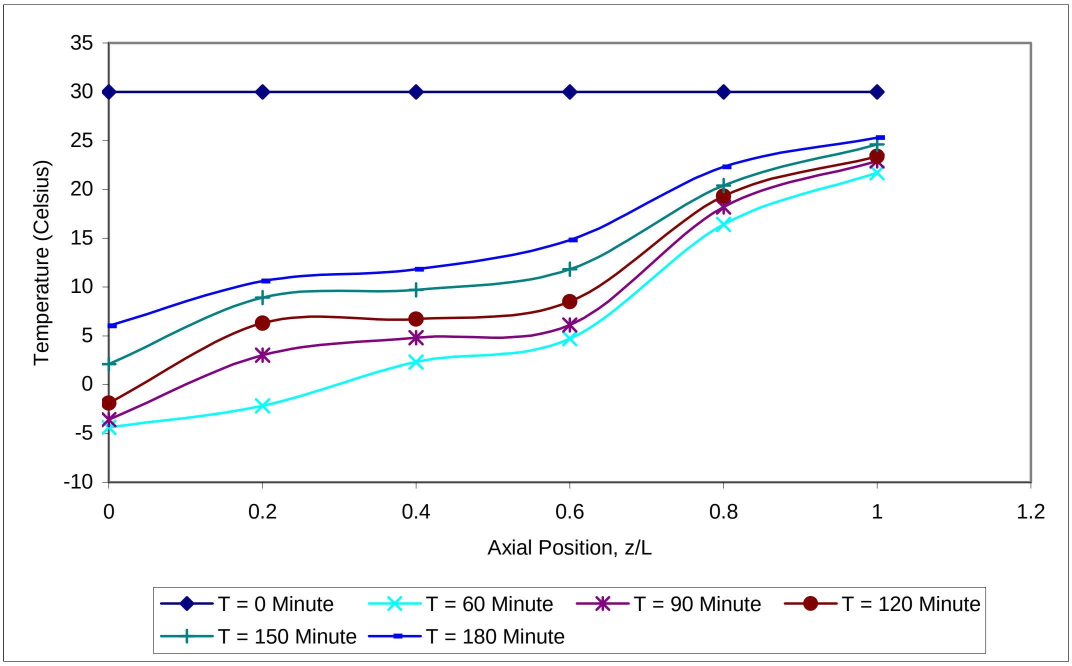
A511: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Weight of 4 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



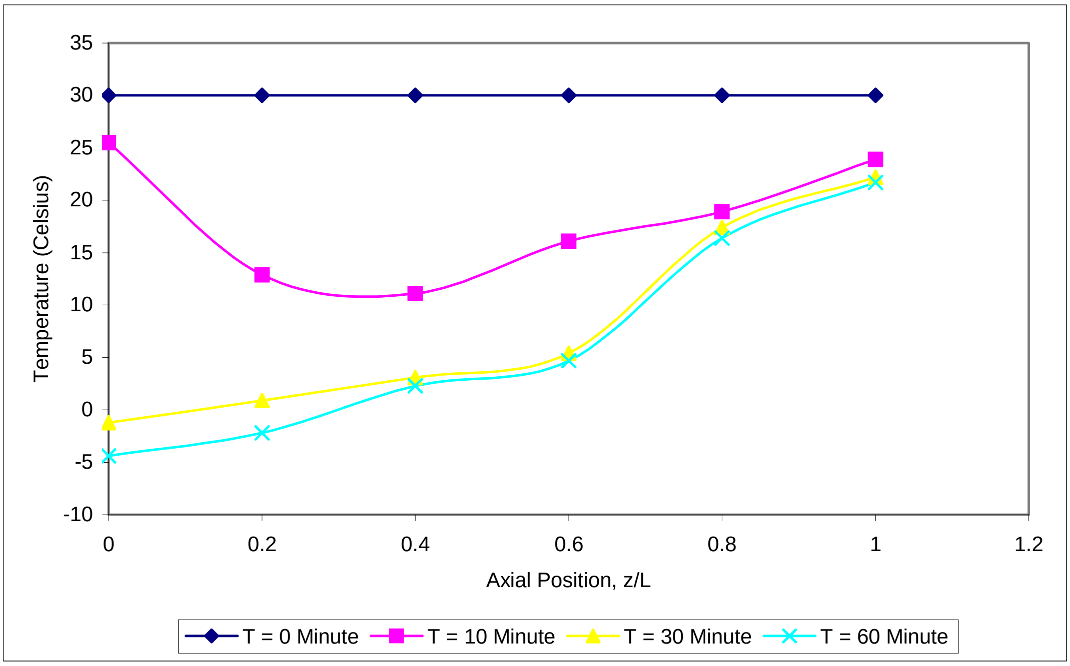
A512: Dimensionless Axial Profile of Temperature at External Wall of Weight of 4 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



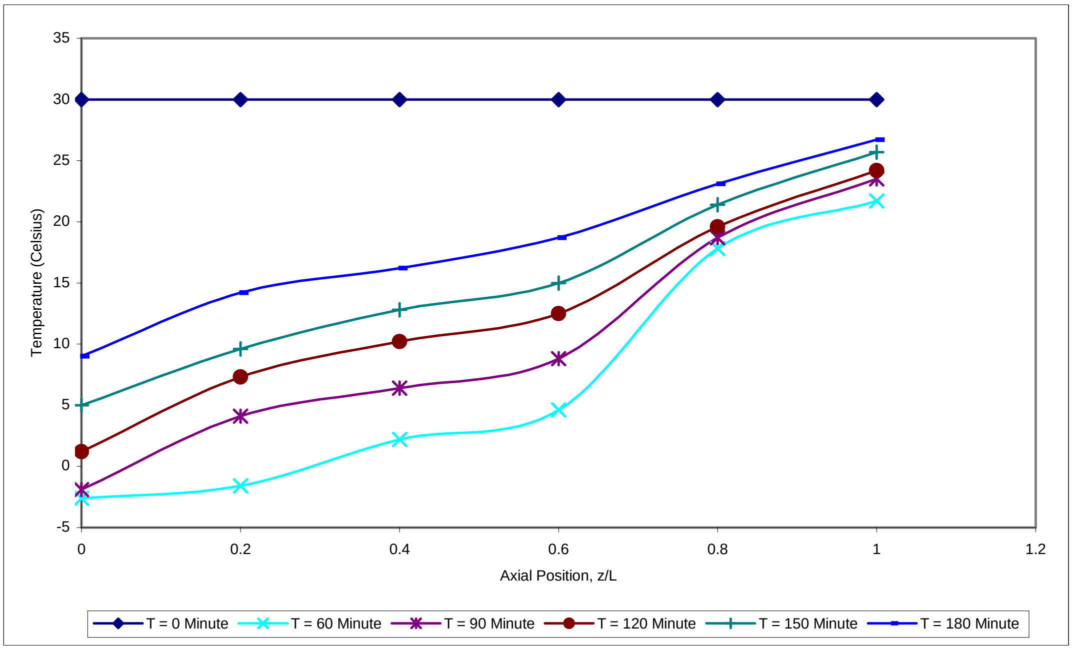
A513: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Weight of 4 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



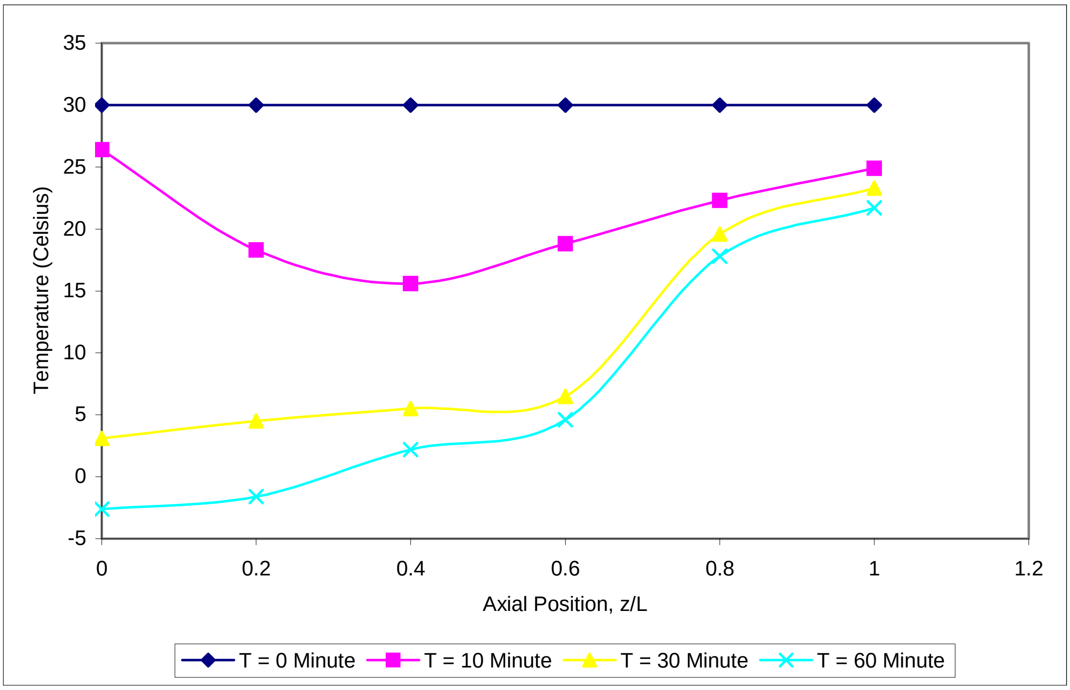
A514: Dimensionless Axial Profile of Temperature Center of Weight of 3 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



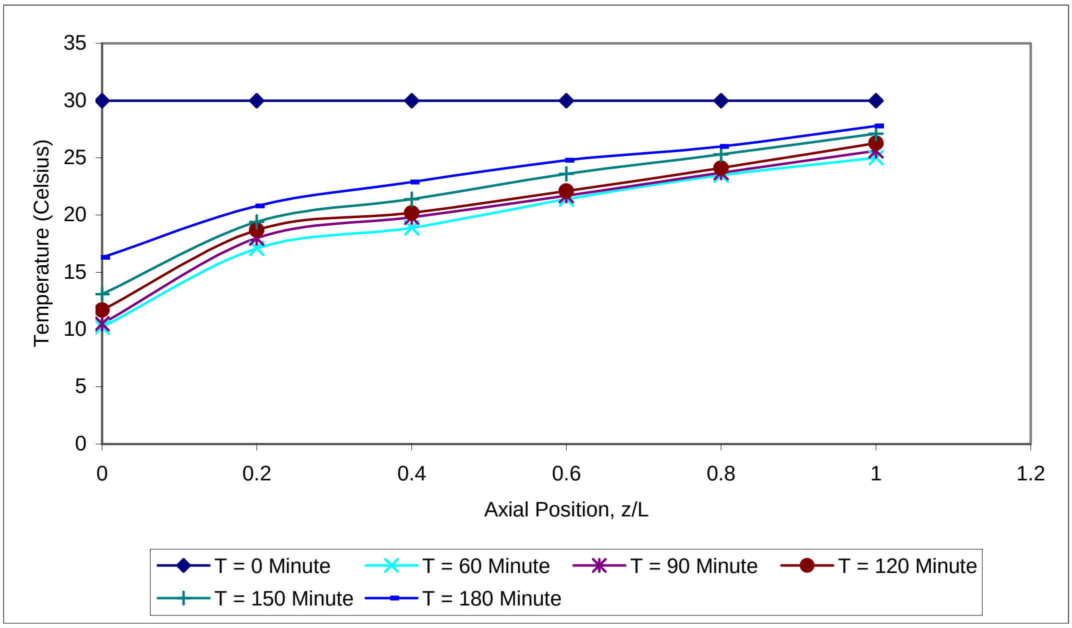
A515: Dimensionless Axial Profile of Temperature at Early Stage at Center of Weight of 3 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



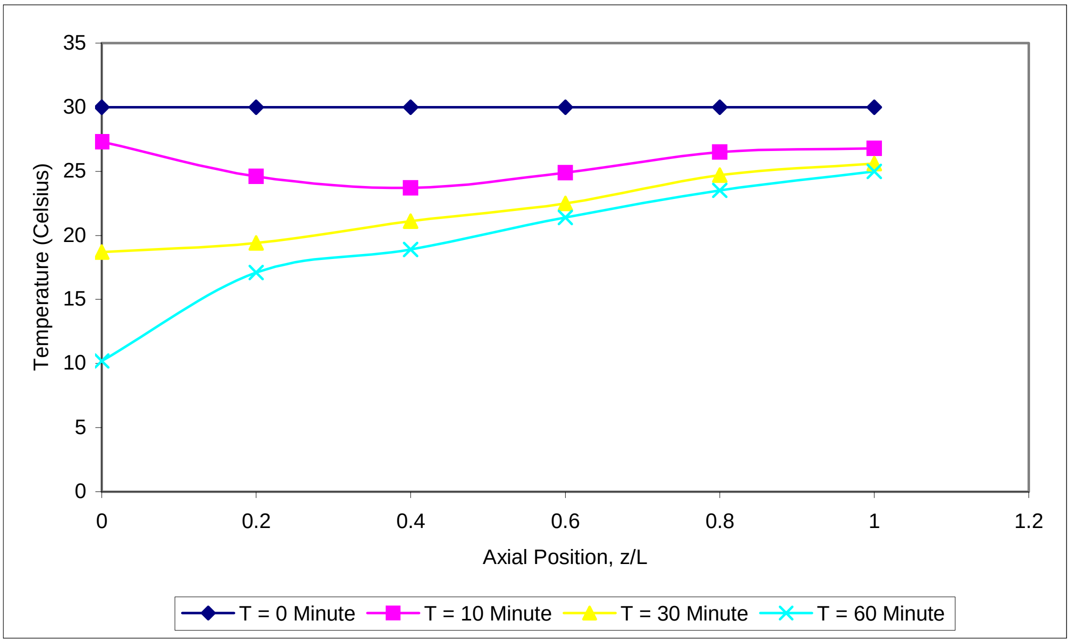
A516: Dimensionless Axial Profile of Temperature at Internal Wall of Weight of 3 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



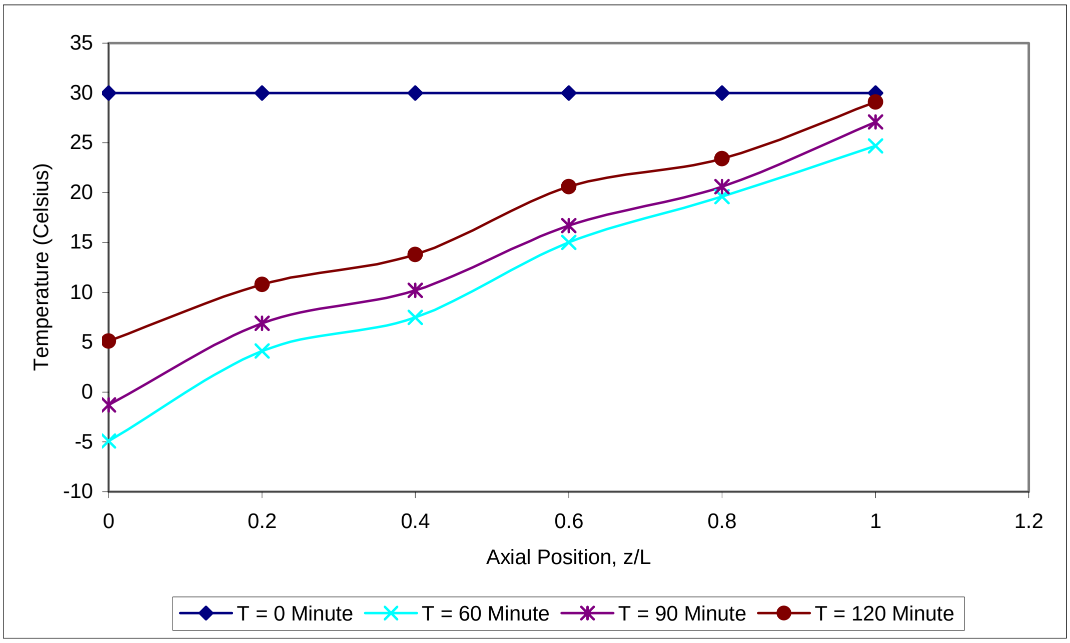
A517: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Weight of 3 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



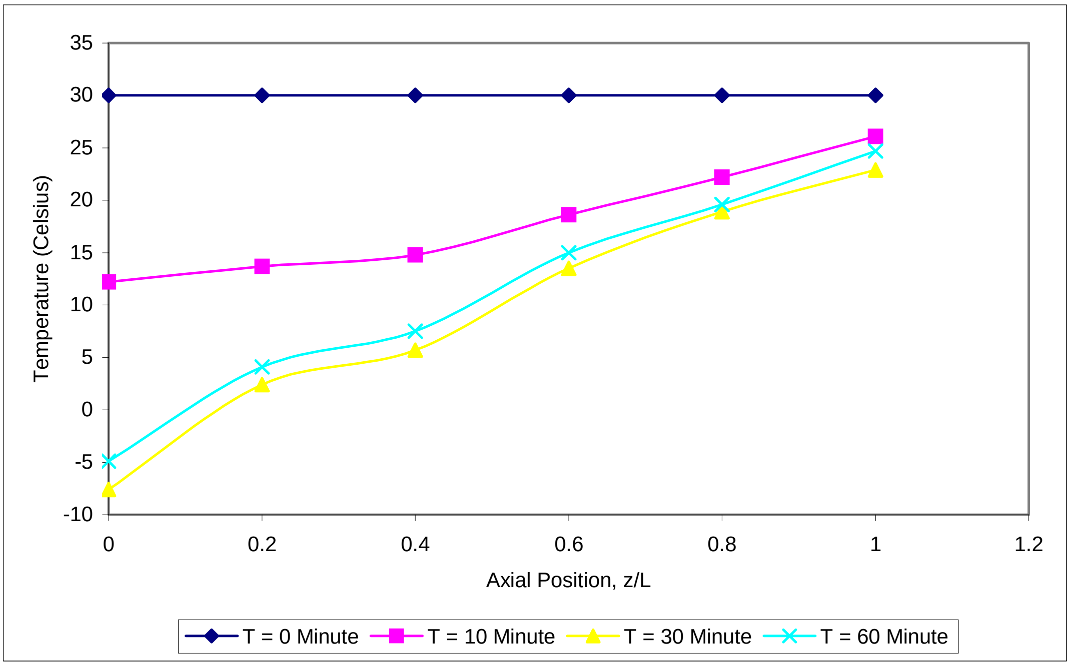
A518: Dimensionless Axial Profile of Temperature at External Wall of Weight of 3 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



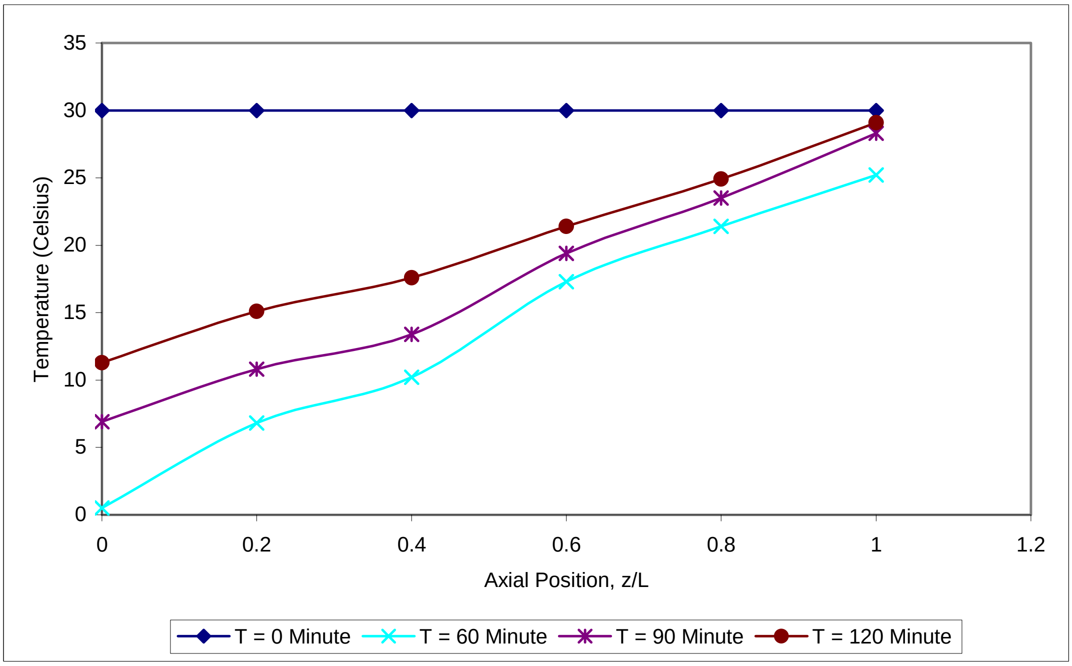
A519: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Weight of 3 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



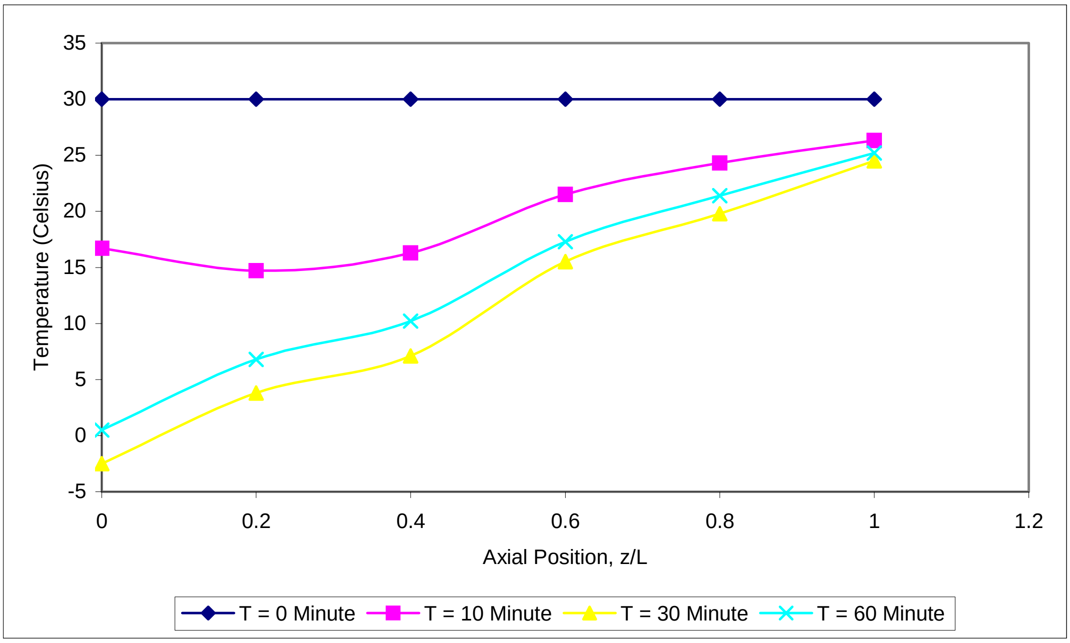
A520: Dimensionless Axial Profile of Temperature Center of Weight of 2 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



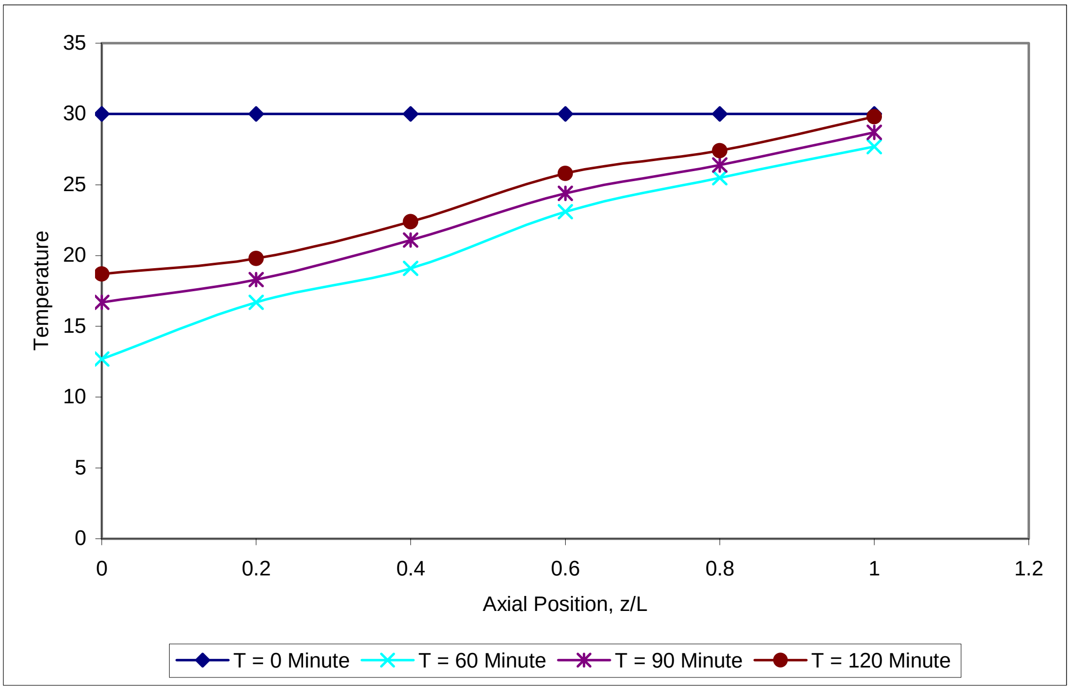
A521: Dimensionless Axial Profile of Temperature at Early Stage at Center of Weight of 2 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30°C



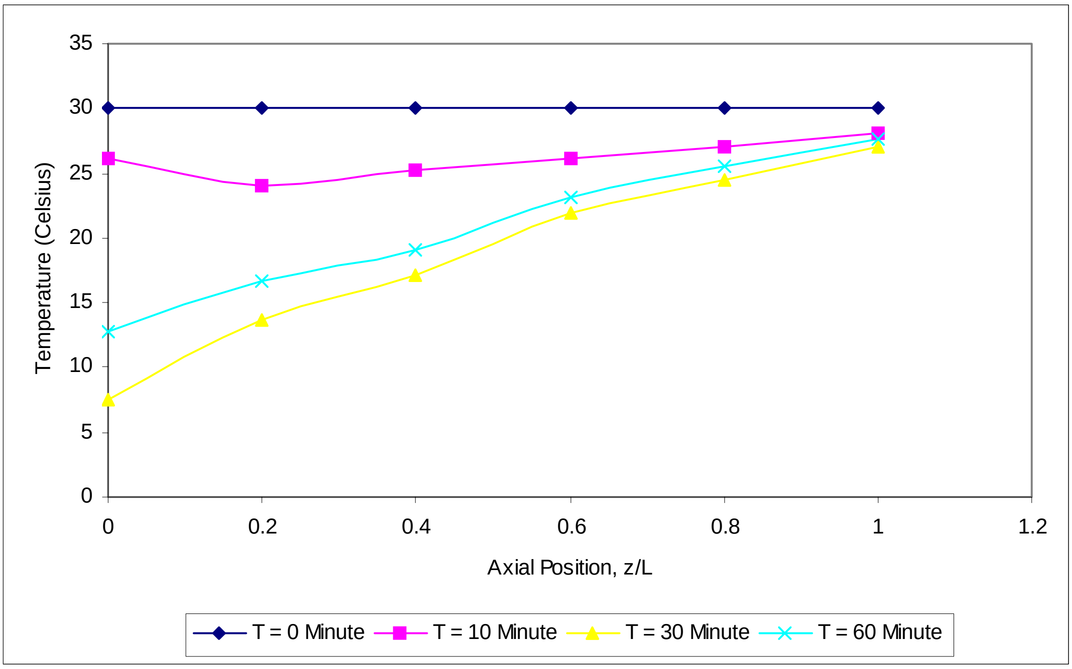
A522: Dimensionless Axial Profile of Temperature at Internal Wall of Weight of 2 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30°C



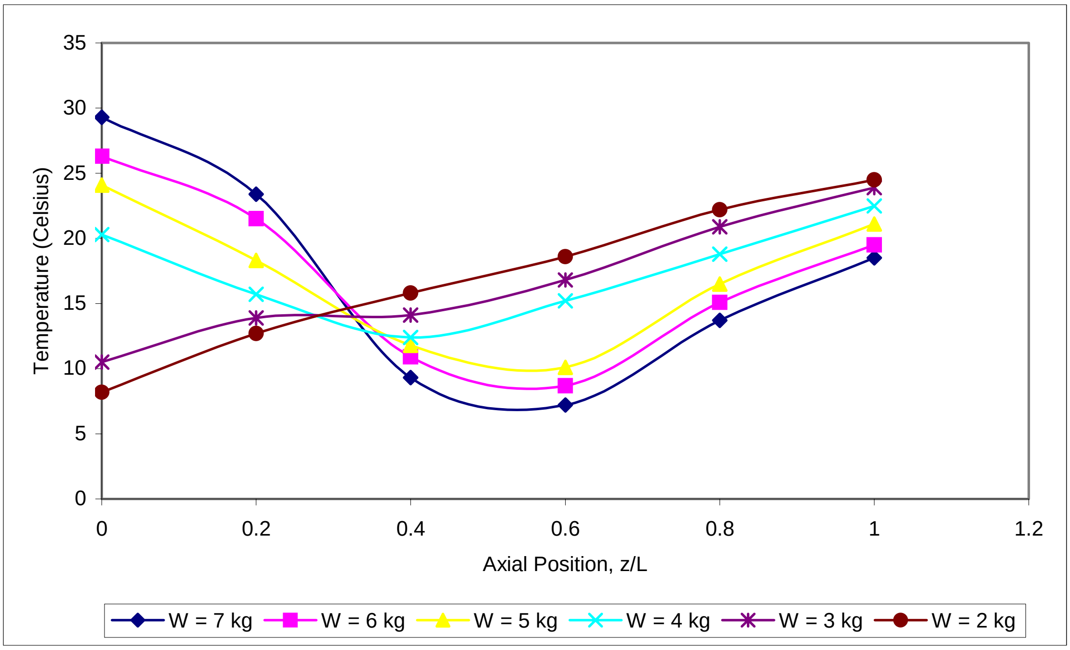
A523: Dimensionless Axial Profile of Temperature at Early Stage at Internal Wall of Weight of 2 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



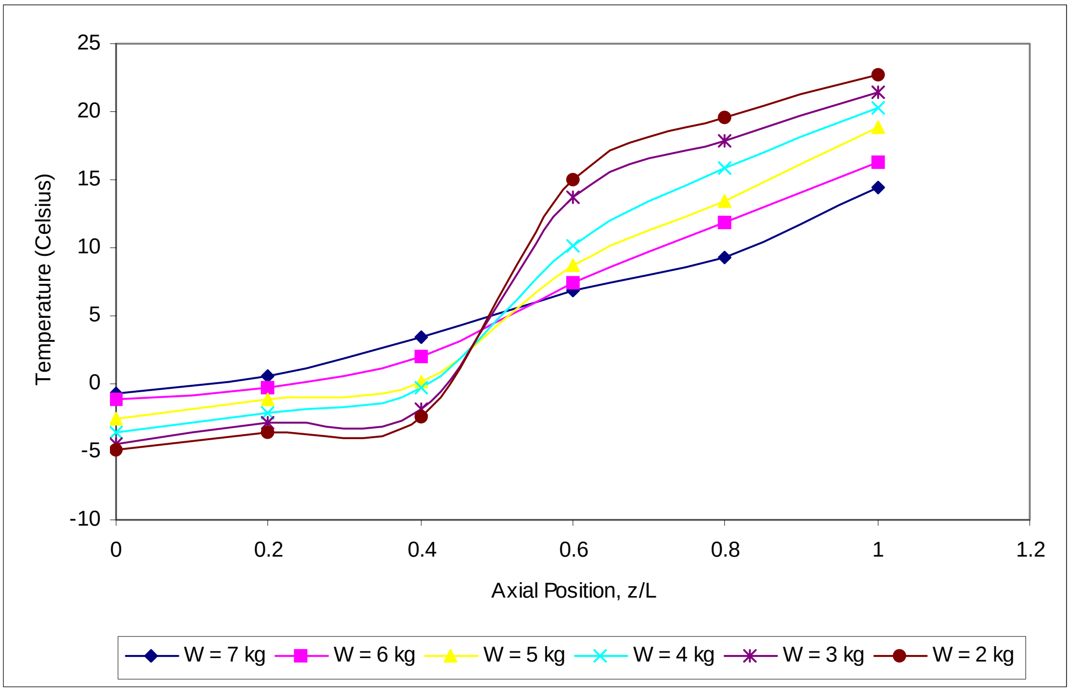
A524: Dimensionless Axial Profile of Temperature at External Wall of Weight of 2 kg at Composition of 4060, rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



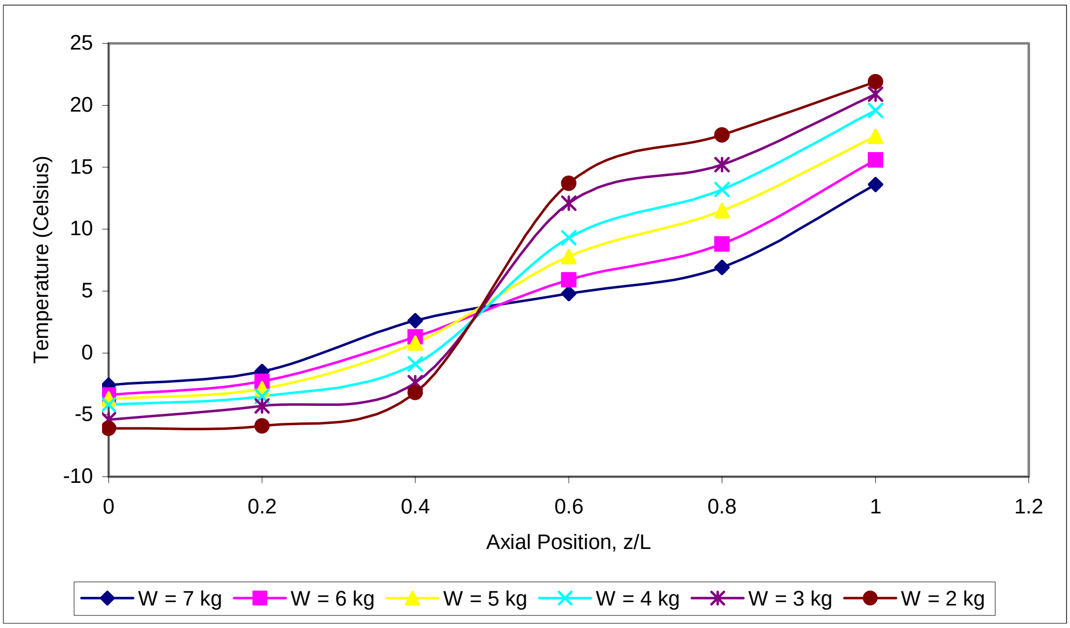
A525: Dimensionless Axial Profile of Temperature at Early Stage at External Wall of Weight of 2 kg at Composition of 4060, Flow rate of 48 liter/minute and Surrounding Temperature of 30^{o}C



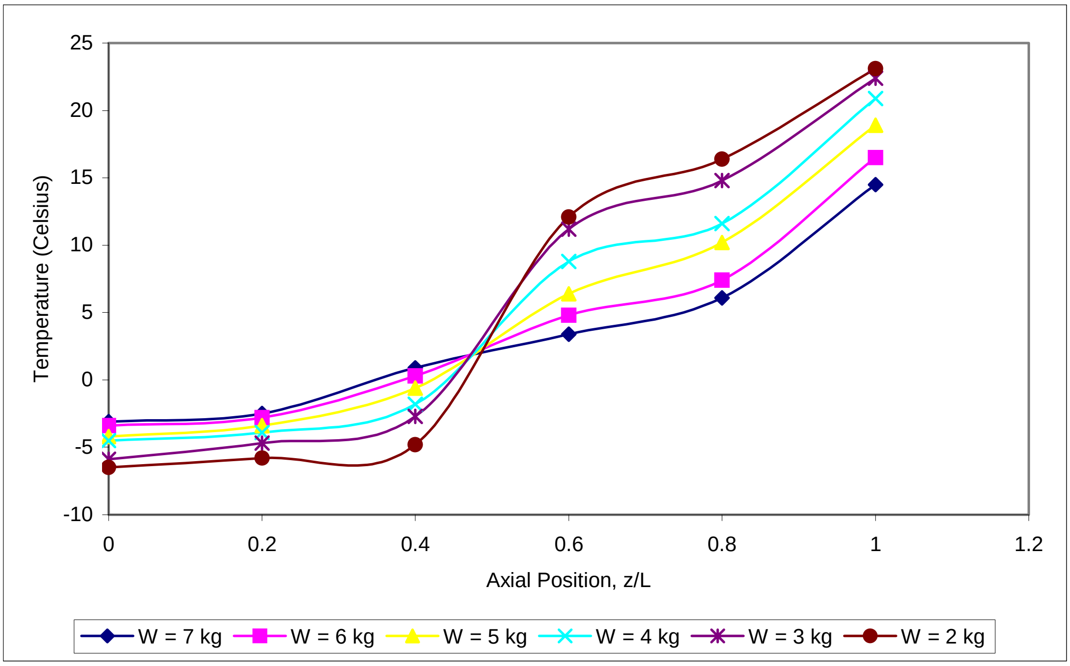
A526: Dimensionless Axial Profile of Temperature at 10 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



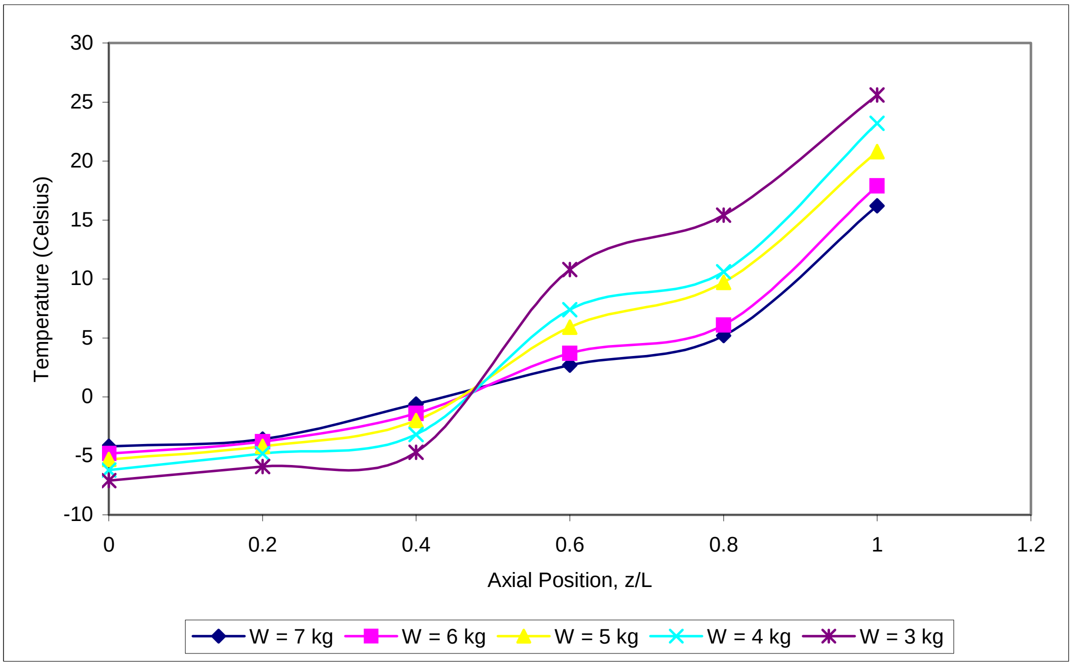
A527: Dimensionless Axial Profile of Temperature at 60 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



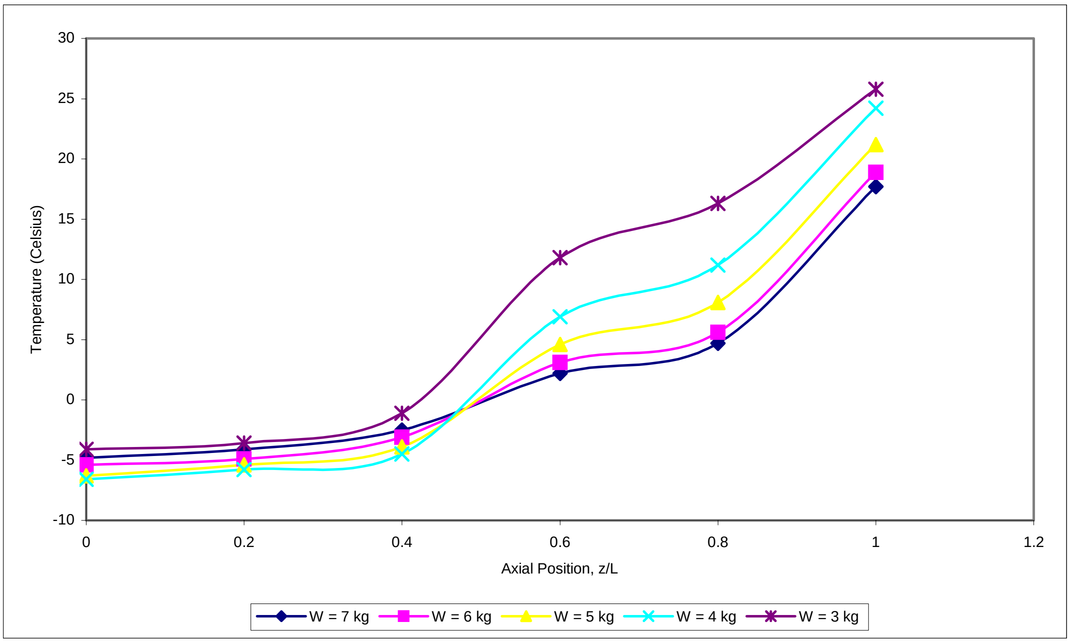
A528: Dimensionless Axial Profile of Temperature at 90 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



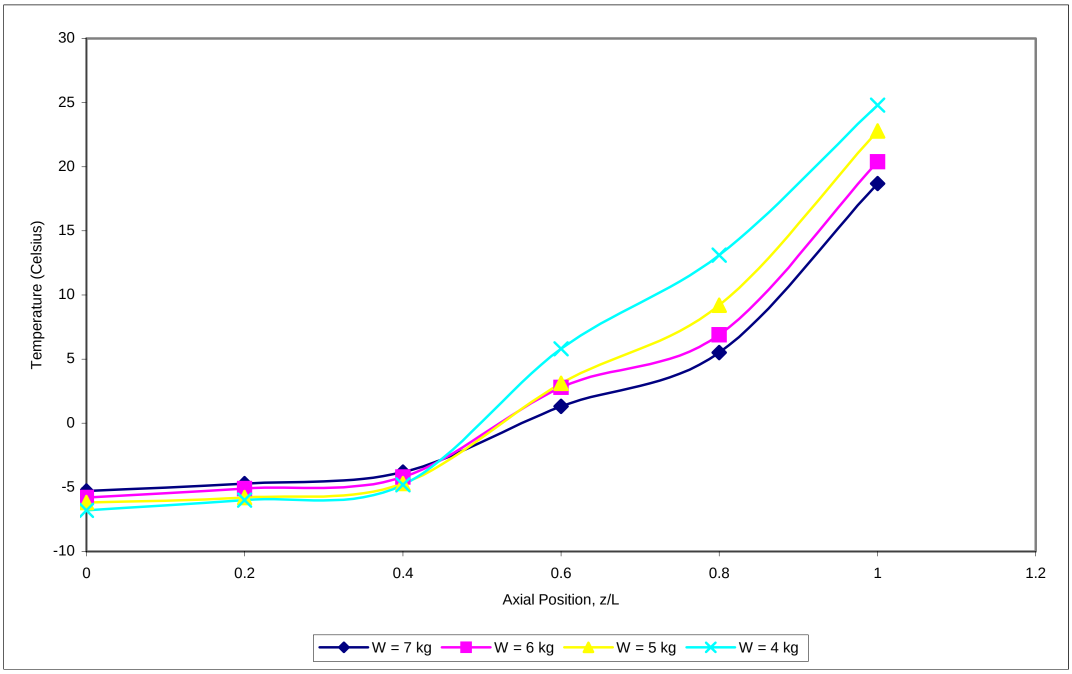
A529: Dimensionless Axial Profile of Temperature at 120 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



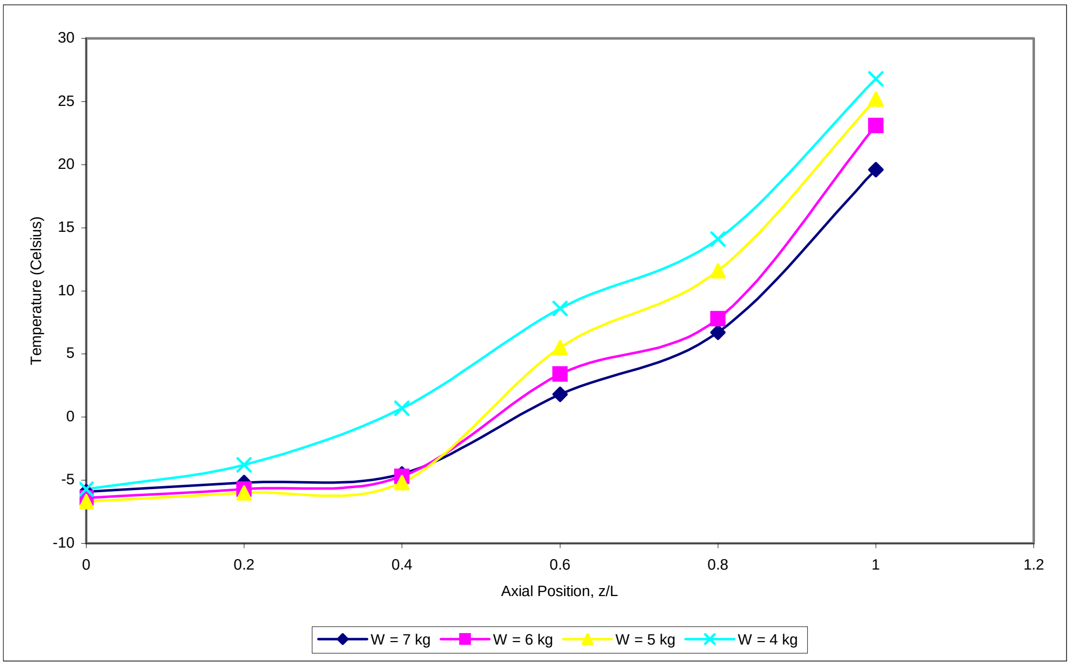
A530: Dimensionless Axial Profile of Temperature at 150 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



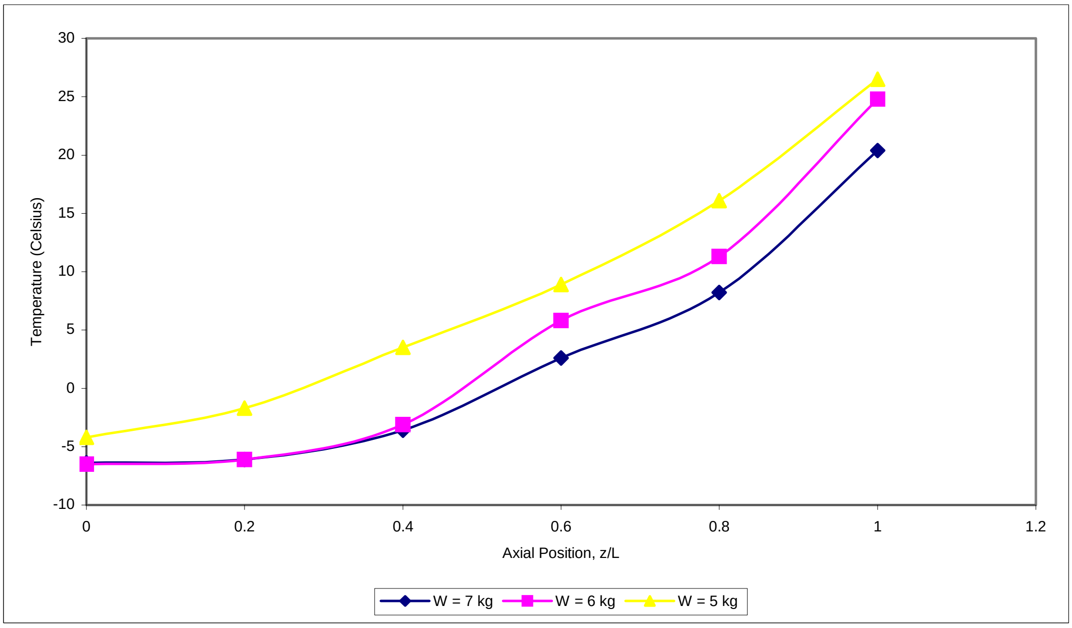
A531: Dimensionless Axial Profile of Temperature at 180 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



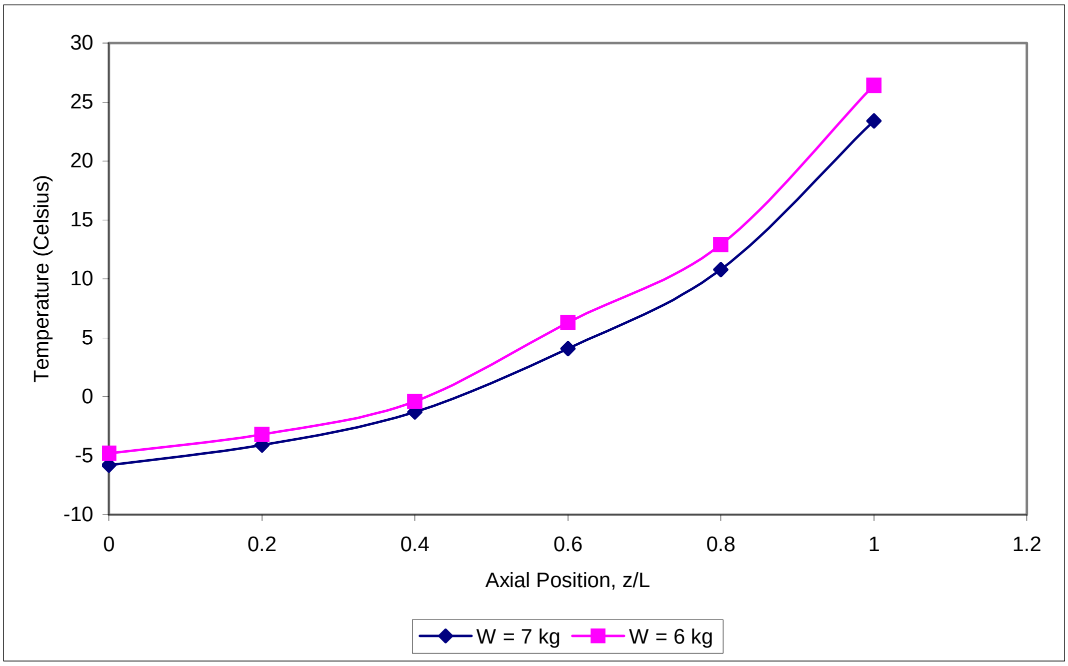
A532: Dimensionless Axial Profile of Temperature at 210 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



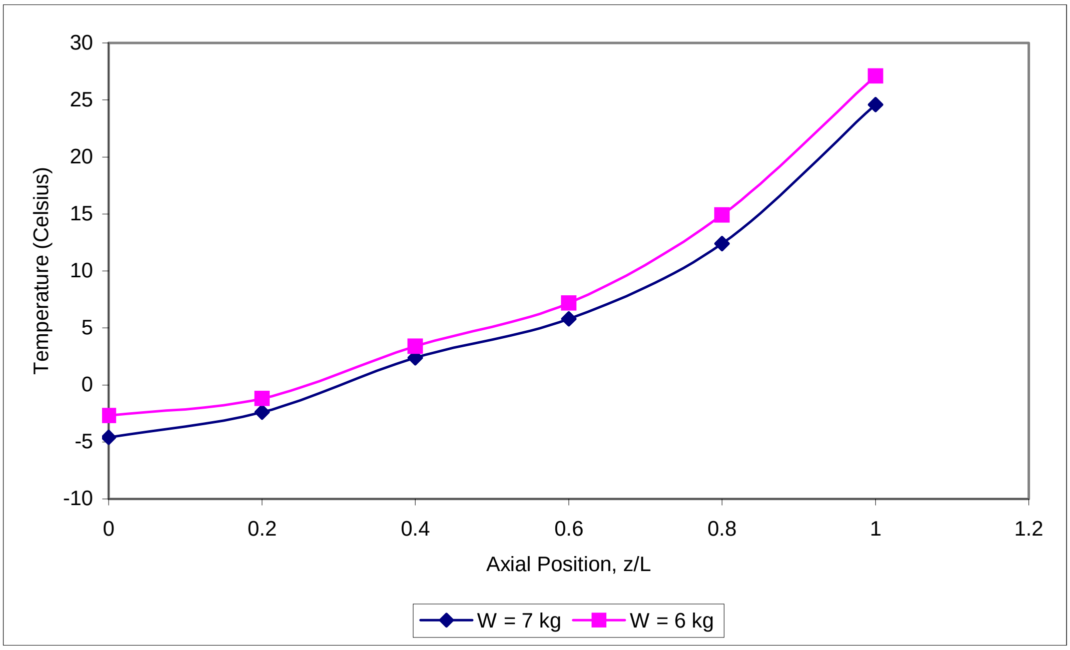
A533: Dimensionless Axial Profile of Temperature at 240 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



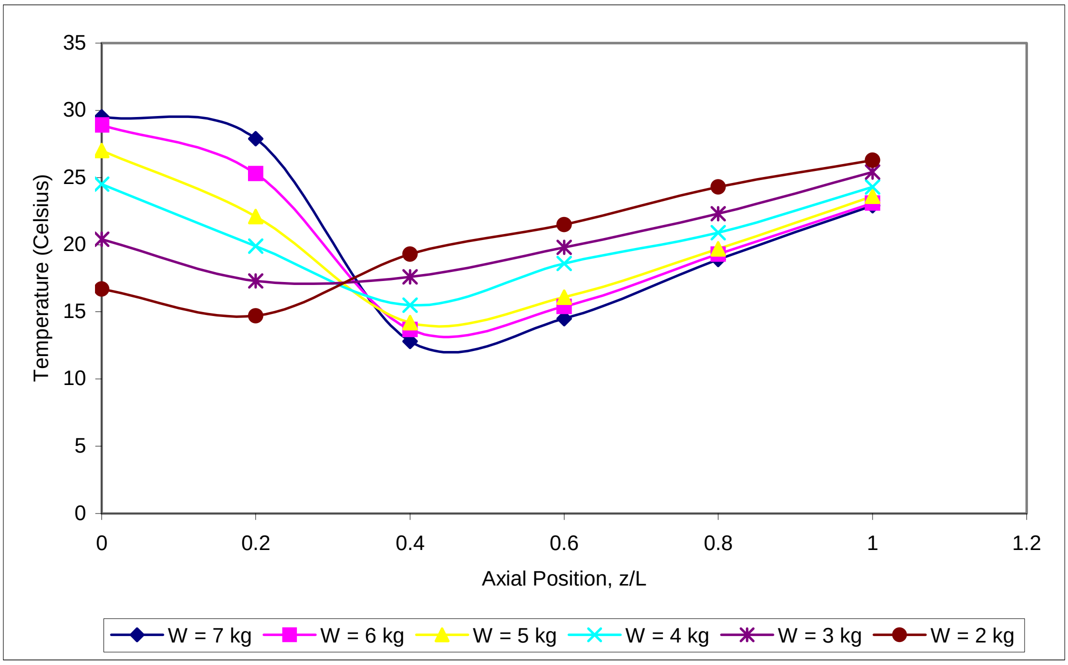
A534: Dimensionless Axial Profile of Temperature at 270 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



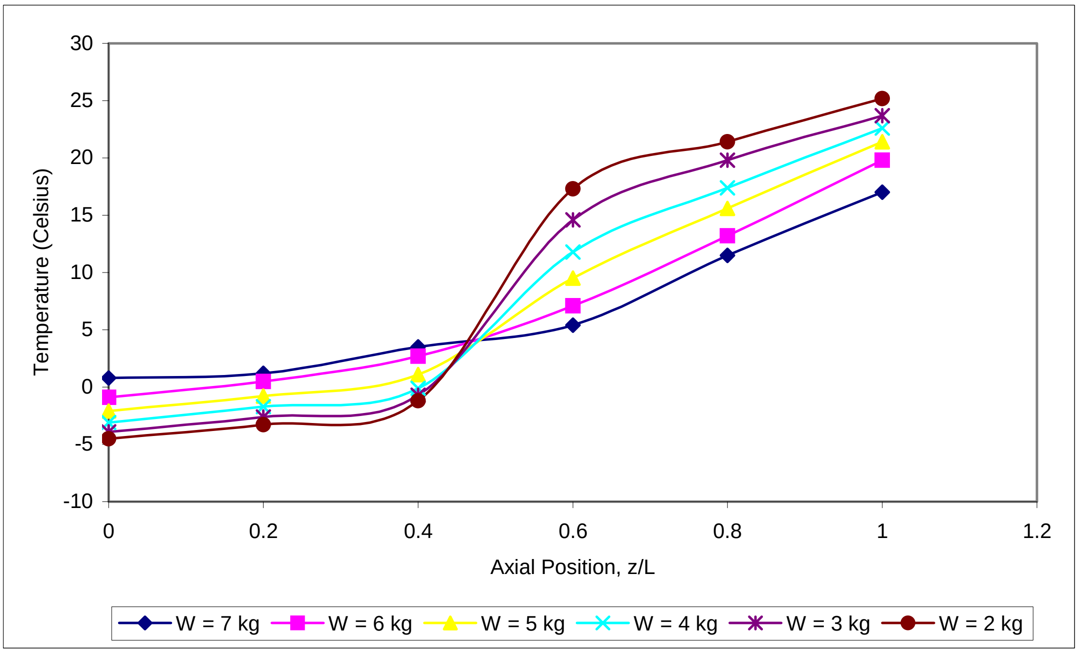
A535: Dimensionless Axial Profile of Temperature at 300 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



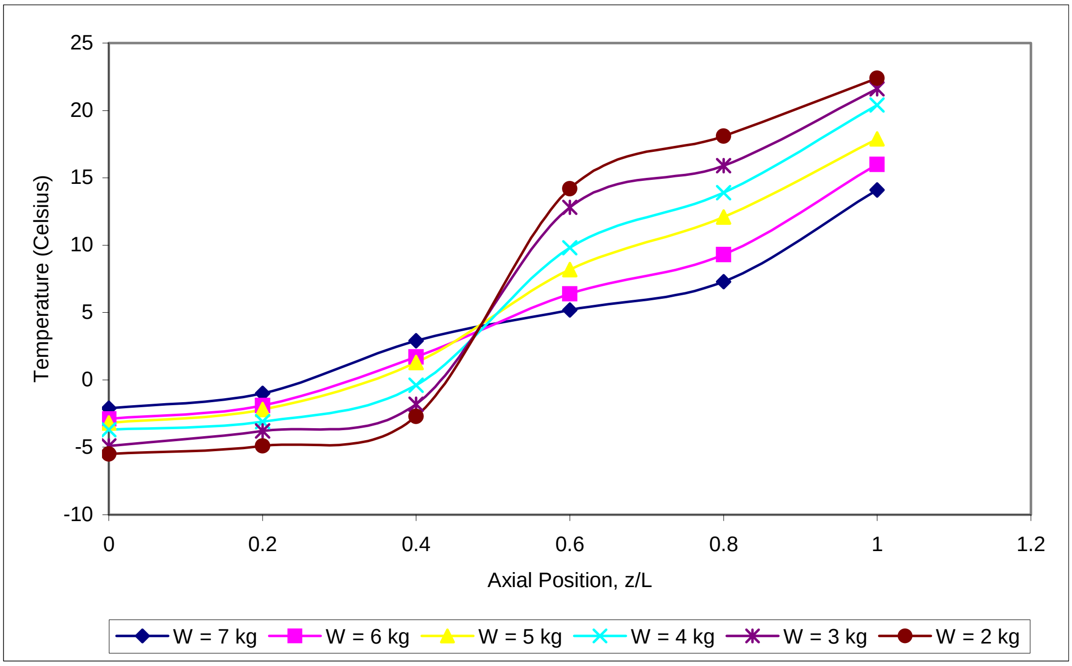
A536: Dimensionless Axial Profile of Temperature at 330 Minute at Center of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



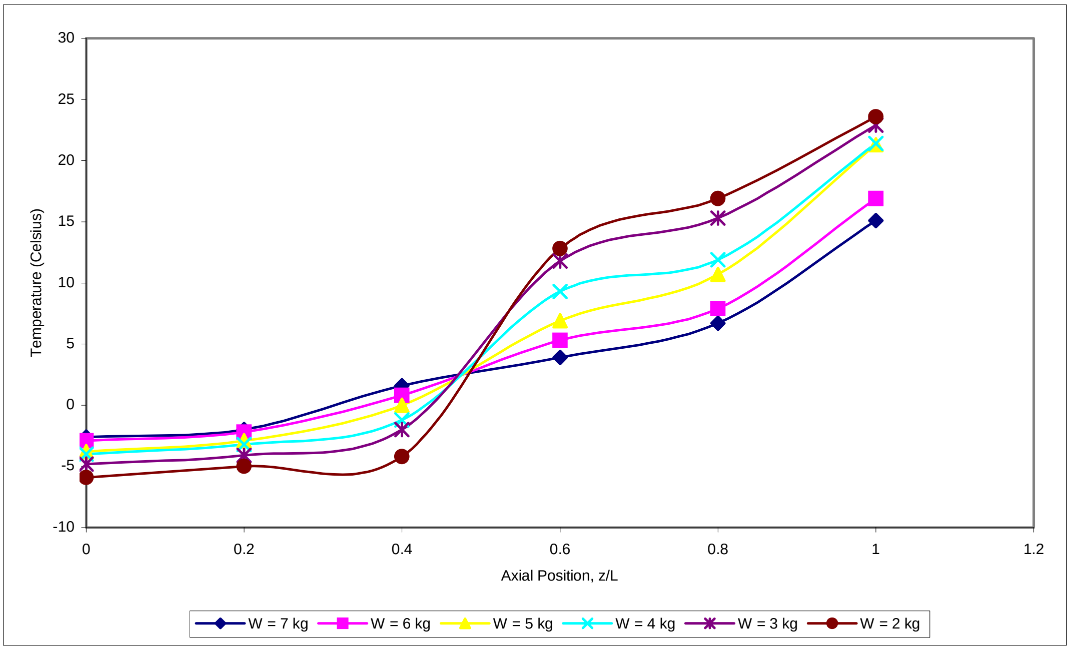
A537: Dimensionless Axial Profile of Temperature at 10 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



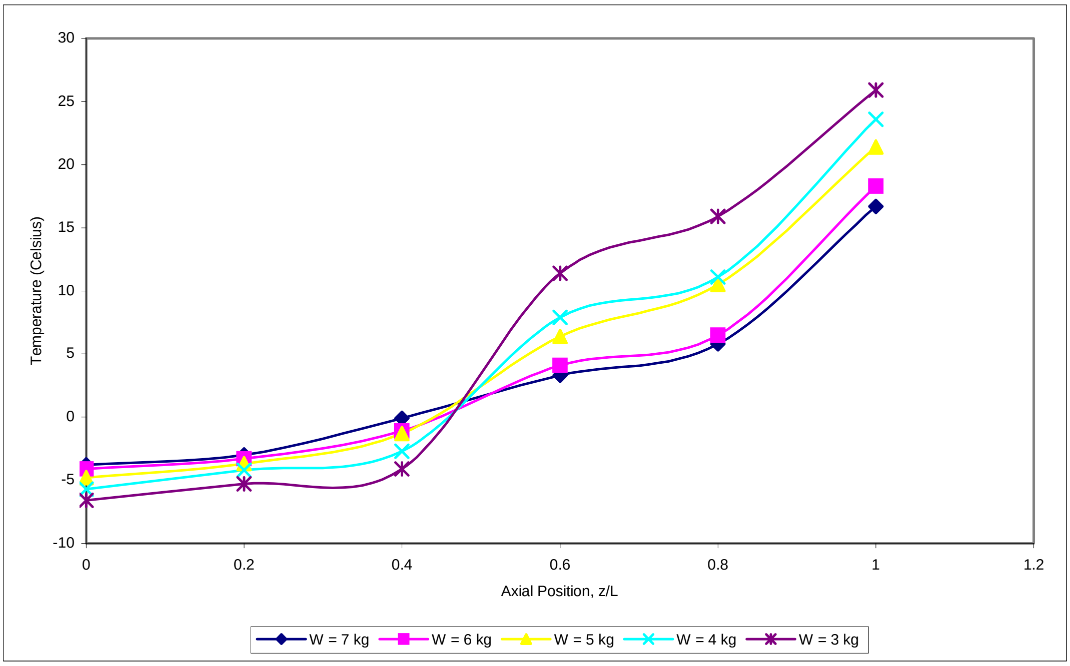
A538: Dimensionless Axial Profile of Temperature at 60 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



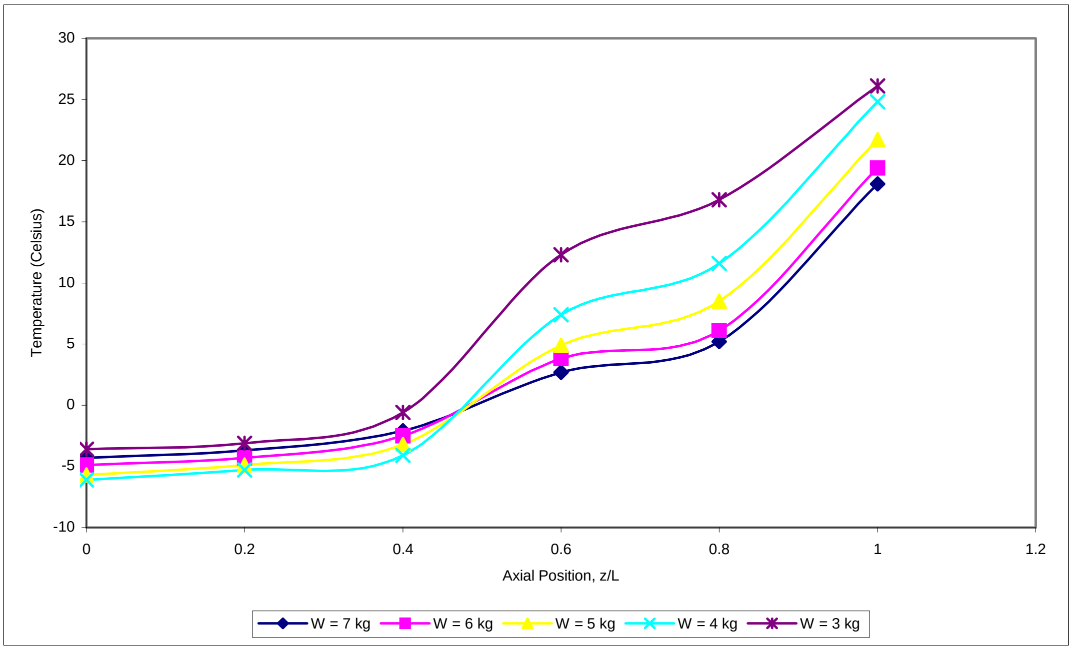
A539: Dimensionless Axial Profile of Temperature at 90 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



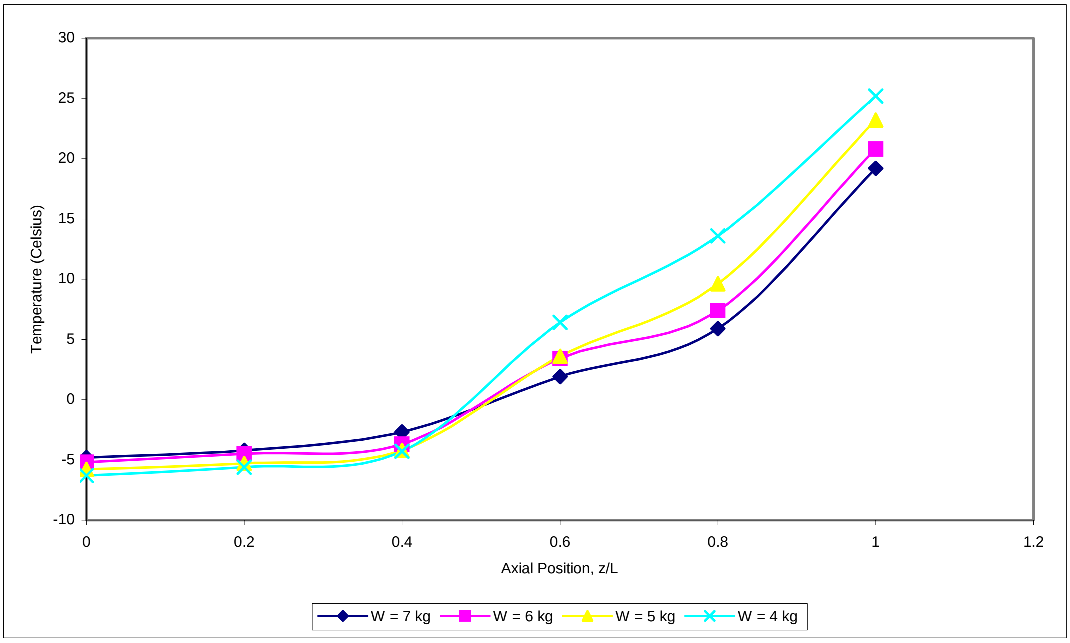
A540: Dimensionless Axial Profile of Temperature at 120 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



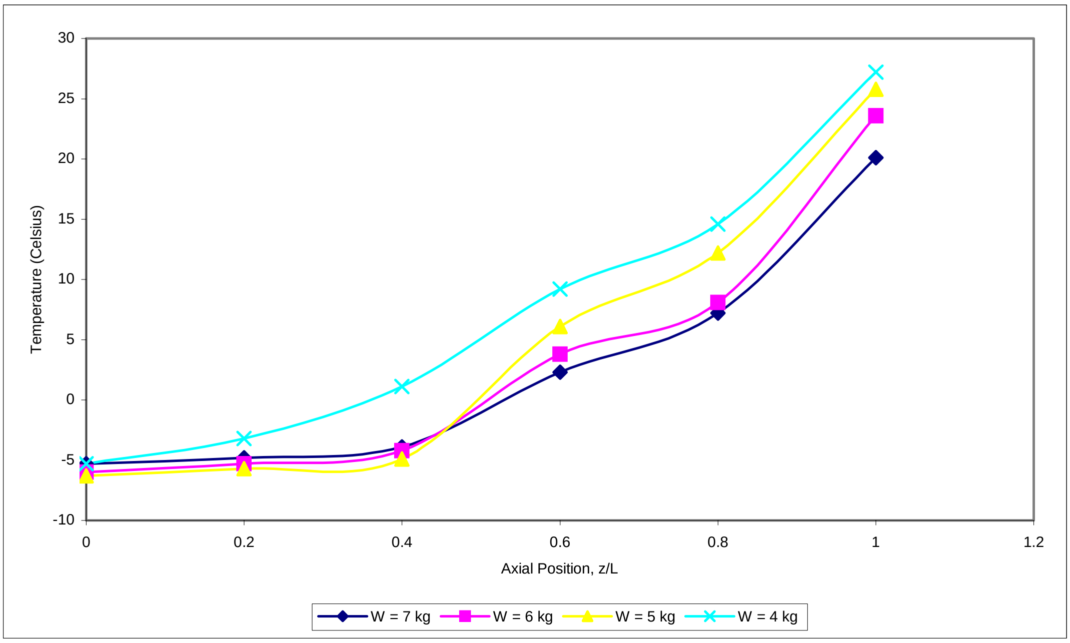
A541: Dimensionless Axial Profile of Temperature at 150 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



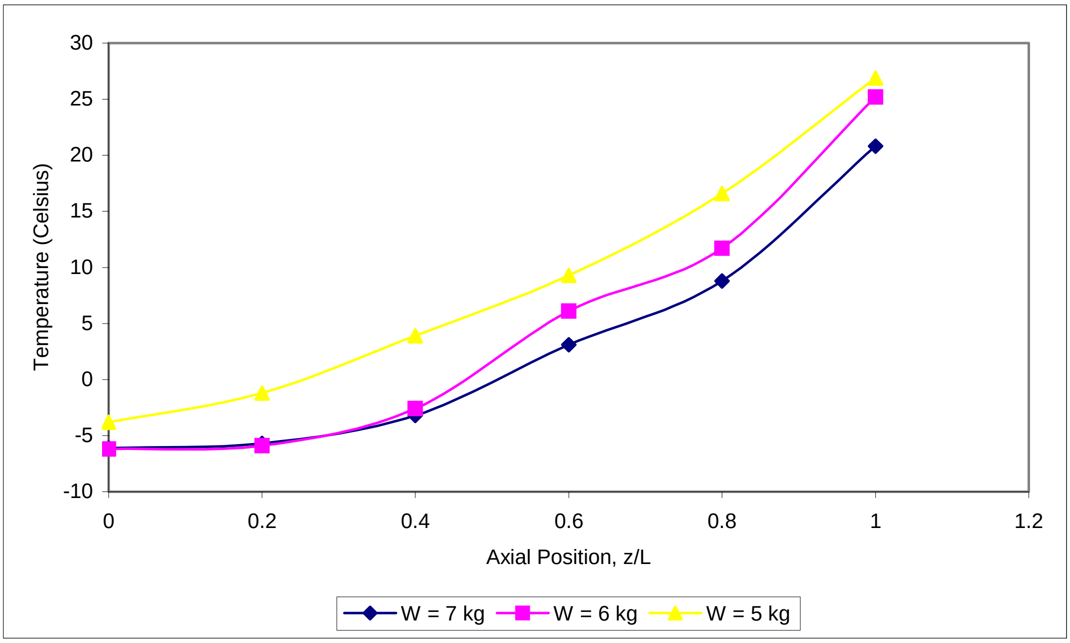
A542: Dimensionless Axial Profile of Temperature at 180 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



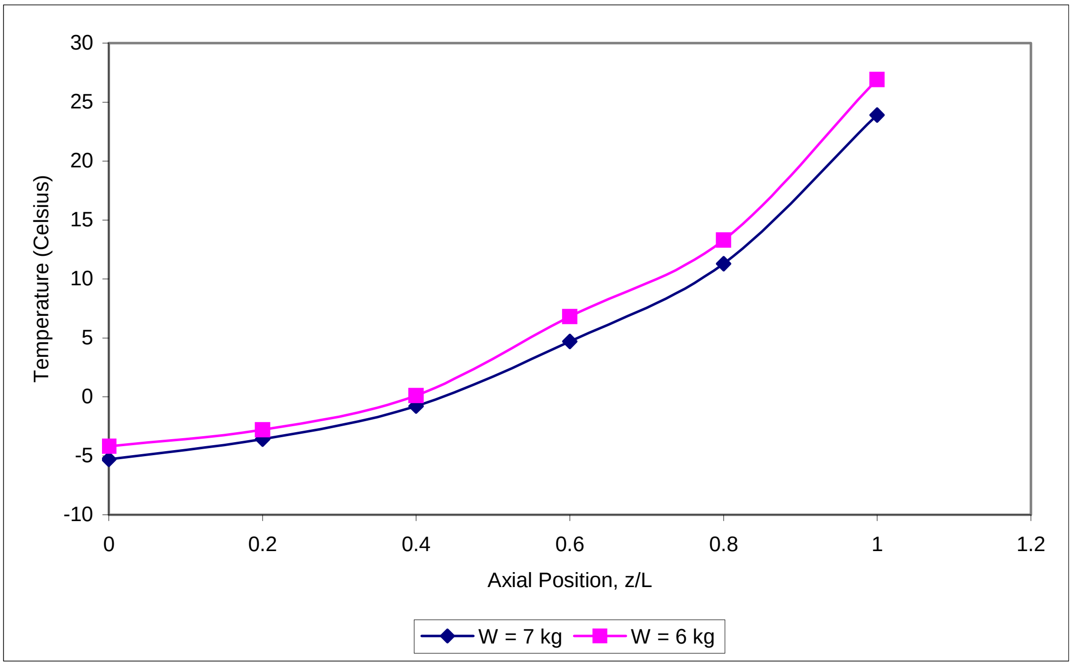
A543: Dimensionless Axial Profile of Temperature at 210 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



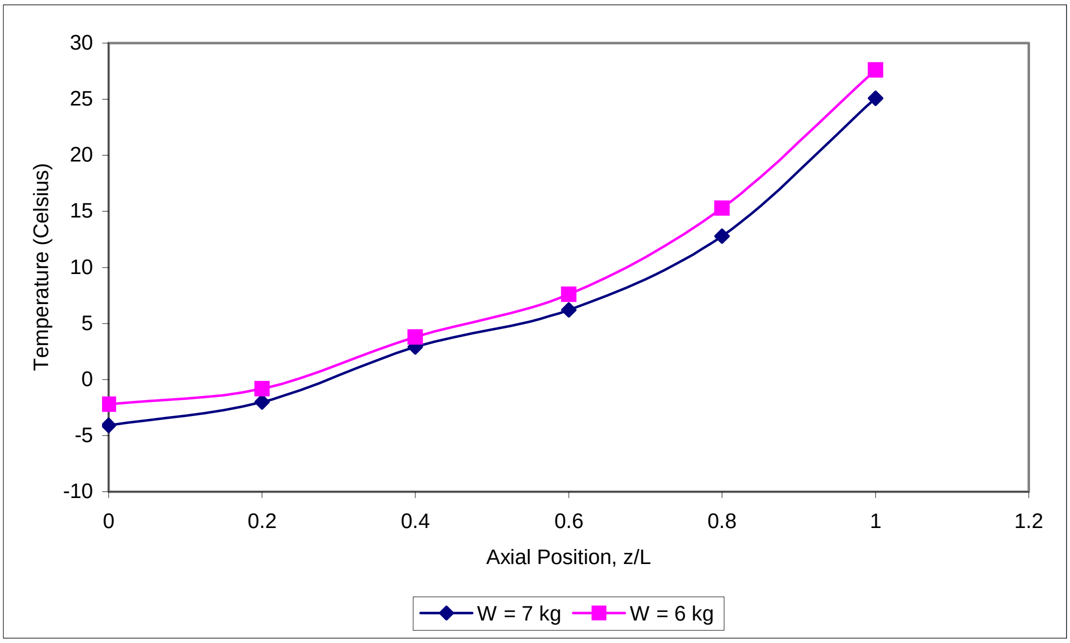
A544: Dimensionless Axial Profile of Temperature at 240 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



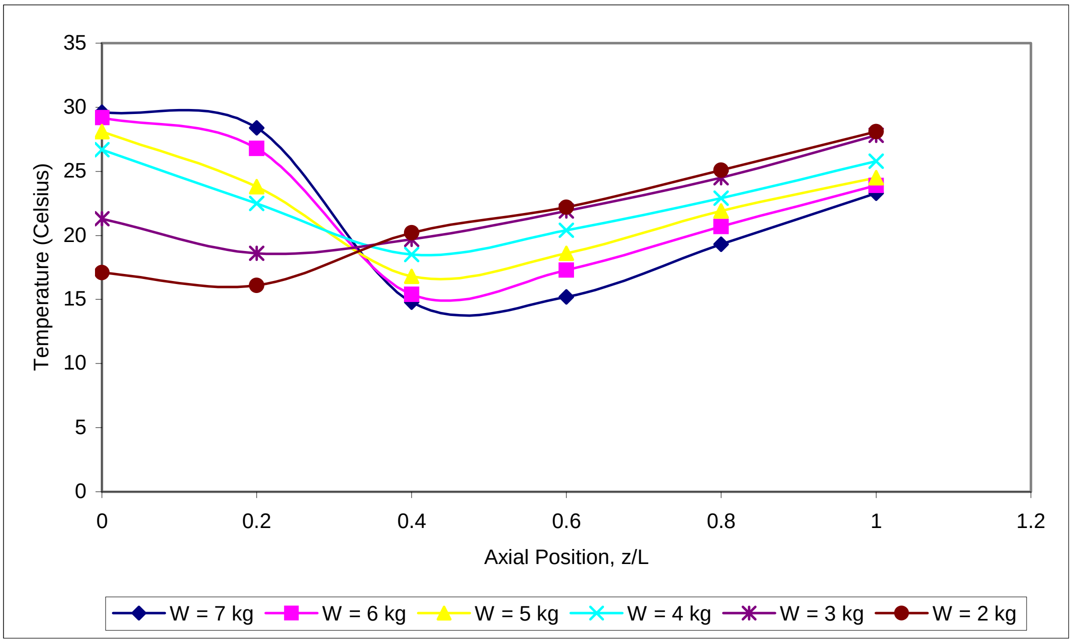
A545: Dimensionless Axial Profile of Temperature at 270 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



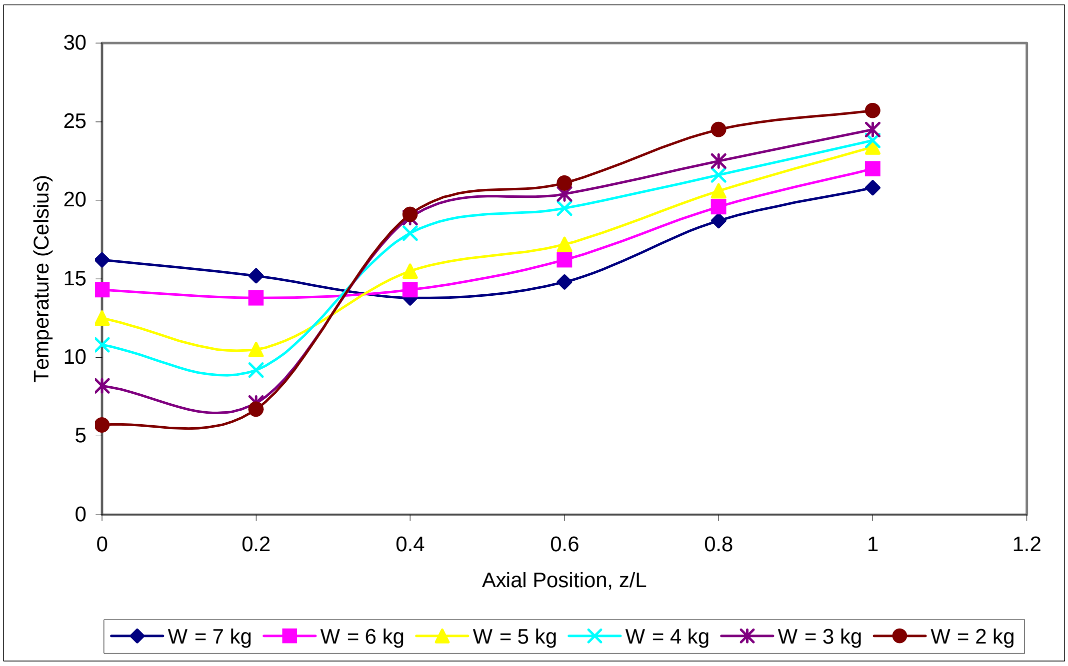
A546: Dimensionless Axial Profile of Temperature at 300 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



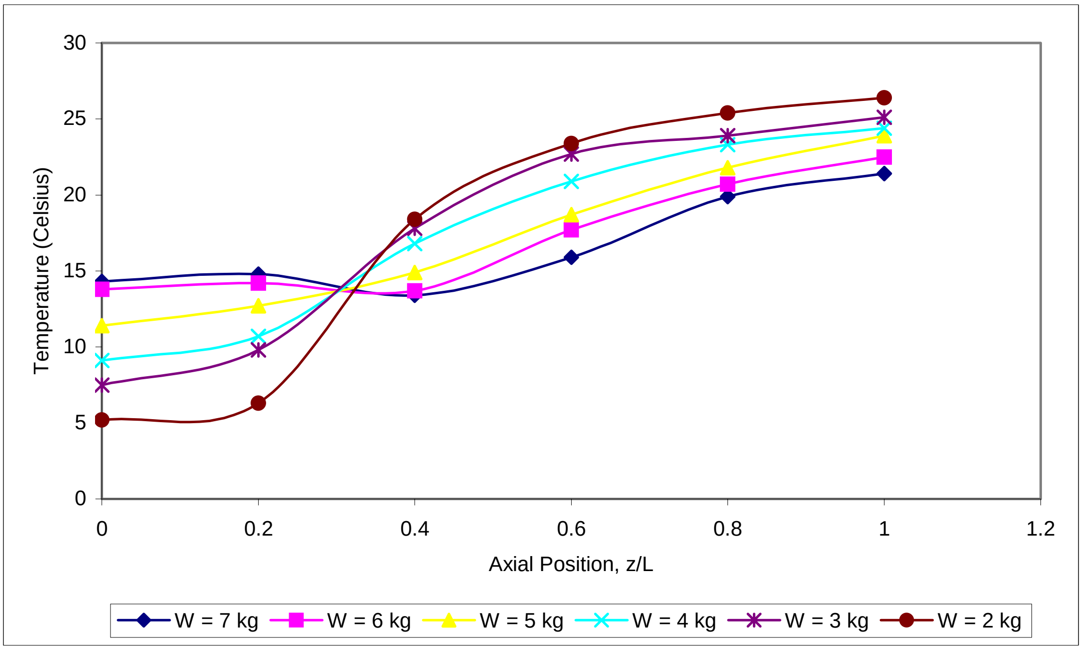
A547: Dimensionless Axial Profile of Temperature at 330 Minute at Internal Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



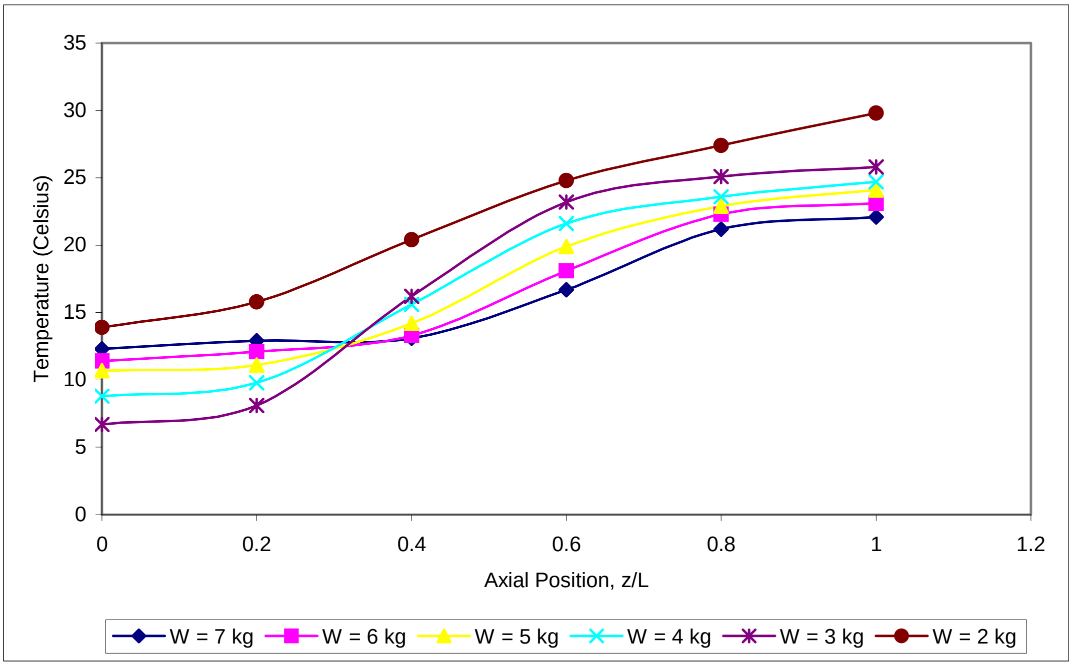
A548: Dimensionless Axial Profile of Temperature at 10 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



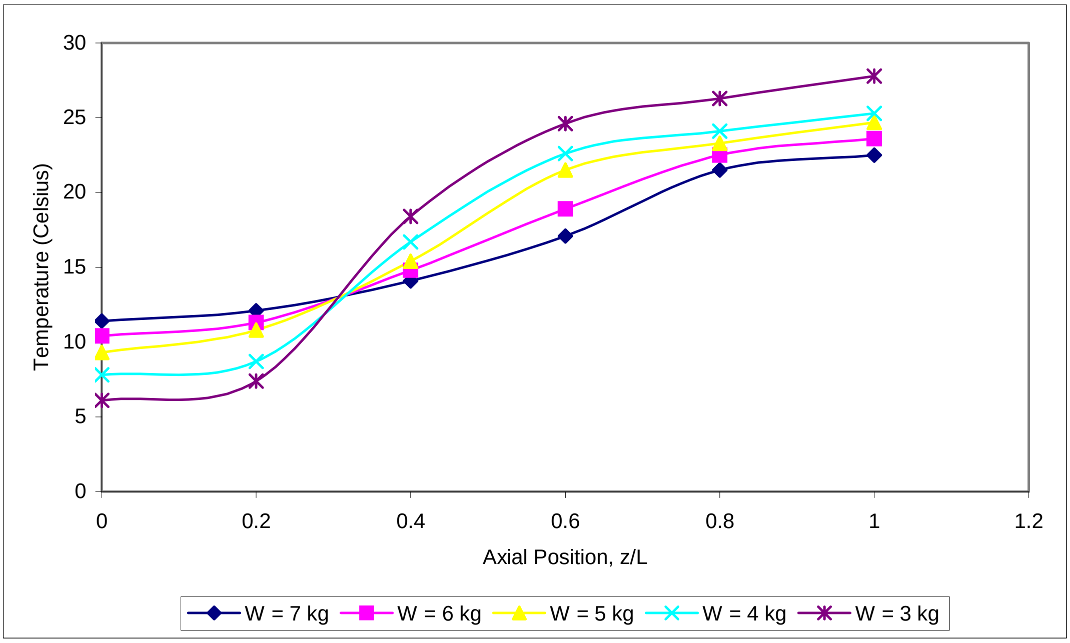
A549: Dimensionless Axial Profile of Temperature at 60 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



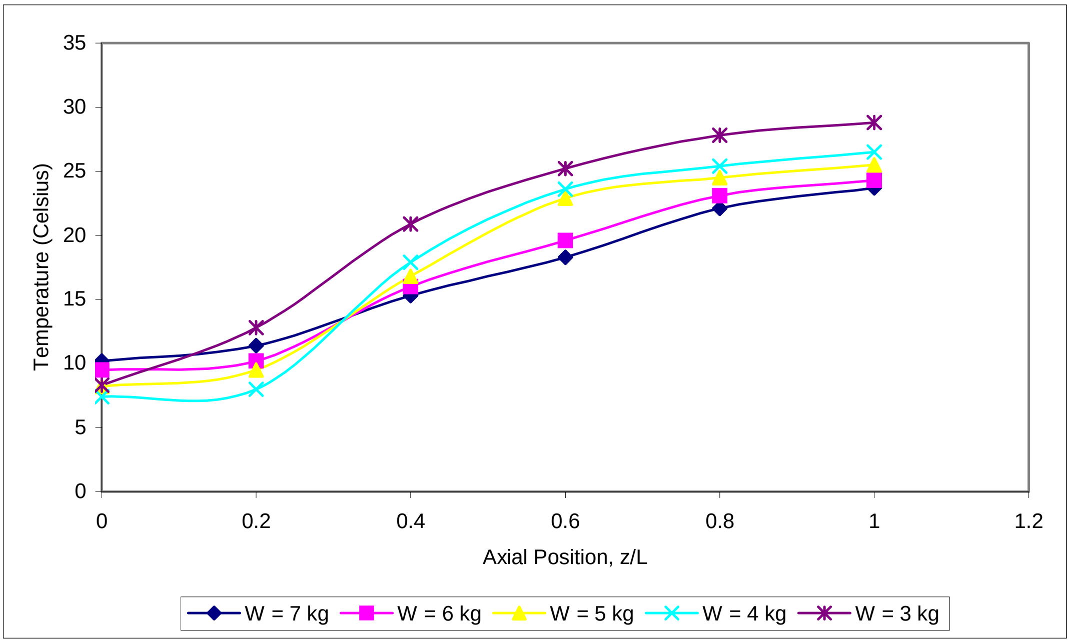
A550: Dimensionless Axial Profile of Temperature at 90 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



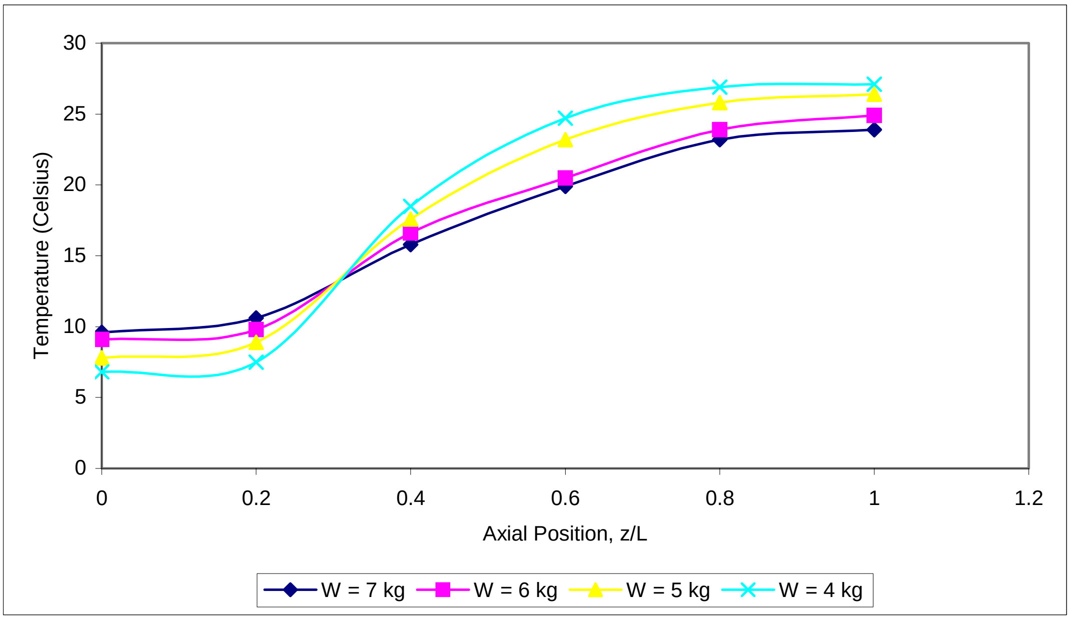
A551: Dimensionless Axial Profile of Temperature at 120 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



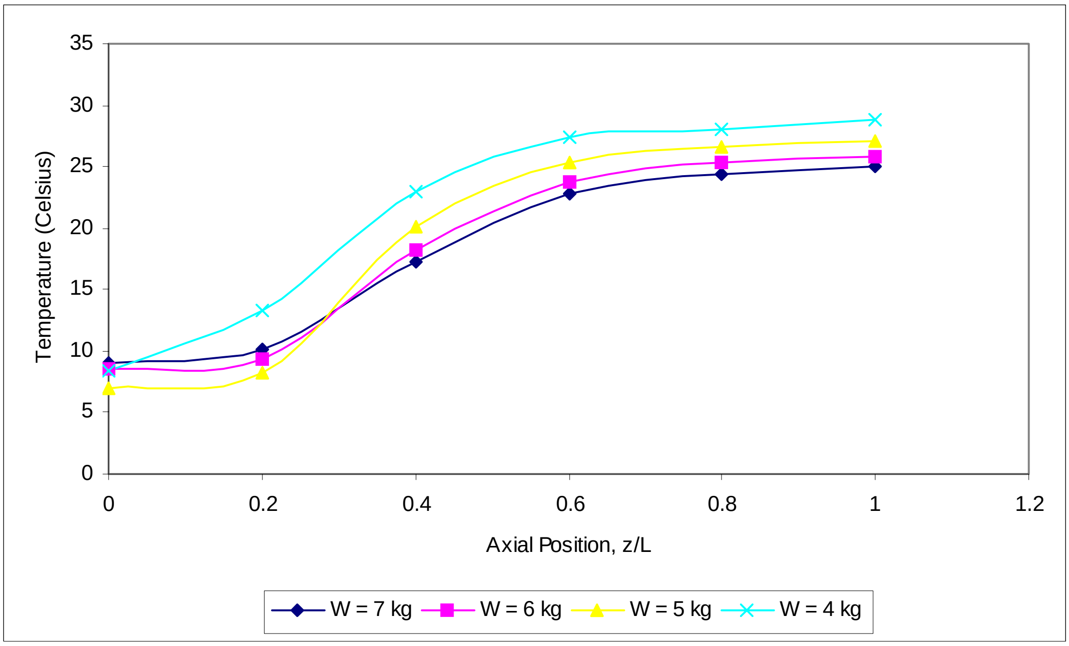
A552: Dimensionless Axial Profile of Temperature at 150 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



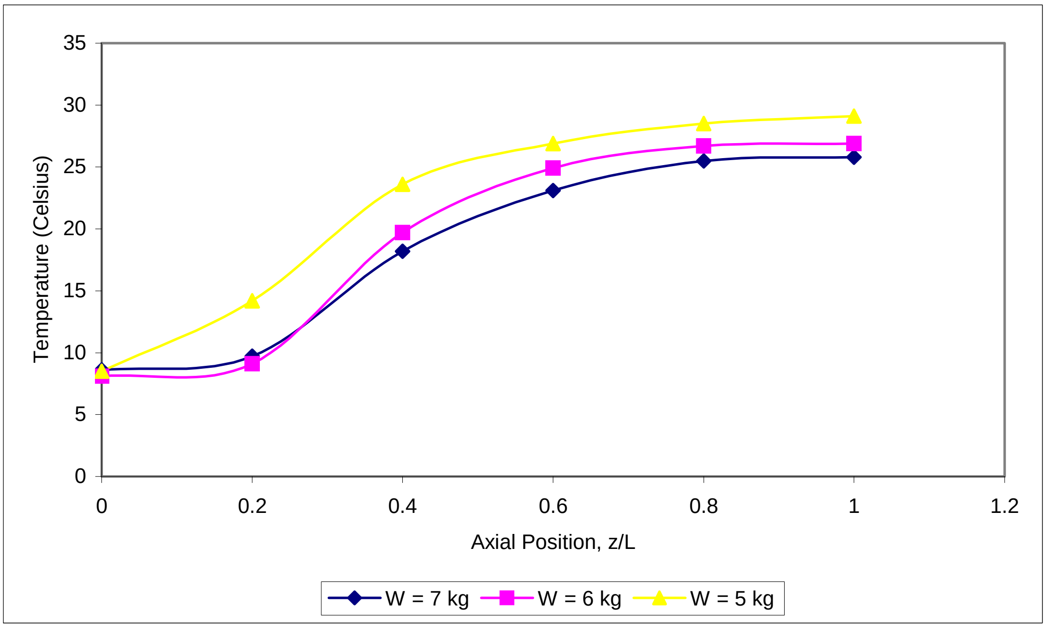
A553: Dimensionless Axial Profile of Temperature at 180 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



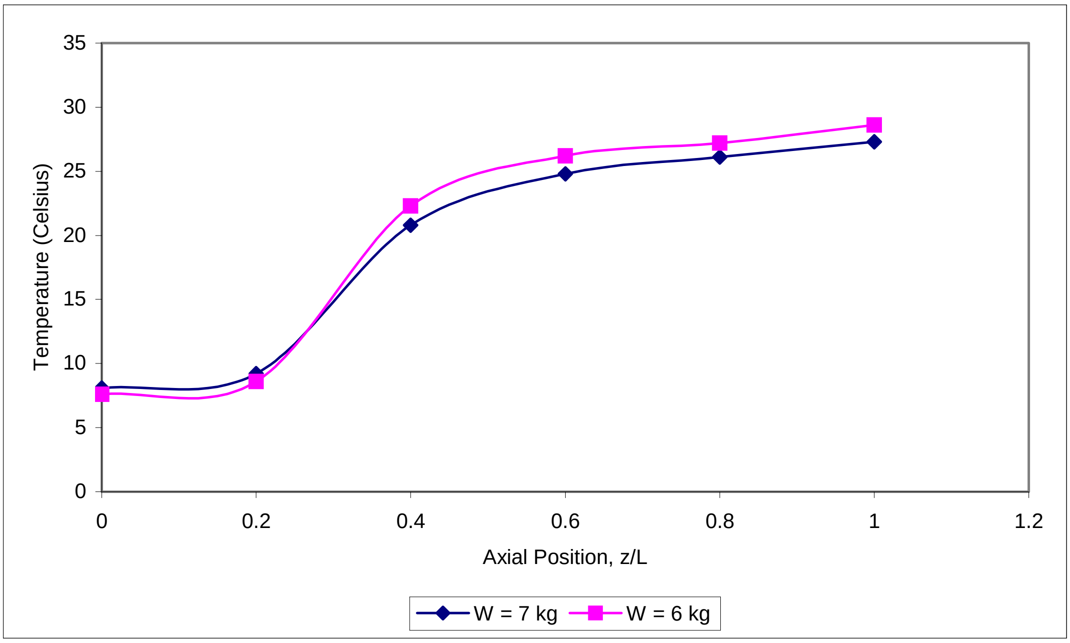
A554: Dimensionless Axial Profile of Temperature at 210 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



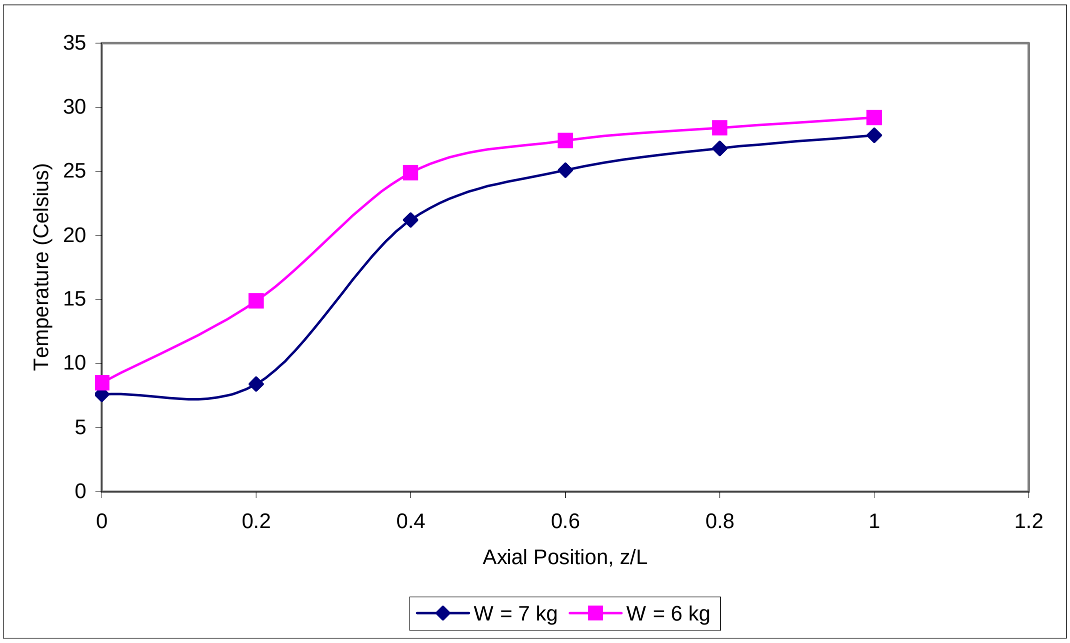
A555: Dimensionless Axial Profile of Temperature at 240 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



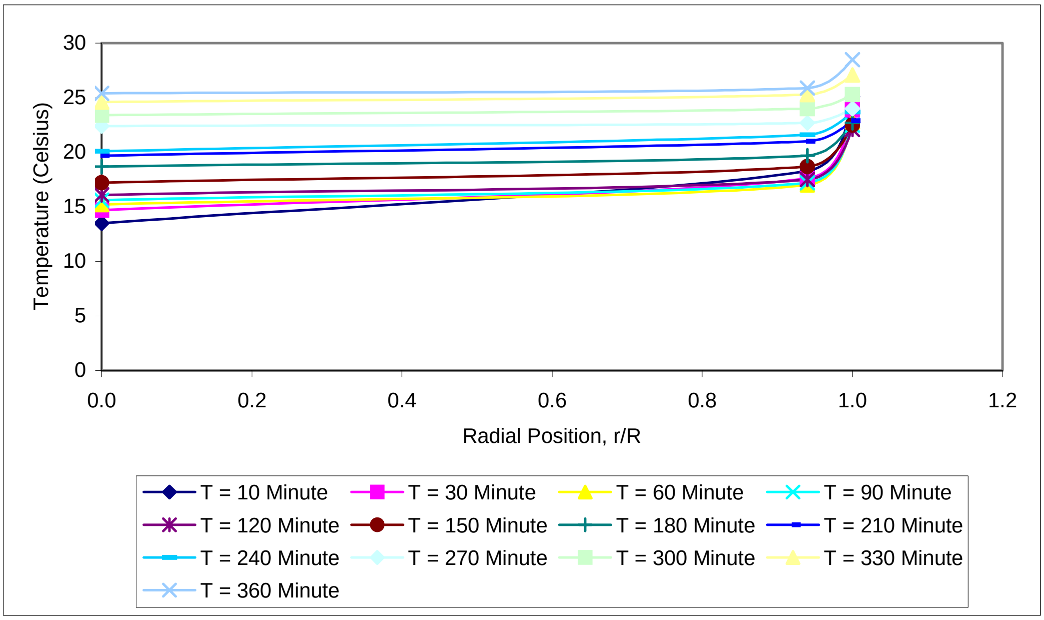
A556: Dimensionless Axial Profile of Temperature at 270 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



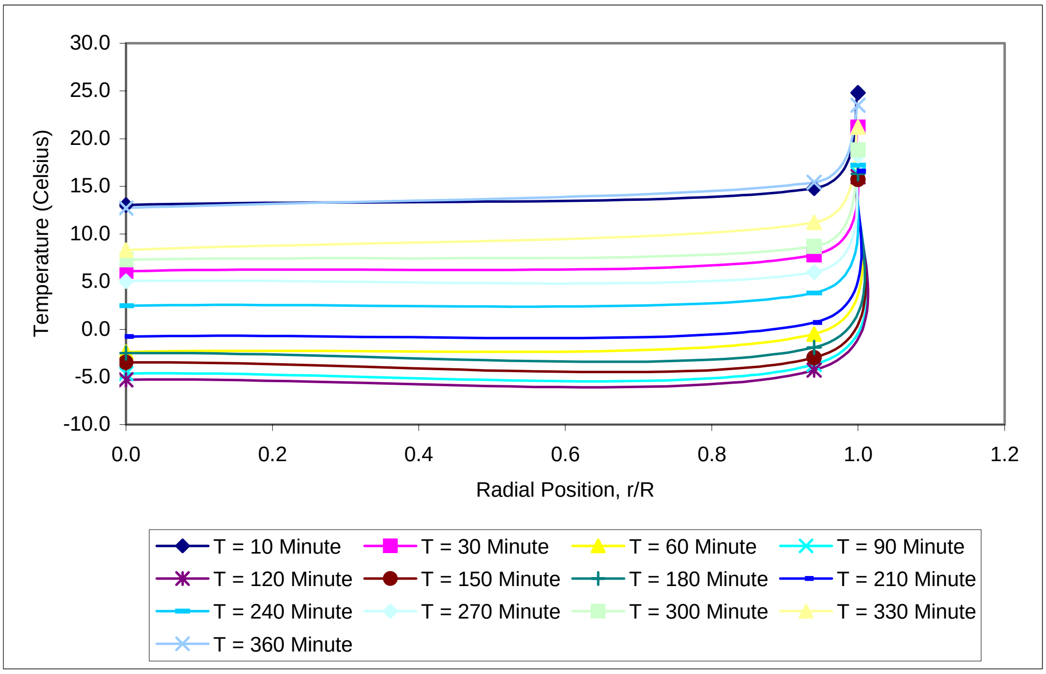
A557: Dimensionless Axial Profile of Temperature at 300 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



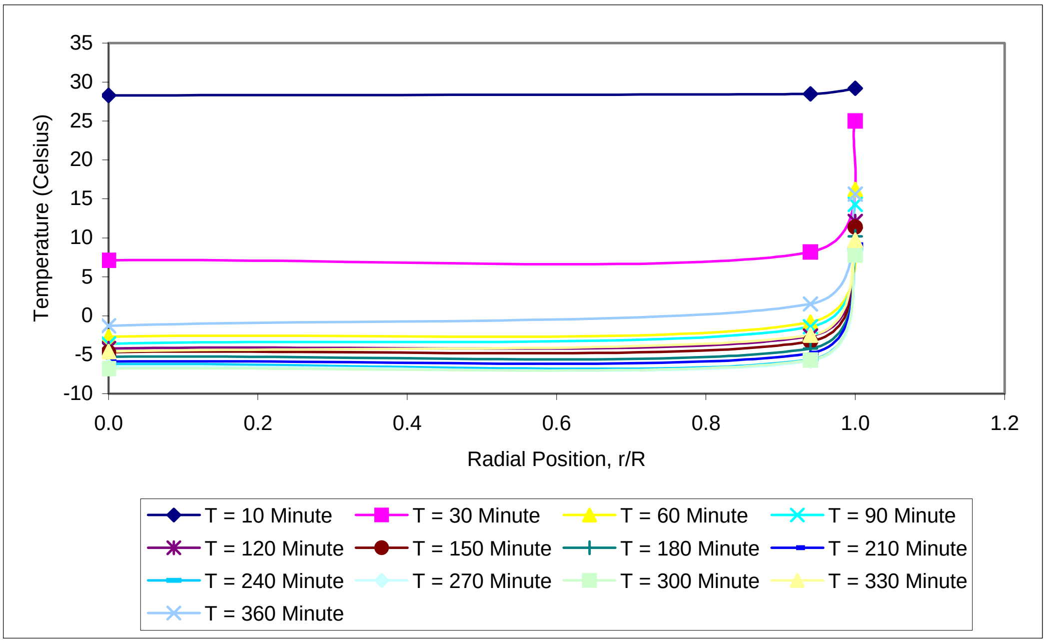
A558: Dimensionless Axial Profile of Temperature at 330 Minute at External Wall of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



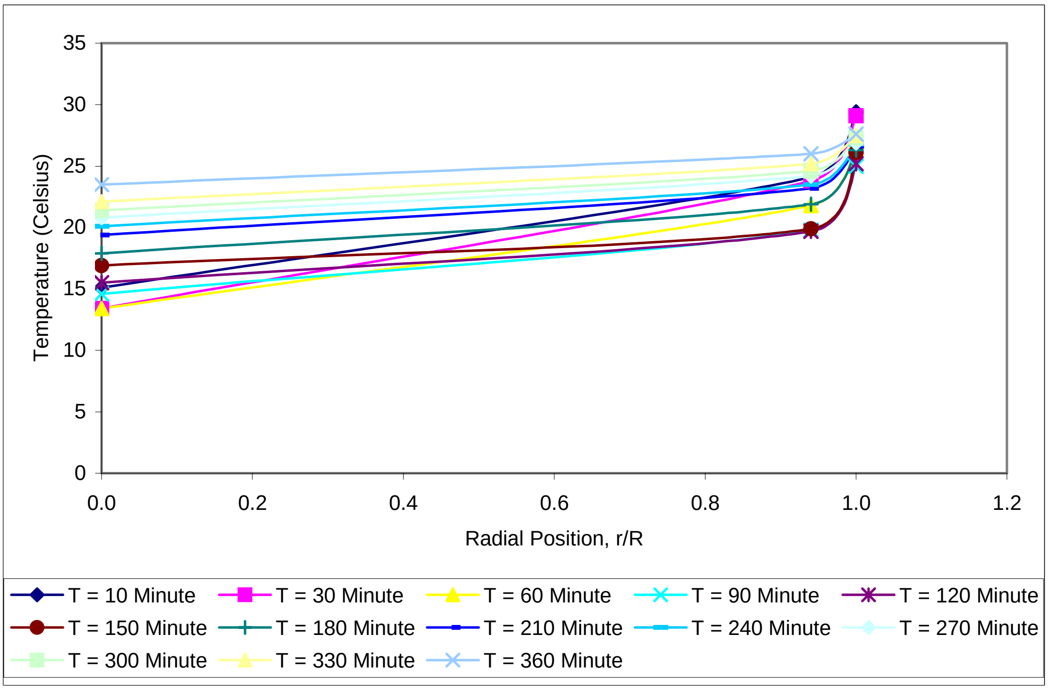
A559: Dimensionless Radial Profile of Temperature at Level 1 of Weight of 7 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



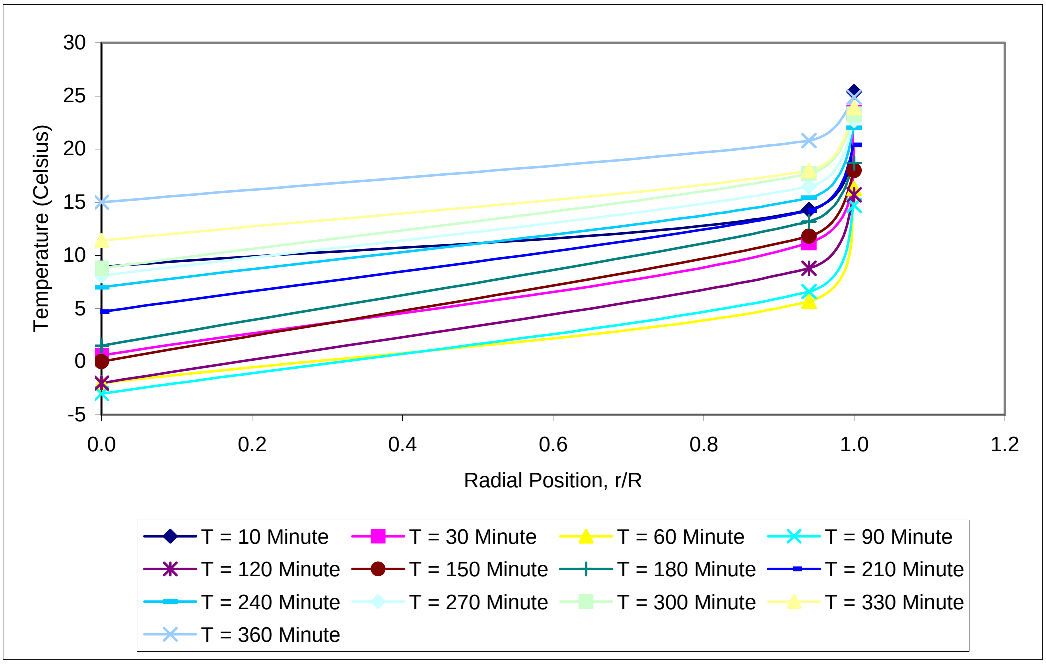
A560: Dimensionless Radial Profile of Temperature at Level 4 of Weight of 7 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



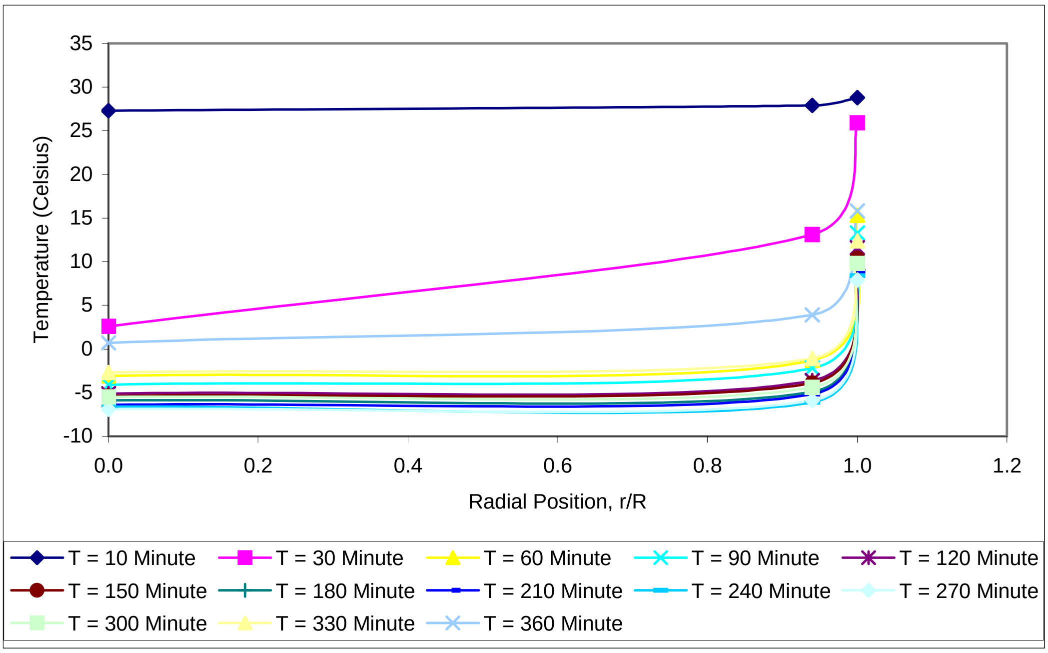
A561: Dimensionless Radial Profile of Temperature at Level 6 of Weight of 7 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



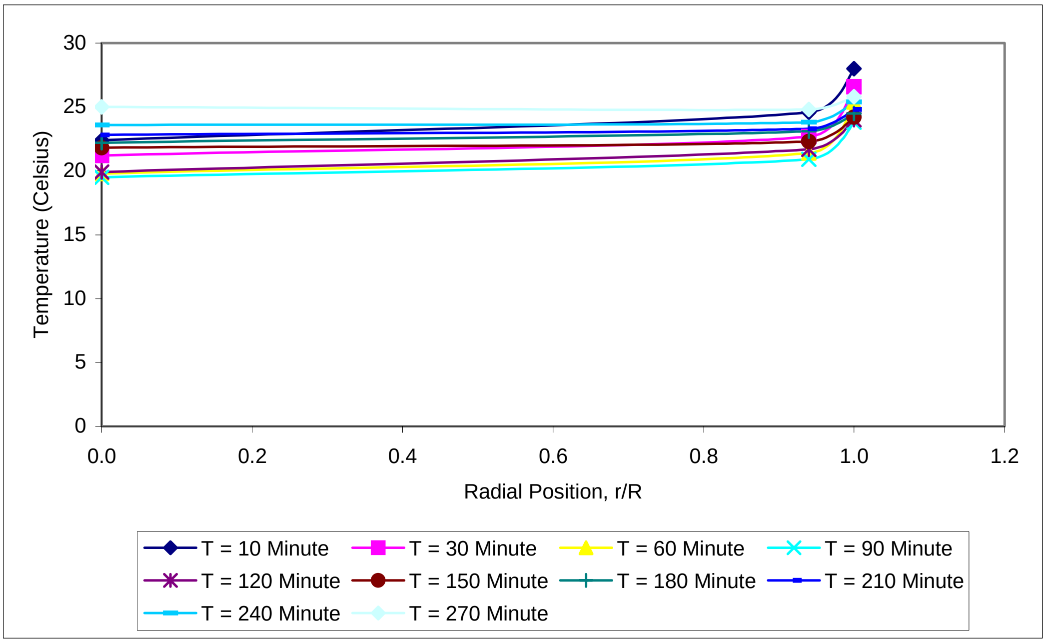
A562: Dimensionless Radial Profile of Temperature at Level 1 of Weight of 6 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



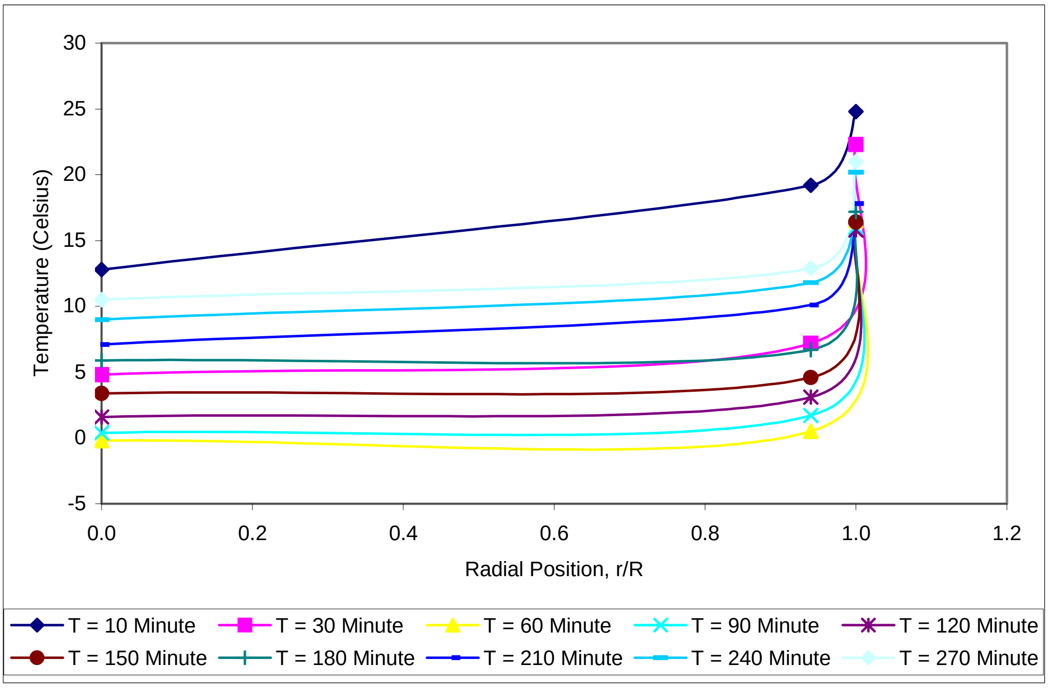
A563: Dimensionless Radial Profile of Temperature at Level 4 of Weight of 6 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



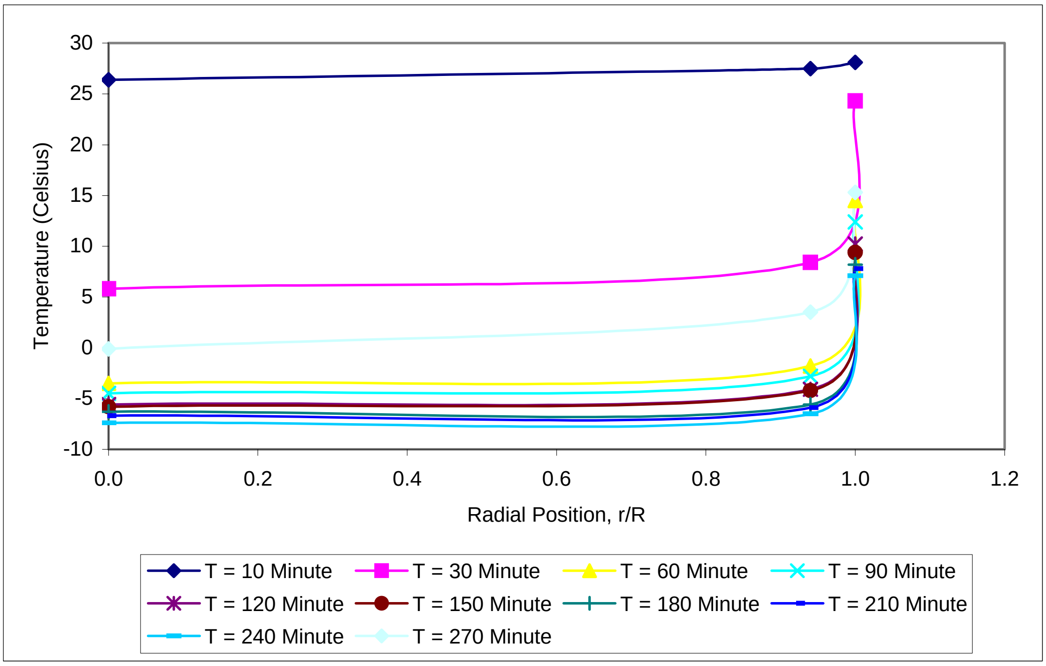
A564: Dimensionless Radial Profile of Temperature at Level 6 of Weight of 6 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



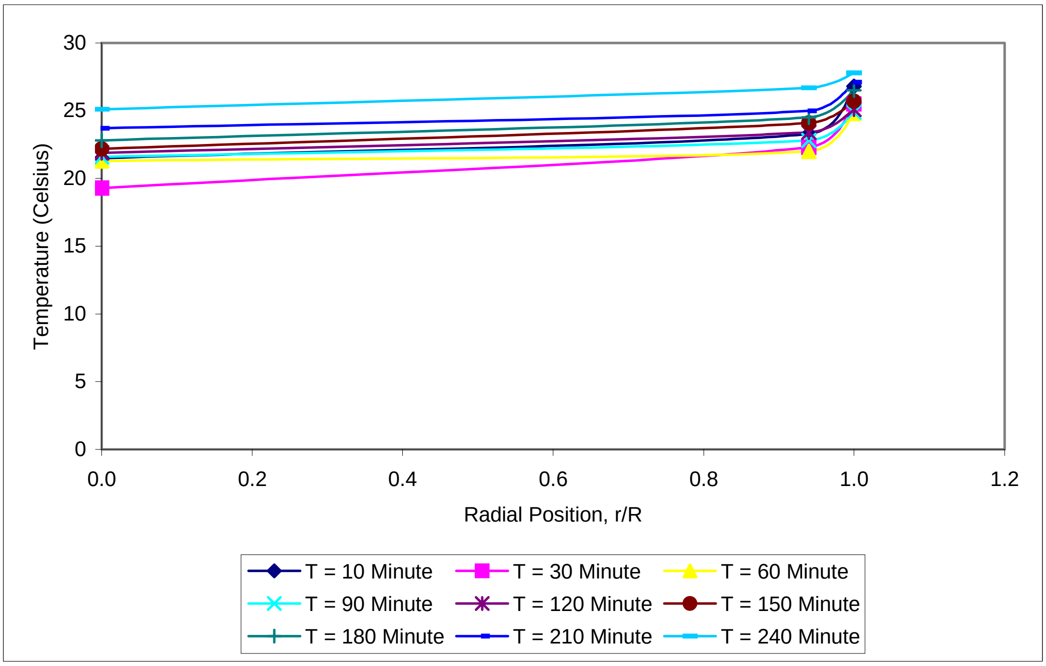
A565: Dimensionless Radial Profile of Temperature at Level 1 of Weight of 5 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



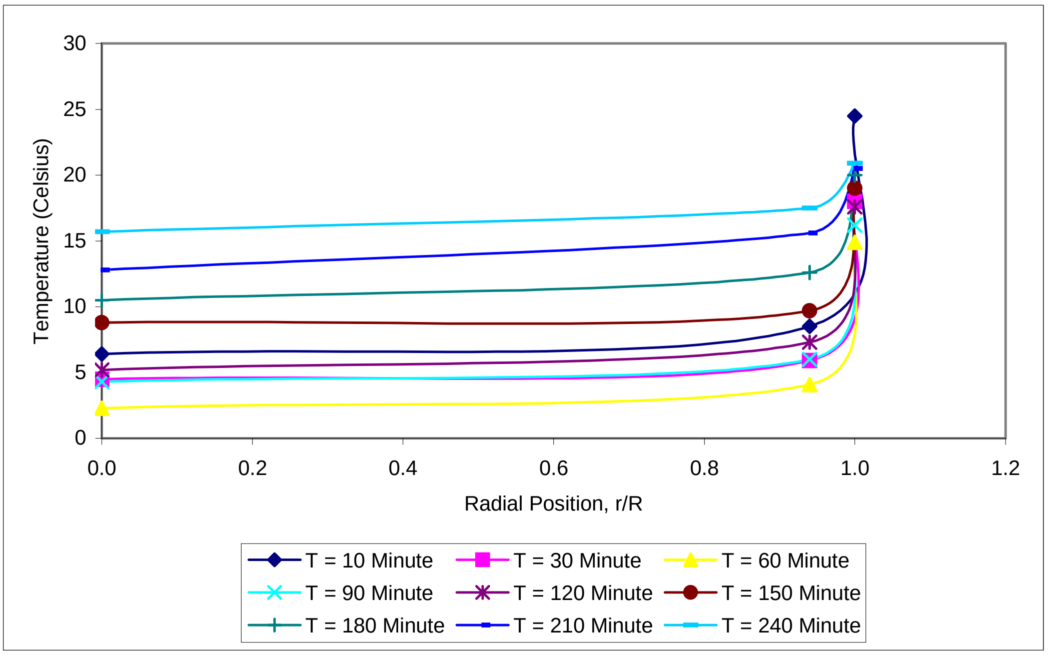
A566: Dimensionless Radial Profile of Temperature at Level 4 of Weight of 5 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



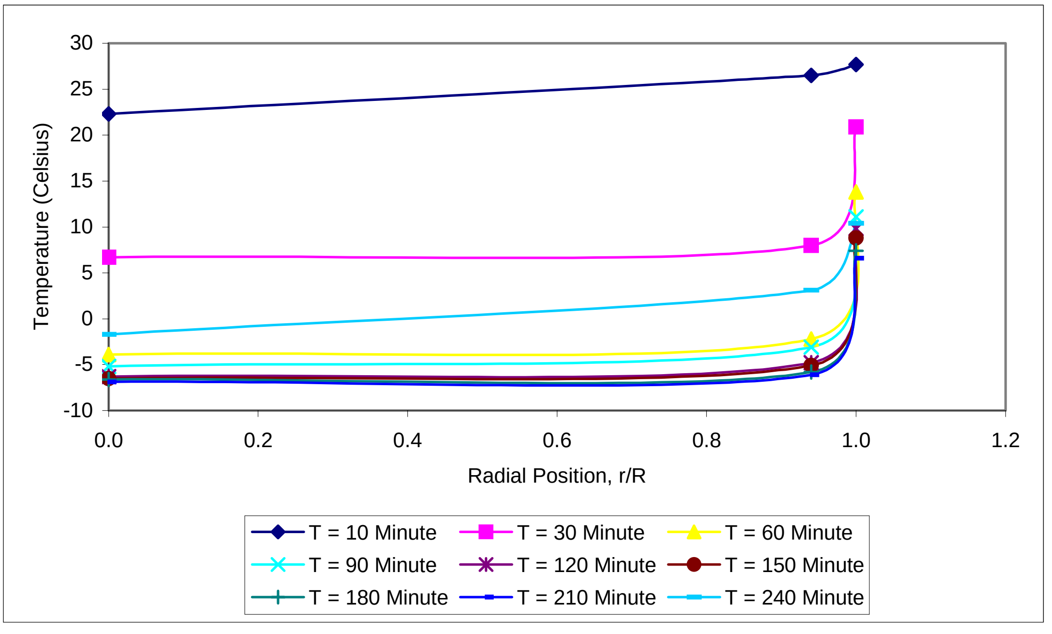
A567: Dimensionless Radial Profile of Temperature at Level 6 of Weight of 5 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



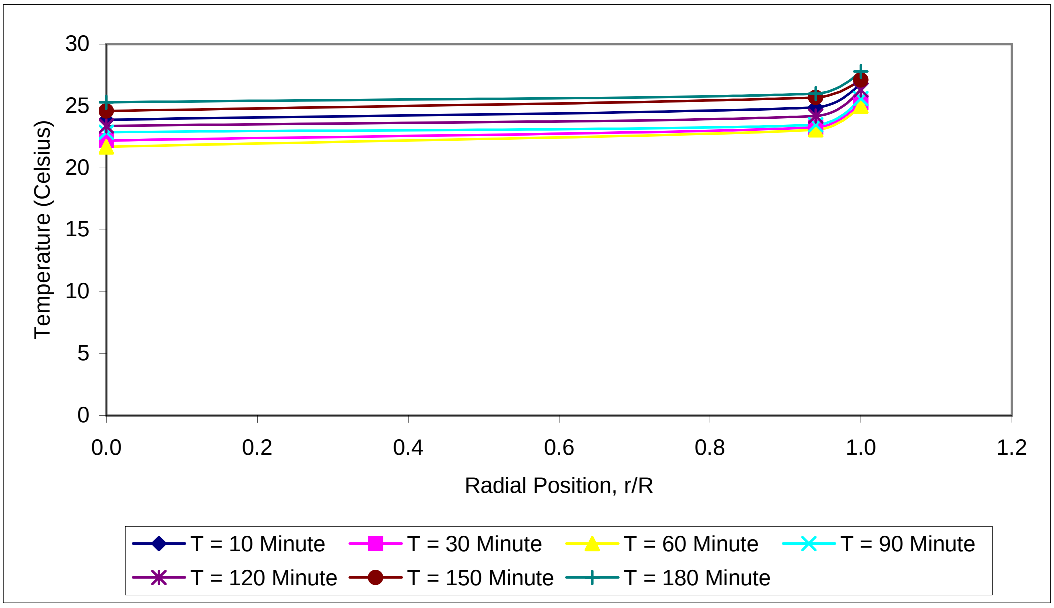
A568: Dimensionless Radial Profile of Temperature at Level 1 of Weight of 4 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



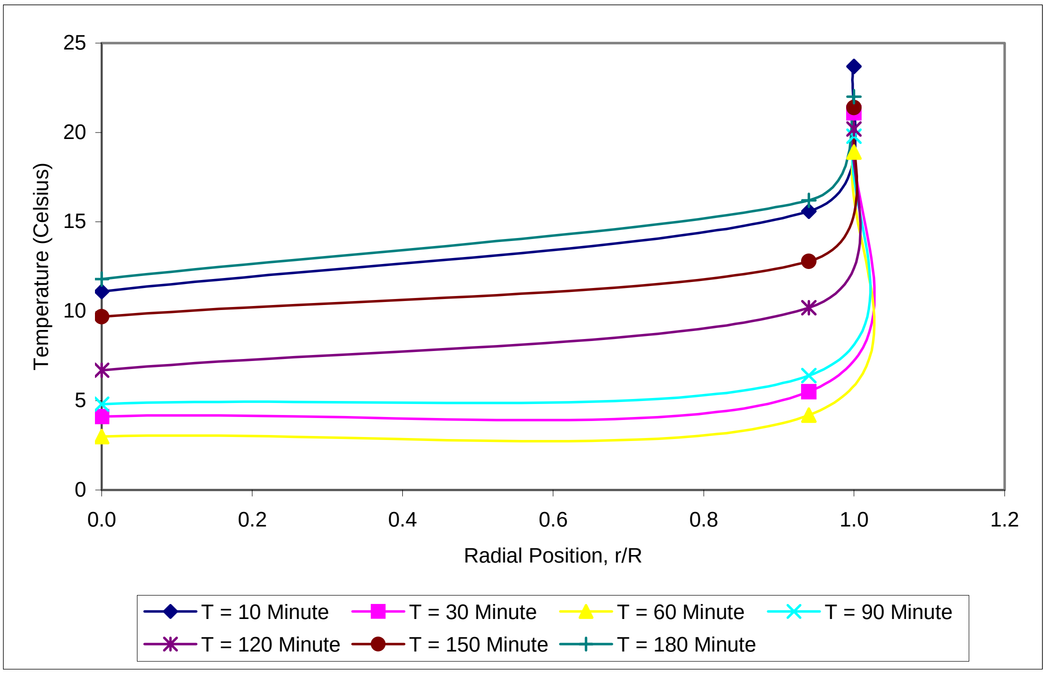
A569: Dimensionless Radial Profile of Temperature at Level 4 of Weight of 4 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



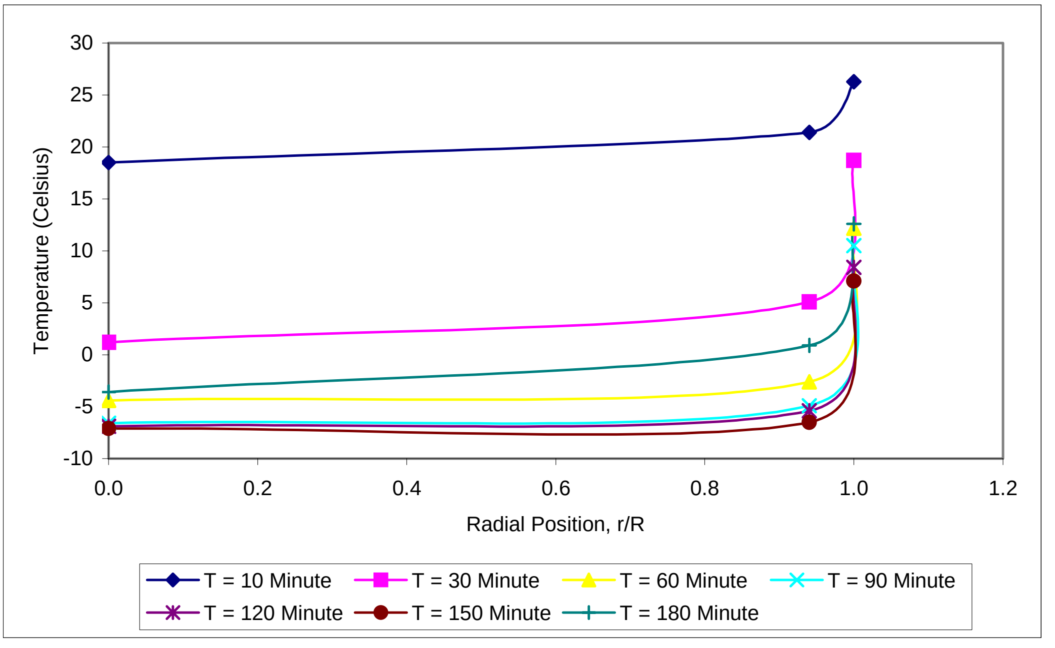
A570: Dimensionless Radial Profile of Temperature at Level 6 of Weight of 4 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



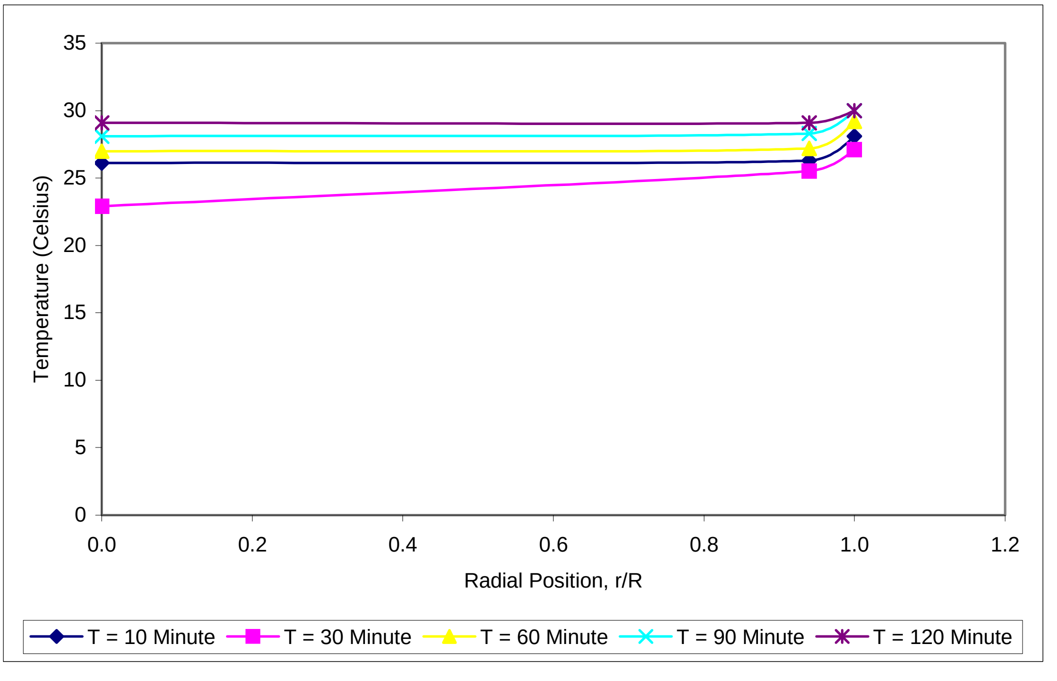
A571: Dimensionless Radial Profile of Temperature at Level 1 of Weight of 3 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



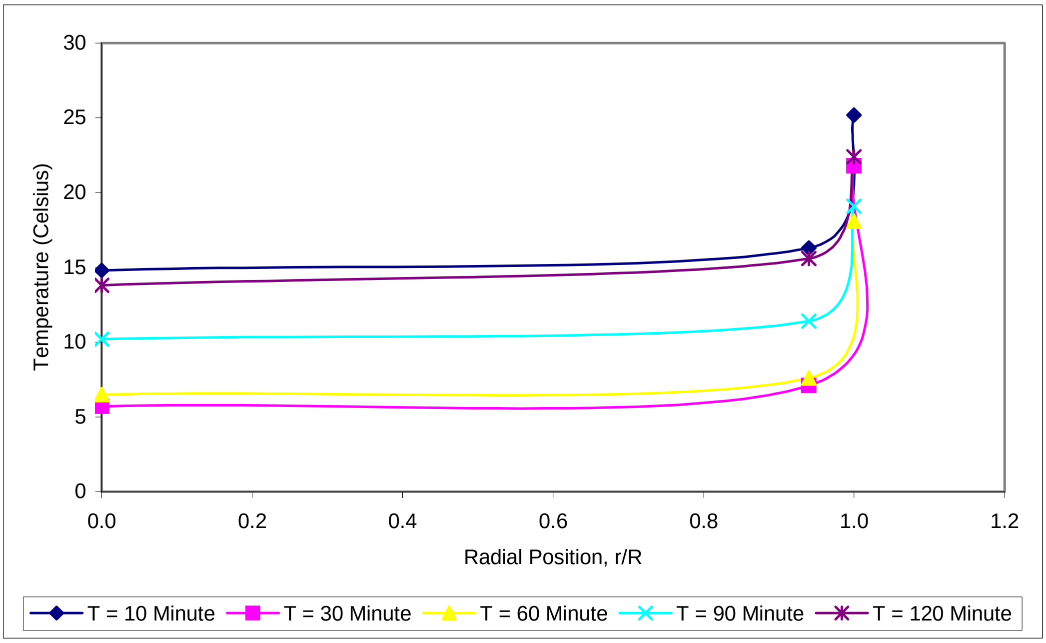
A572: Dimensionless Radial Profile of Temperature at Level 4 of Weight of 3 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



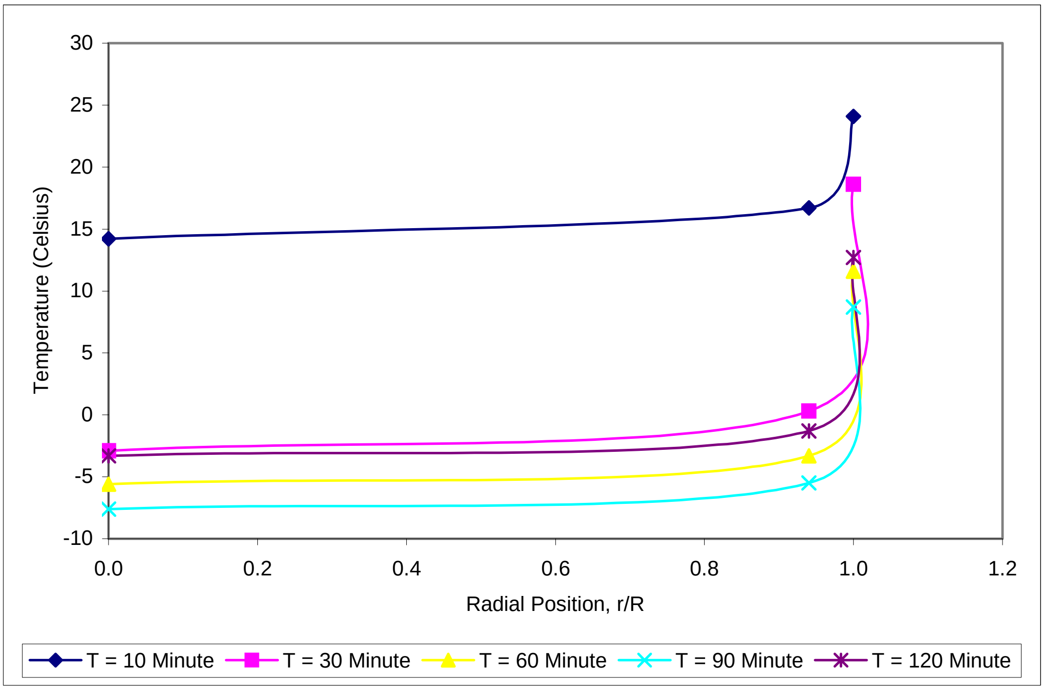
A573: Dimensionless Radial Profile of Temperature at Level 6 of Weight of 3 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



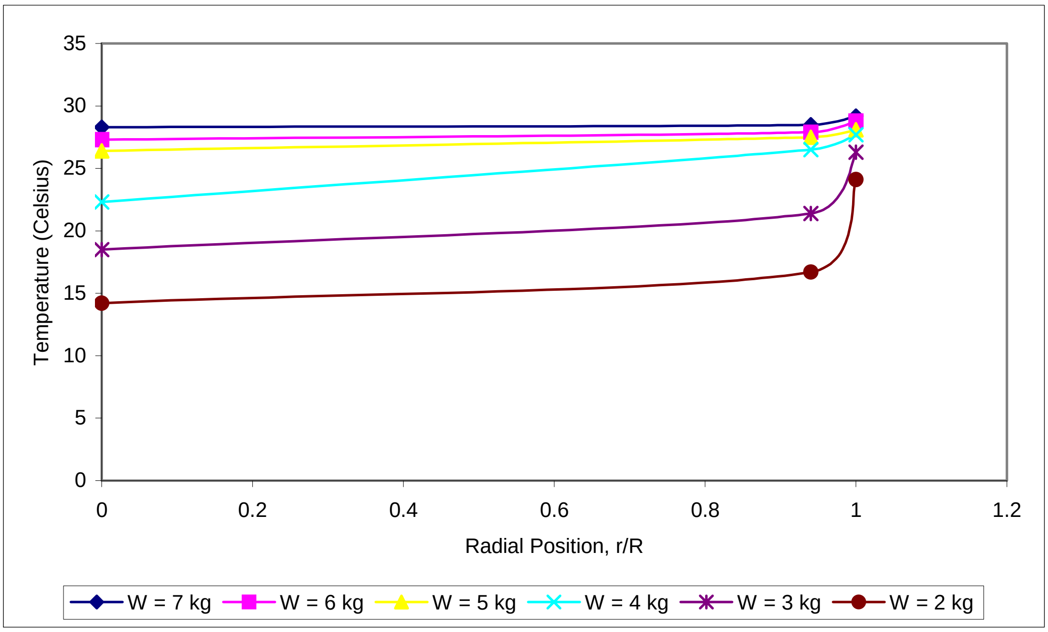
A574: Dimensionless Radial Profile of Temperature at Level 1 of Weight of 2 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



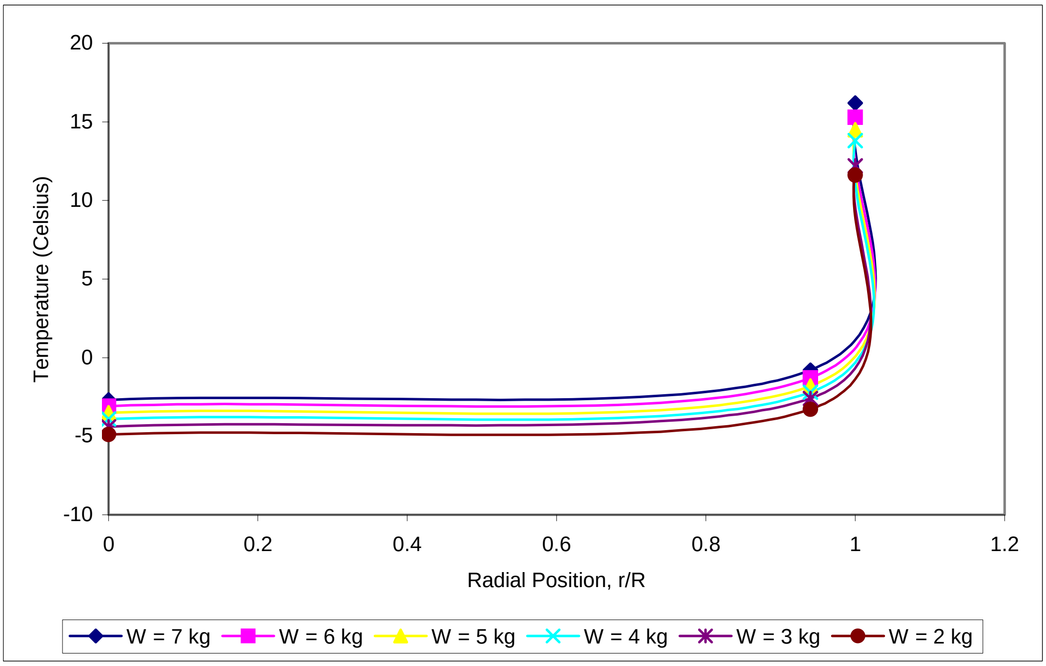
A575: Dimensionless Radial Profile of Temperature at Level 4 of Weight of 2 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



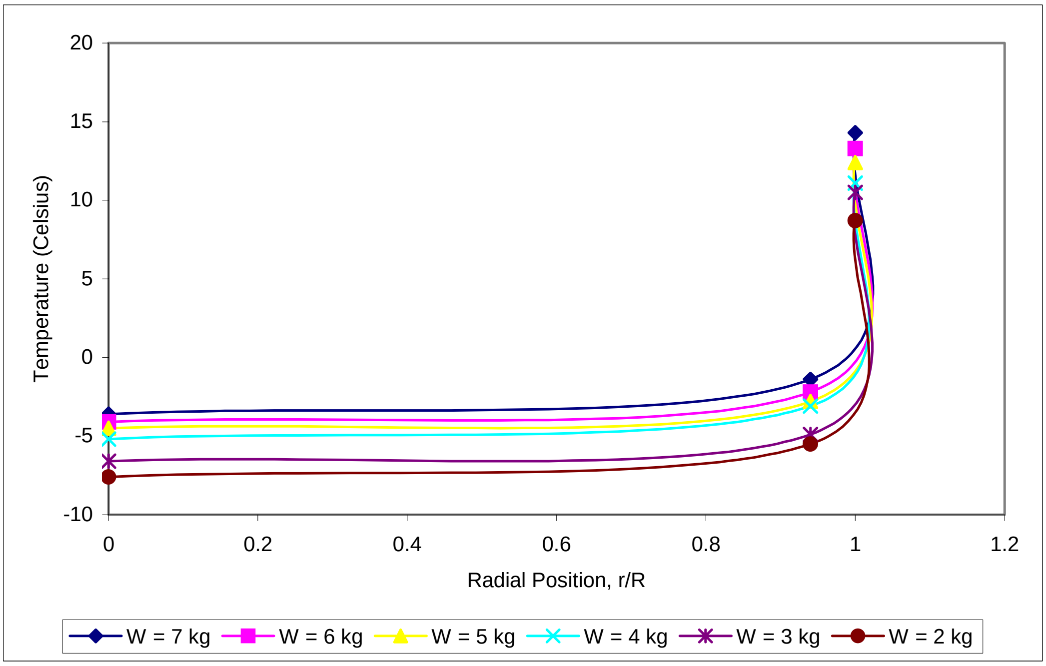
A576: Dimensionless Radial Profile of Temperature at Level 6 of Weight of 2 kg at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



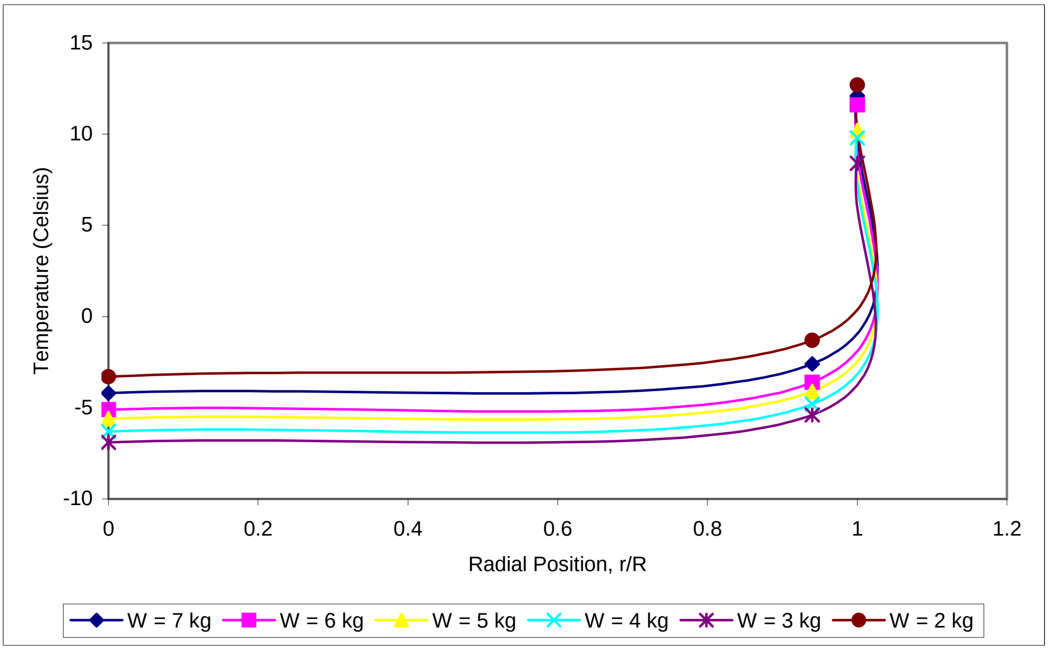
A577: Dimensionless Radial Profile of Temperature at Level 6 at 10 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



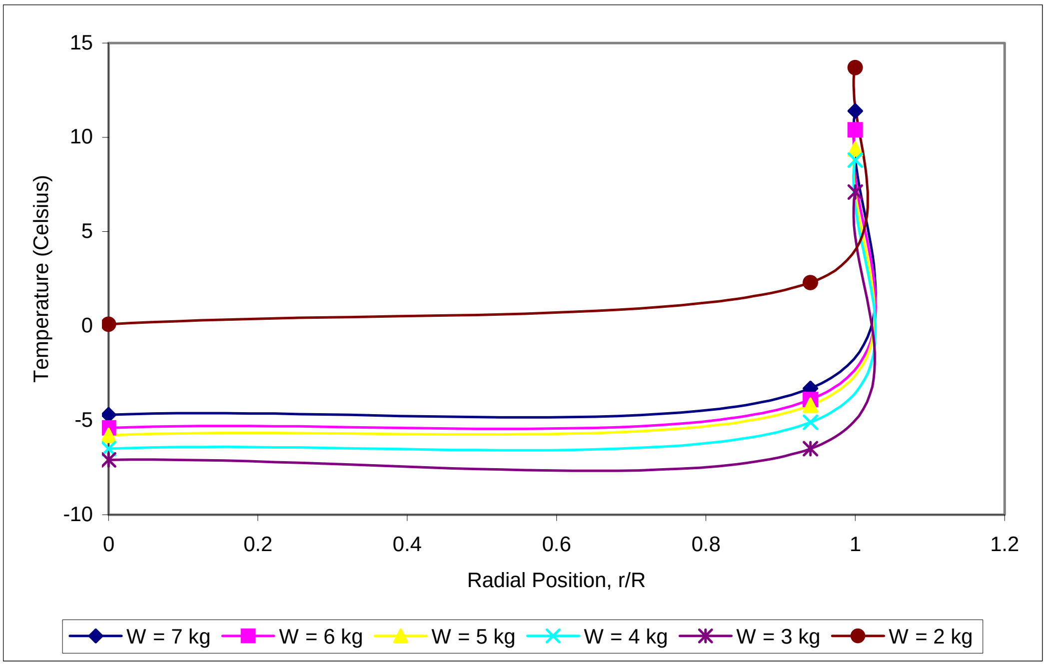
A578: Dimensionless Radial Profile of Temperature at Level 6 at 60 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



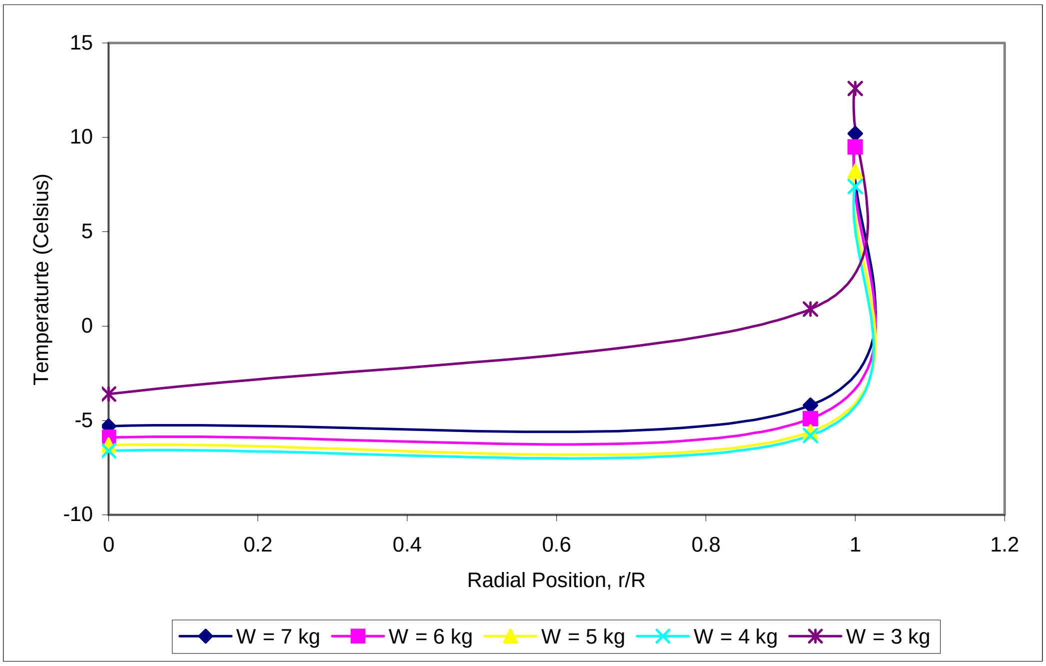
A579: Dimensionless Radial Profile of Temperature at Level 6 at 90 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



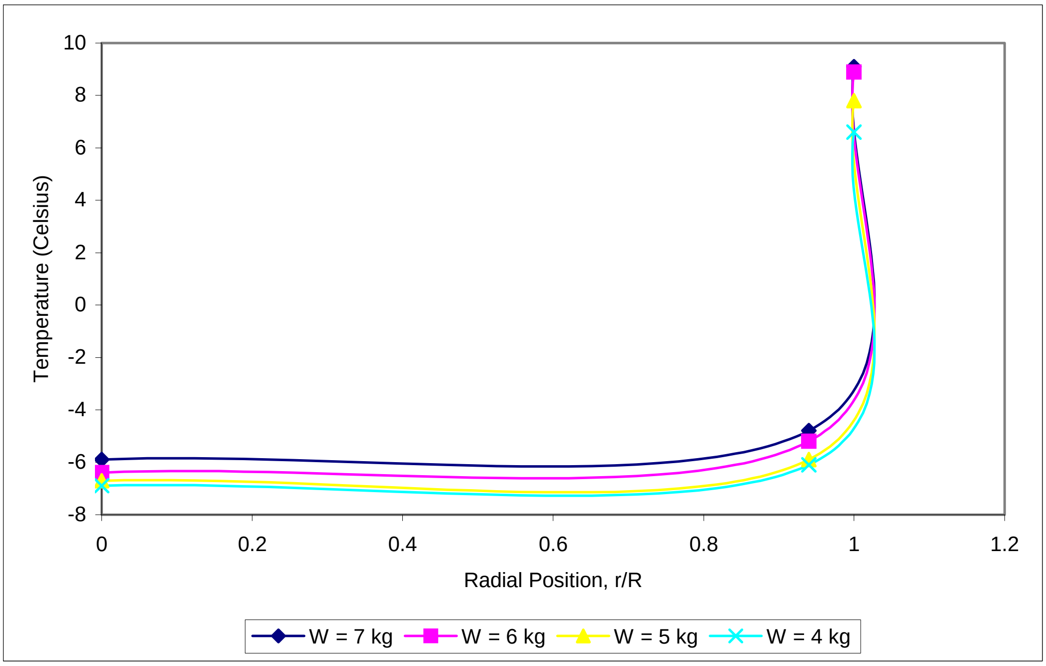
A580: Dimensionless Radial Profile of Temperature at Level 6 at 120 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



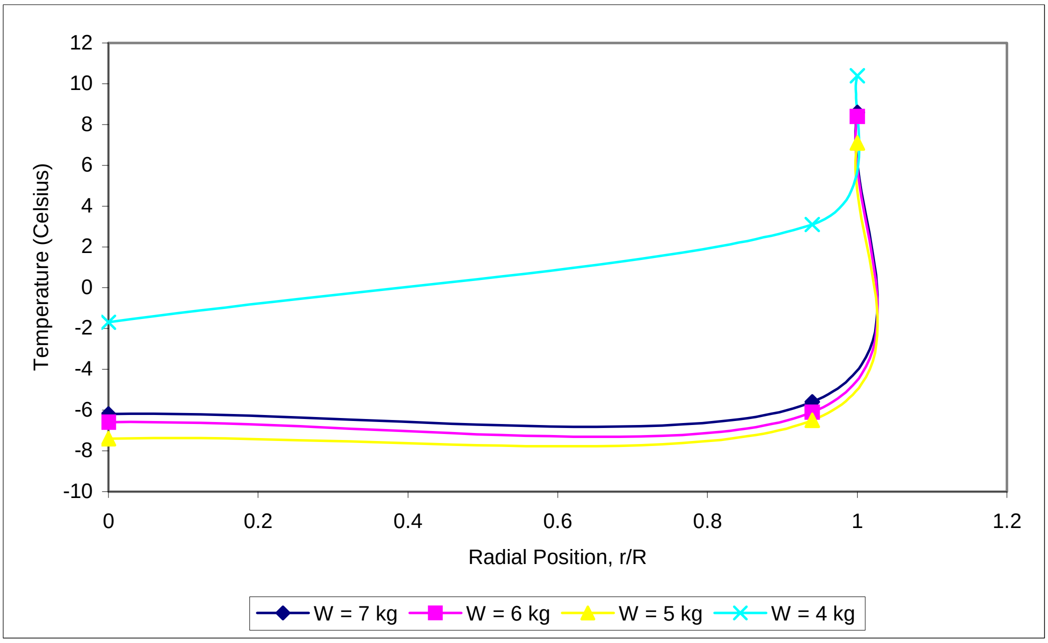
A581: Dimensionless Radial Profile of Temperature at Level 6 at 150 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



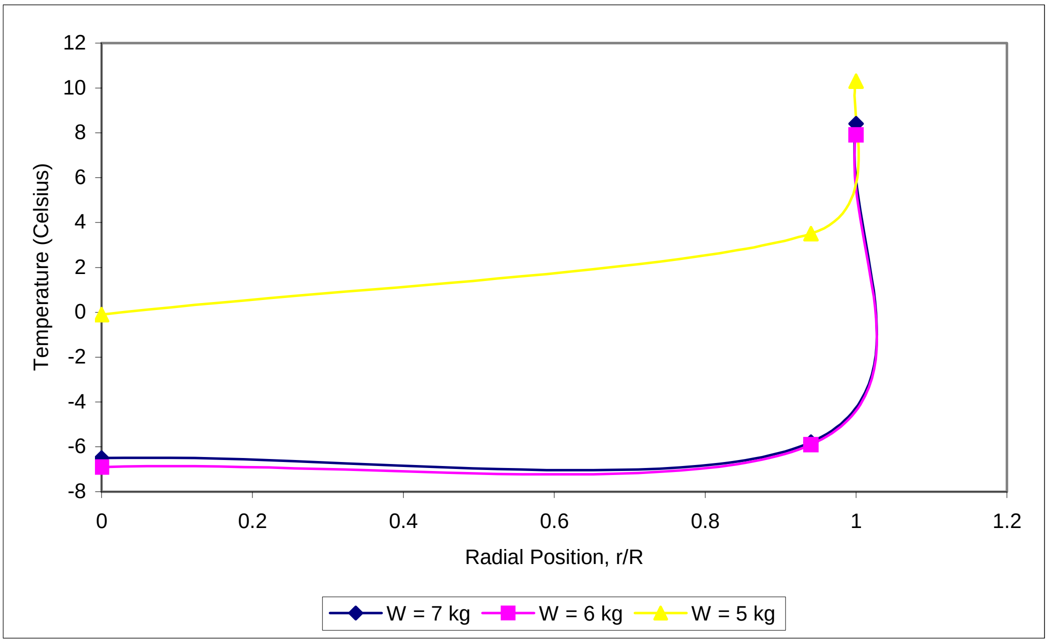
A582: Dimensionless Radial Profile of Temperature at Level 6 at 180 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



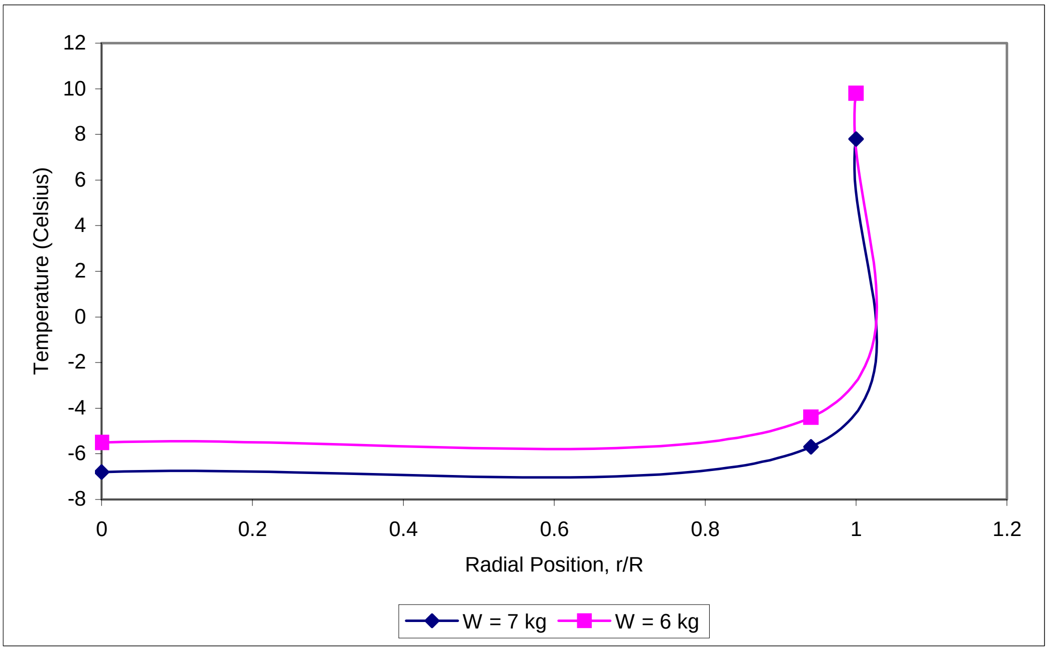
A583: Dimensionless Radial Profile of Temperature at Level 6 at 210 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



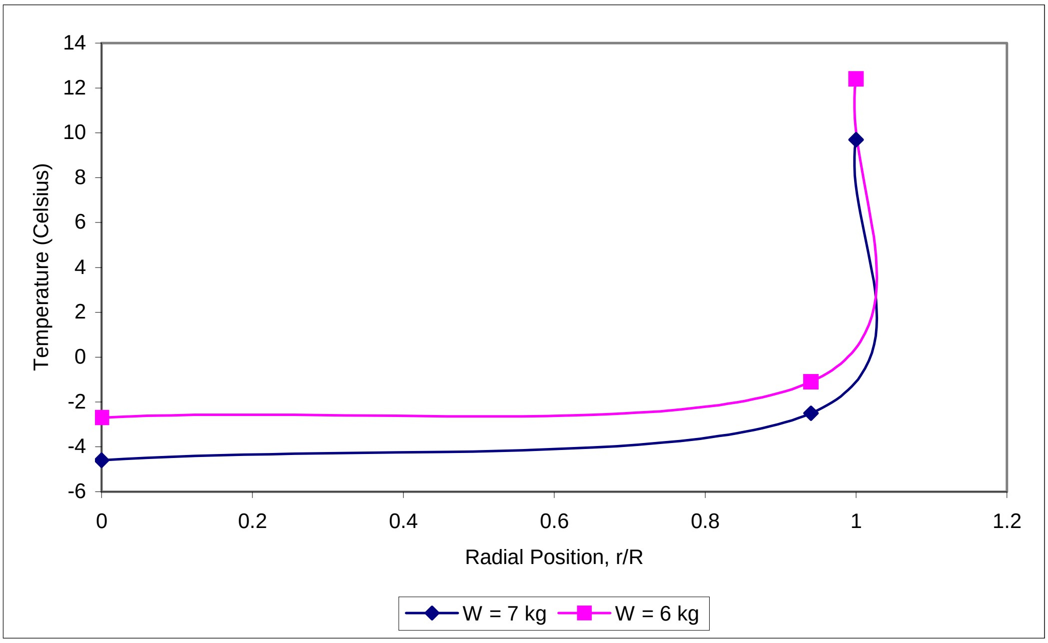
A584: Dimensionless Radial Profile of Temperature at Level 6 at 240 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



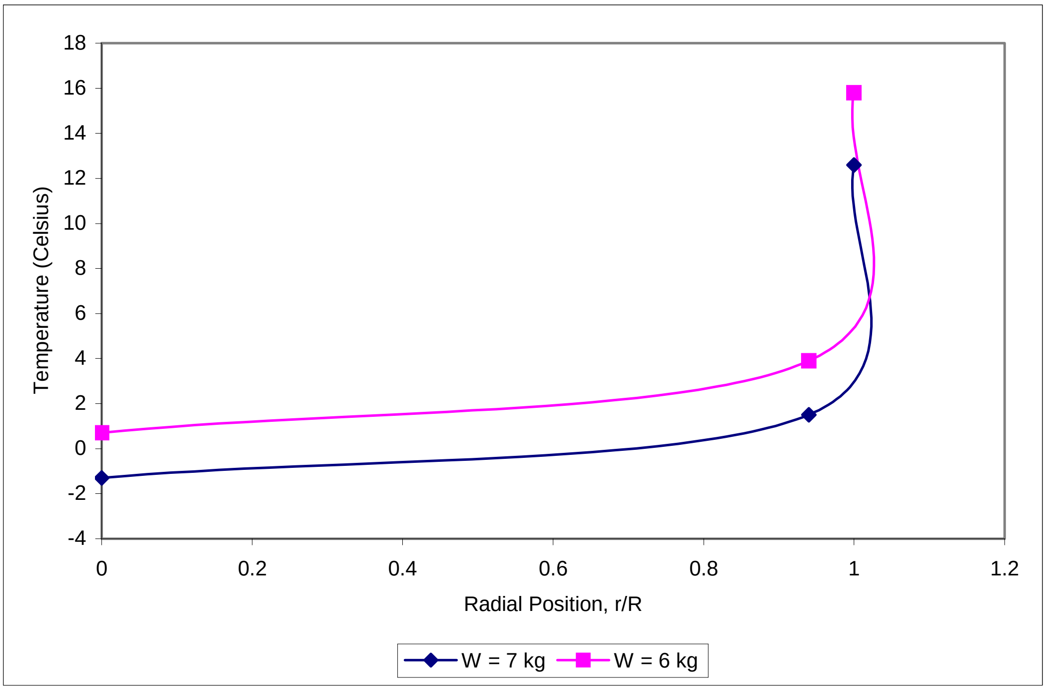
A585: Dimensionless Radial Profile of Temperature at Level 6 at 270 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



A586: Dimensionless Radial Profile of Temperature at Level 6 at 300 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30^{o}C



A587: Dimensionless Radial Profile of Temperature at Level 6 at 330 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C



A588: Dimensionless Radial Profile of Temperature at Level 6 at 360 Minute of Various Weight at Flow rate of 48 liter/minute, Composition of 4060 and Surrounding Temperature of 30°C

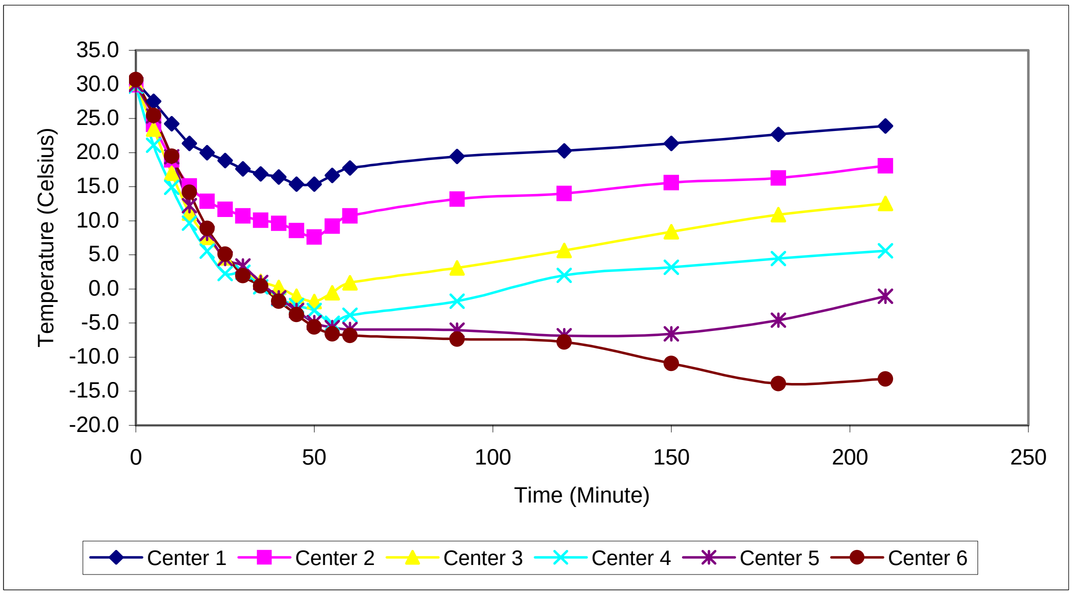


Figure A1: Temperature Profile at Center of the Cylinder of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

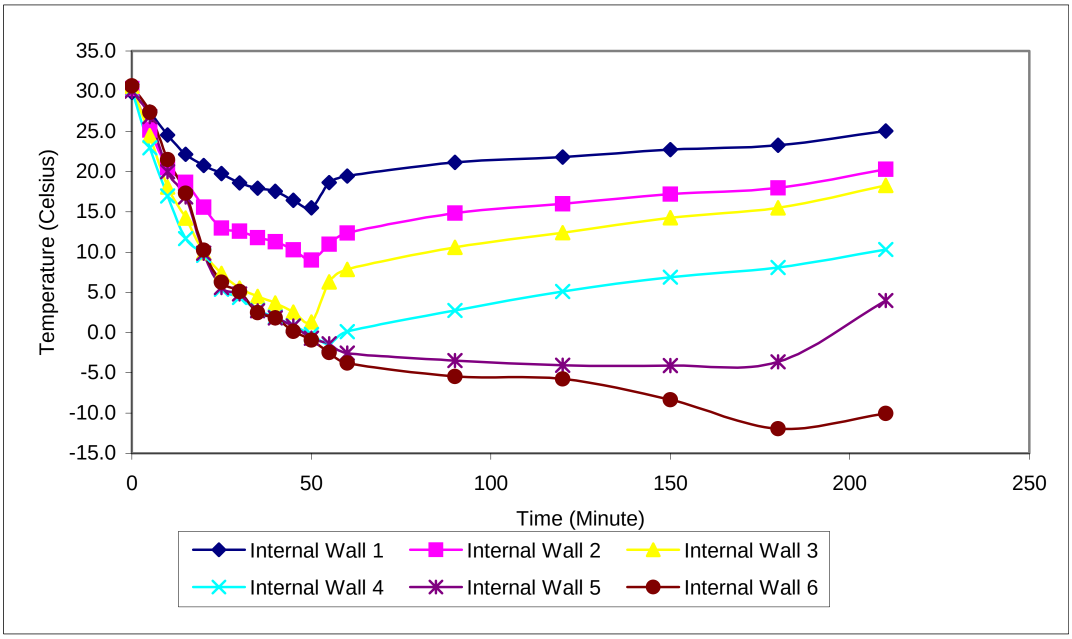


Figure A2: Temperature Profile at Internal Wall of the Cylinder of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

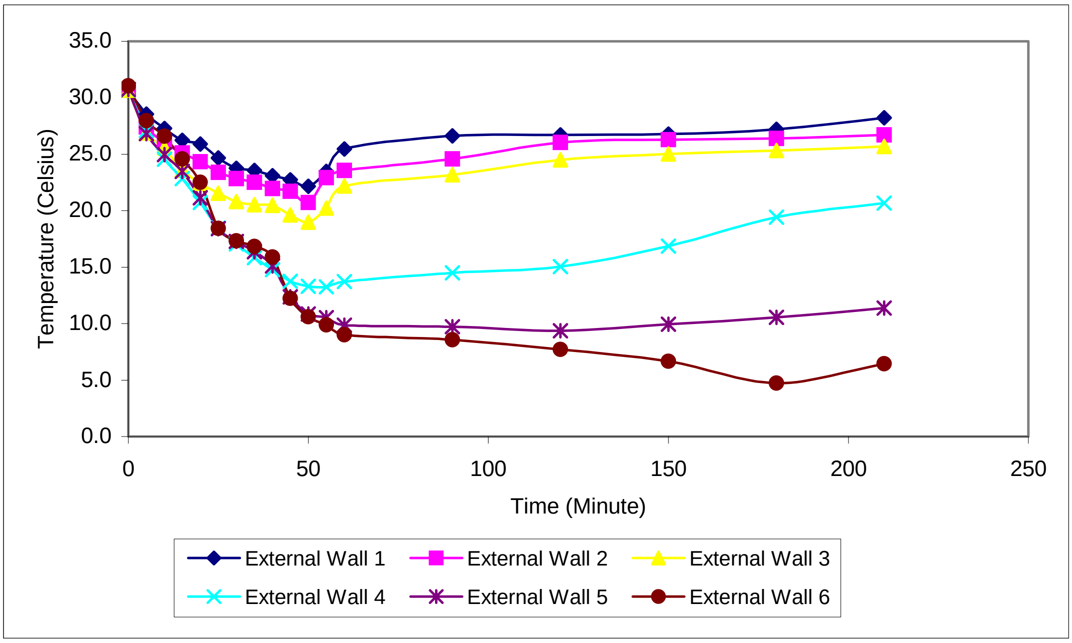


Figure A3: Temperature Profile at External Wall of the Cylinder of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

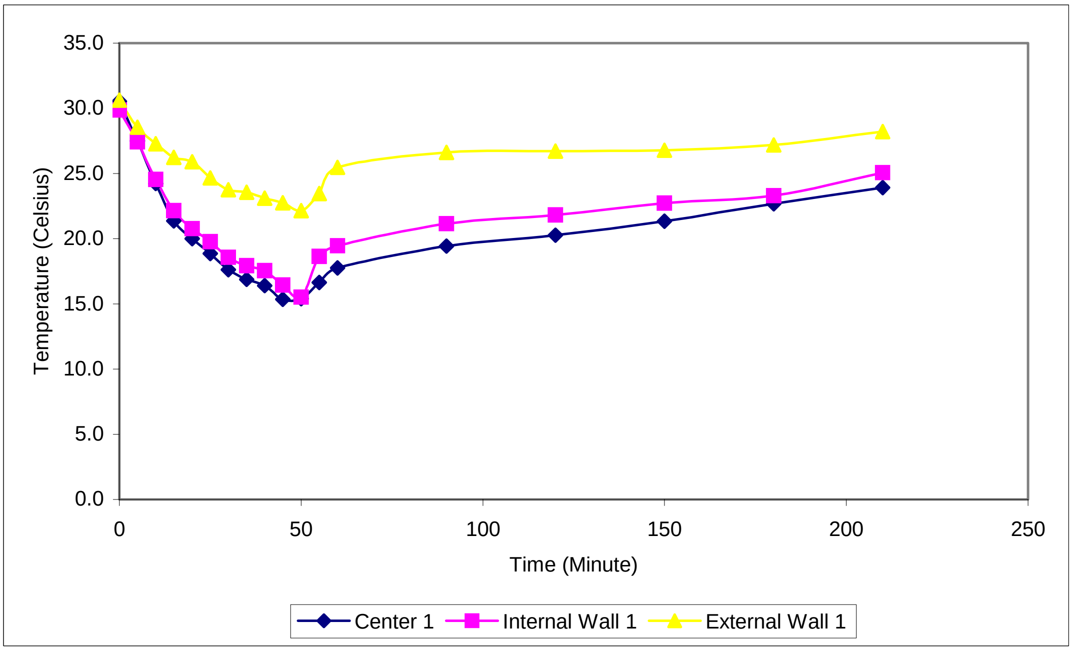


Figure A4: Temperature Profile at Difference Sensor Location of Level 1 Probe of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

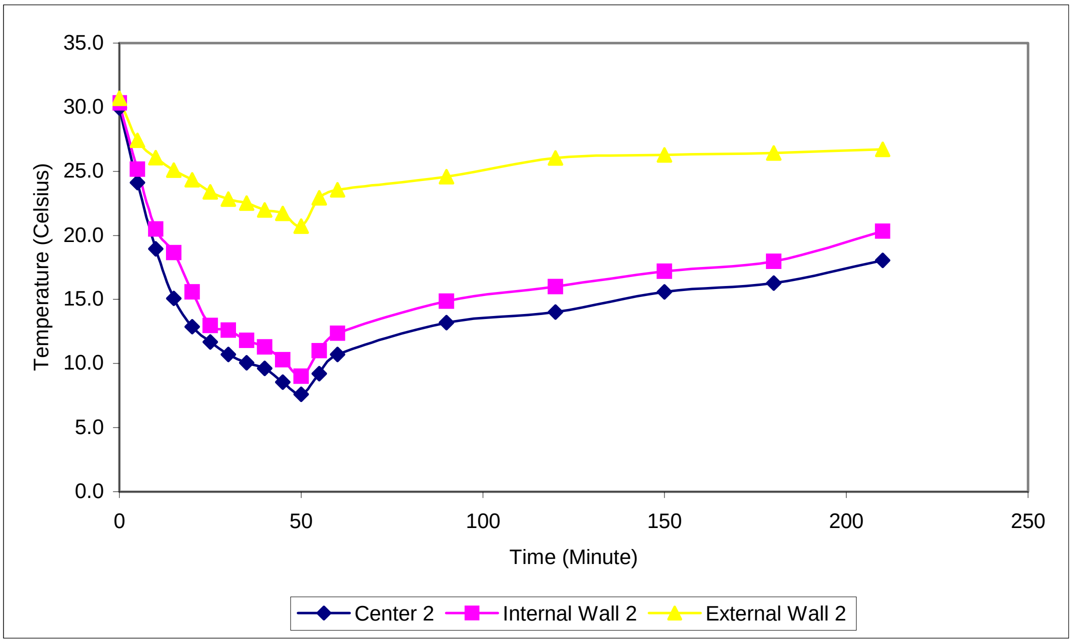


Figure A5: Temperature Profile at Difference Sensor Location of Level 2 Probe of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

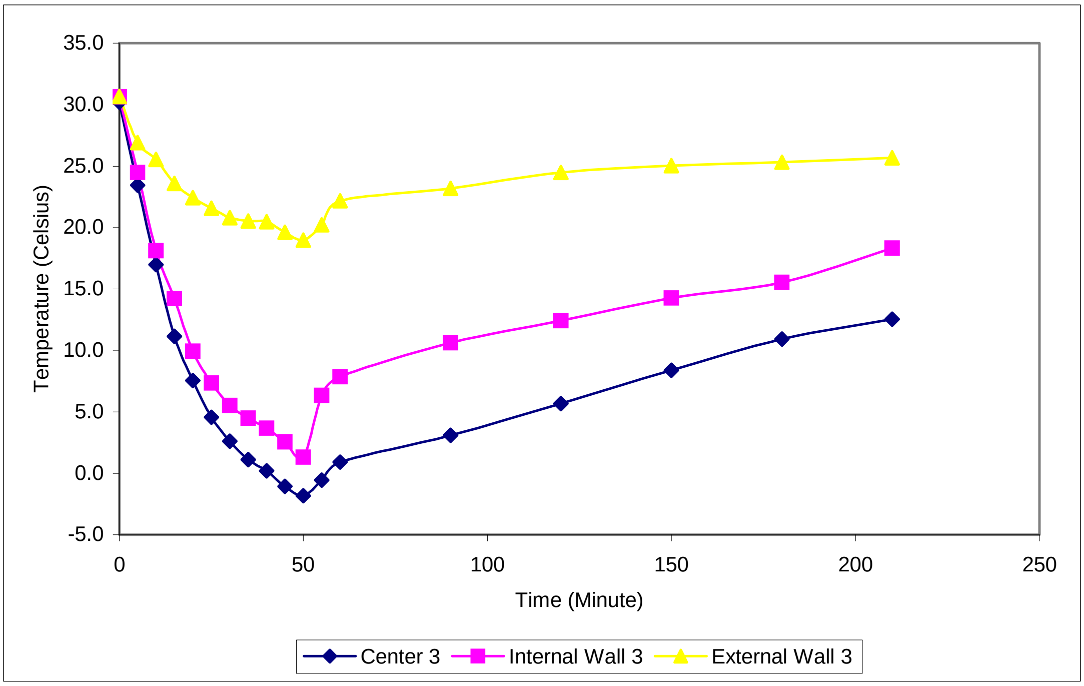


Figure A6: Temperature Profile at Difference Sensor Location of Level 3 Probe of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

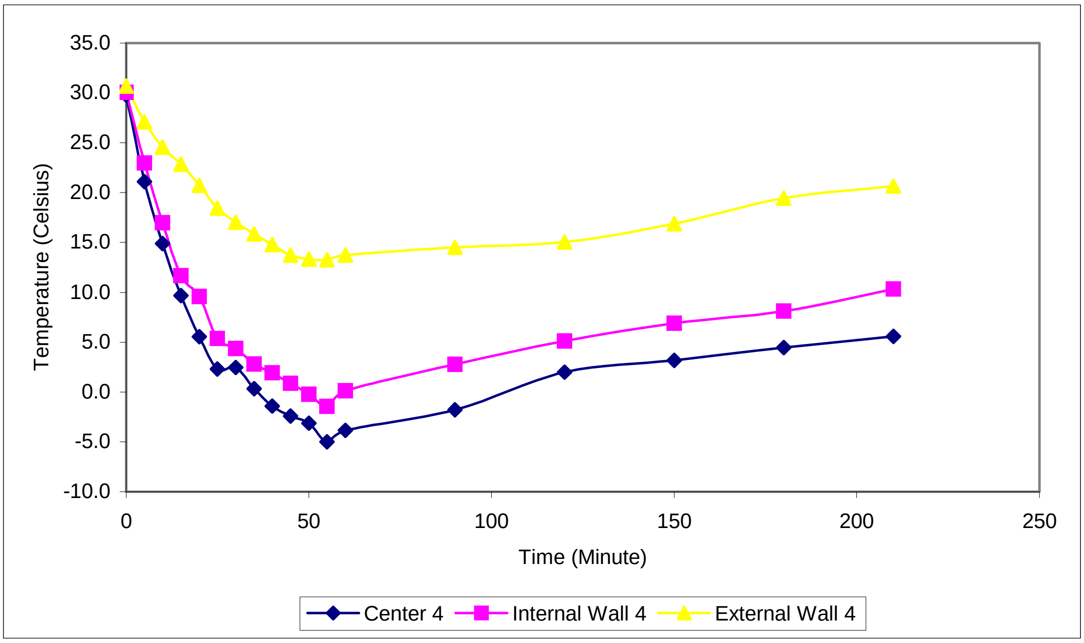


Figure A7: Temperature Profile at Difference Sensor Location of Level 4 Probe of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

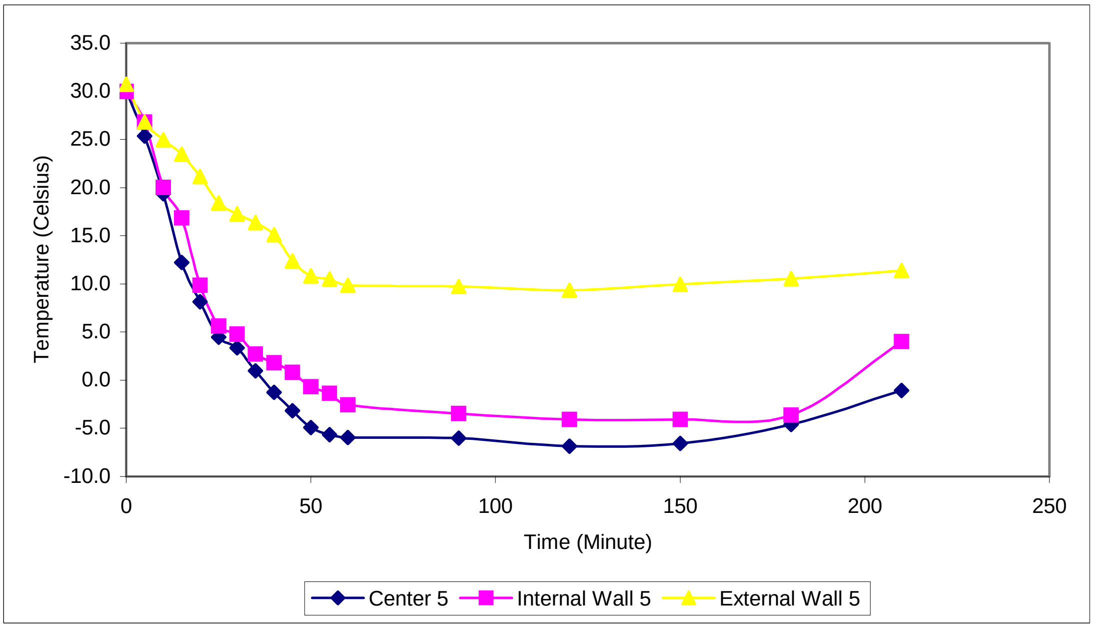


Figure A8: Temperature Profile at Difference Sensor Location of Level 5 Probe of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

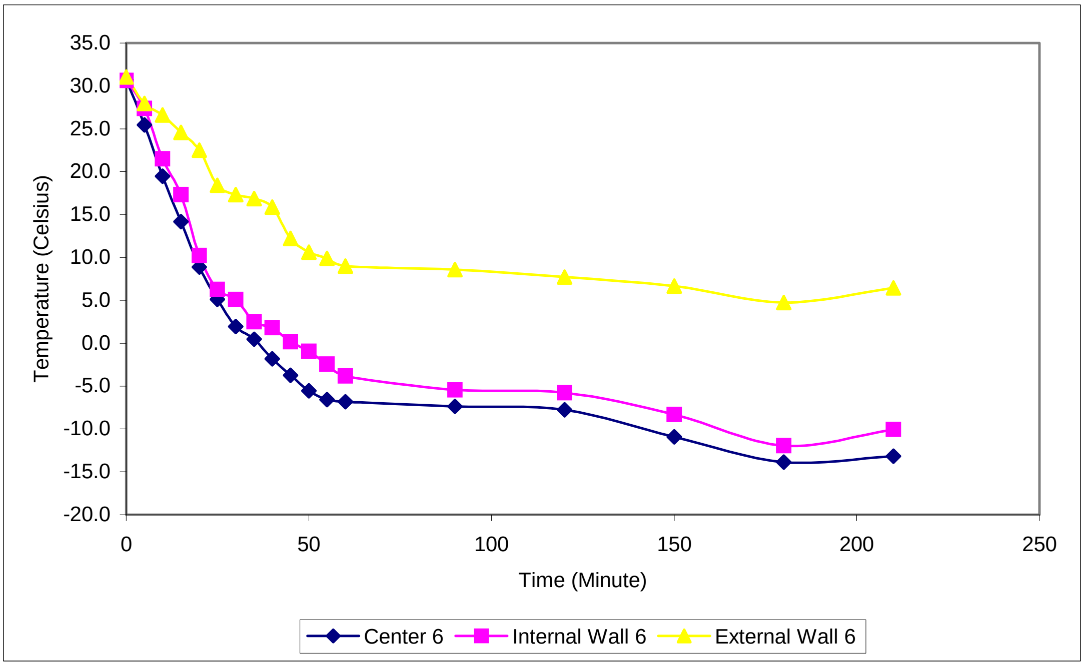


Figure A9: Temperature Profile at Difference Sensor Location of Level 6 Probe of Commercial Propane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

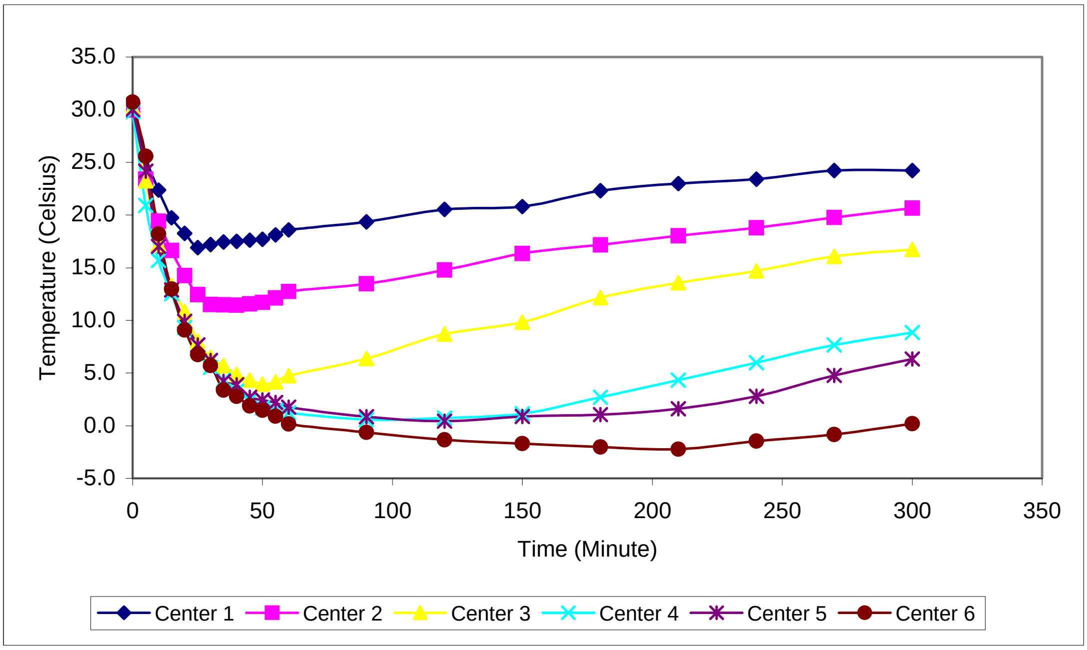


Figure A10: Temperature Profile at Center of the Cylinder of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

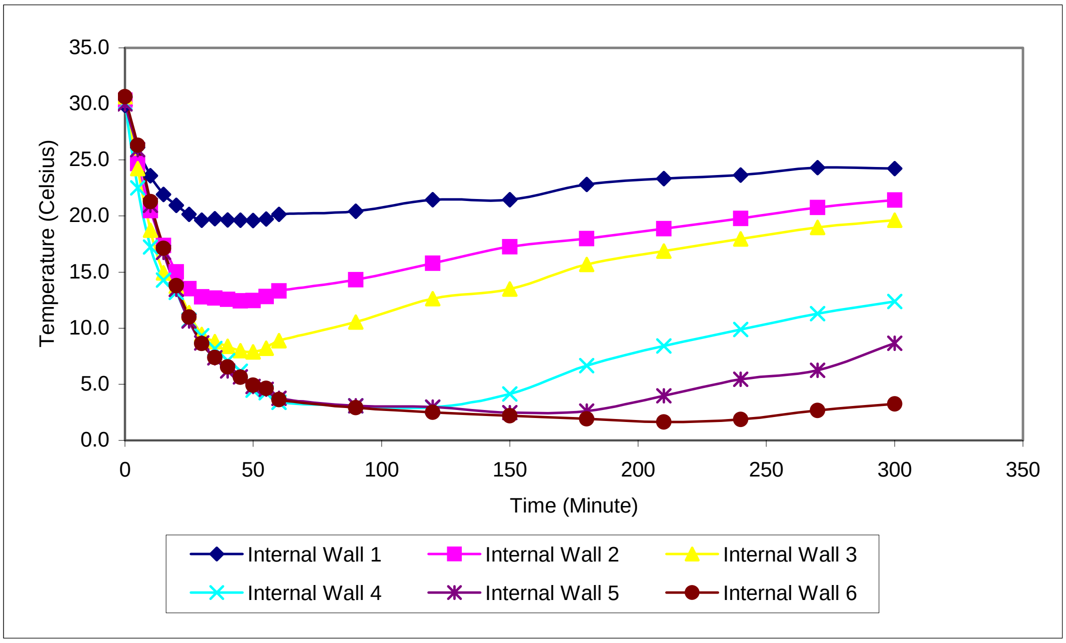


Figure A11: Temperature Profile at Internal Wall of the Cylinder of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

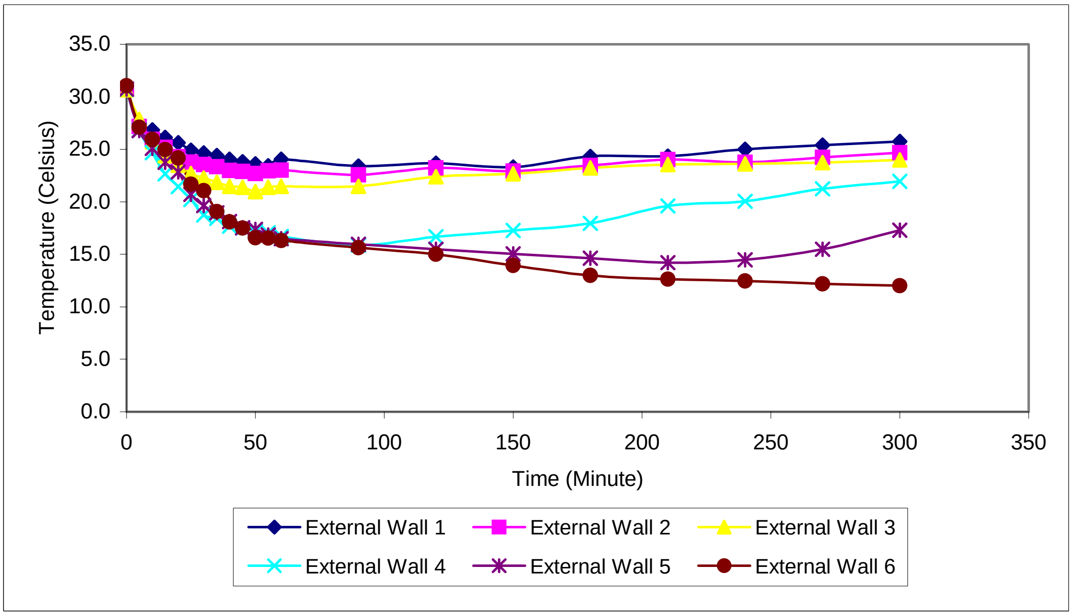


Figure A12: Temperature Profile at External Wall of the Cylinder of Commercial Butane at Flow rate of 48 liter/minute Surrounding Temperature of 30°C and Weight of 6 kg

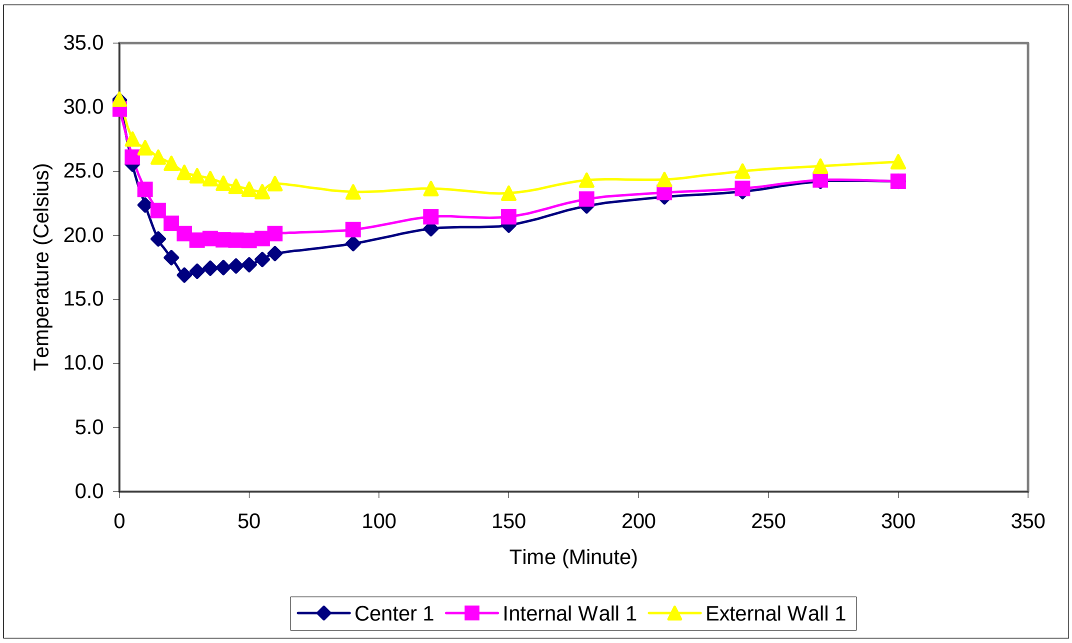


Figure A13: Temperature Profile at Difference Sensor Location of Level 1 Probe of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

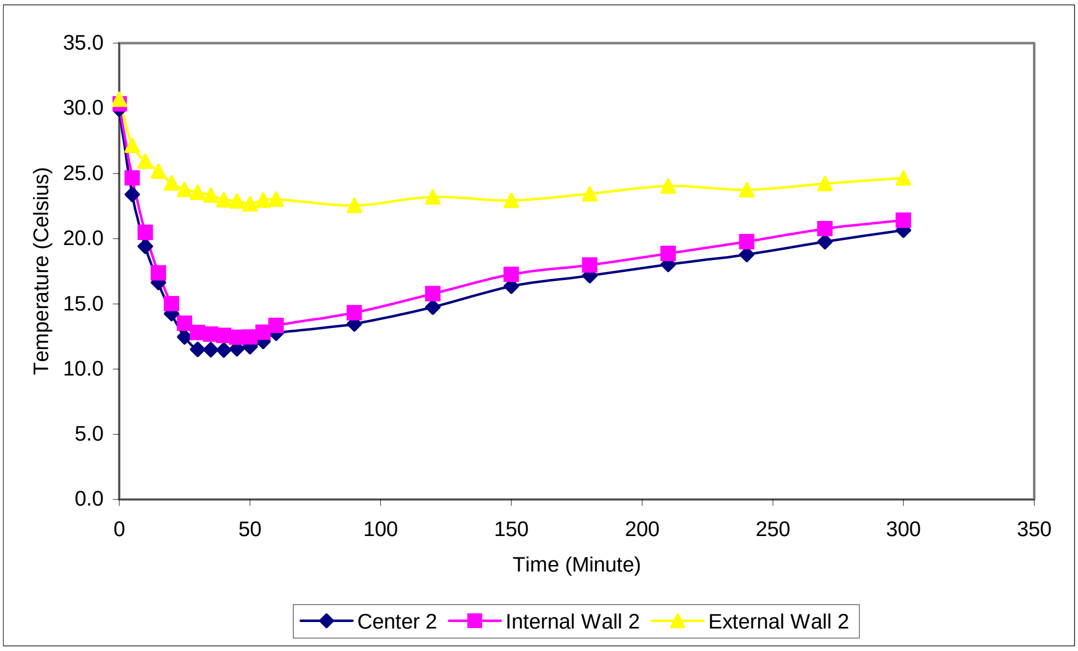


Figure A14: Temperature Profile at Difference Sensor Location of Level 2 Probe of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

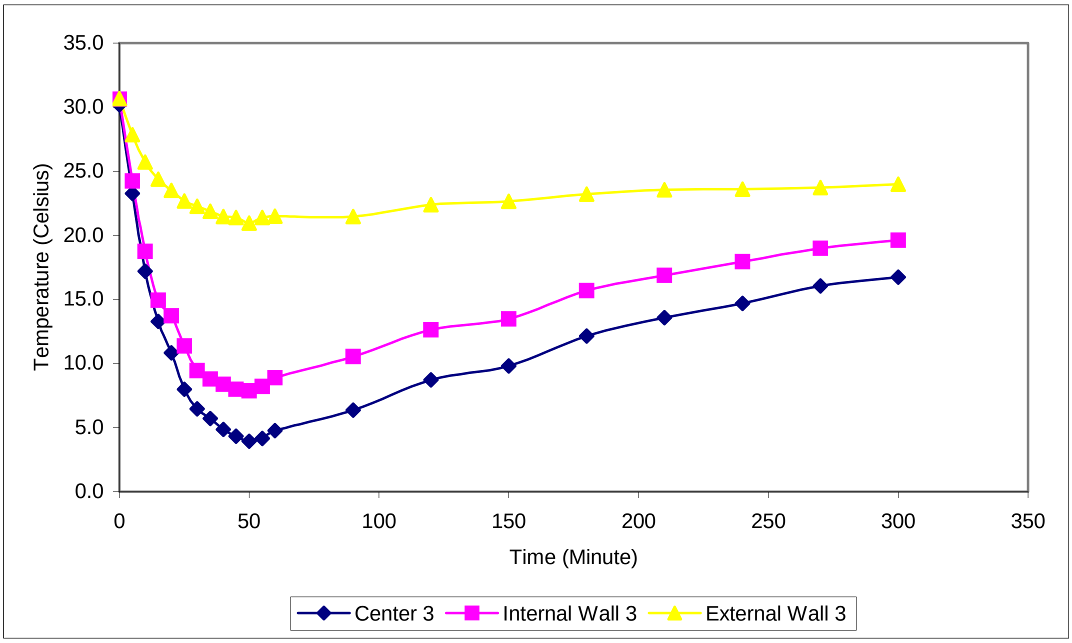


Figure A15: Temperature Profile at Difference Sensor Location of Level 3 Probe of Commercial Butane at Flow rate of 48 liter/minute Surrounding Temperature of 30^{o}C and Weight of 6 kg

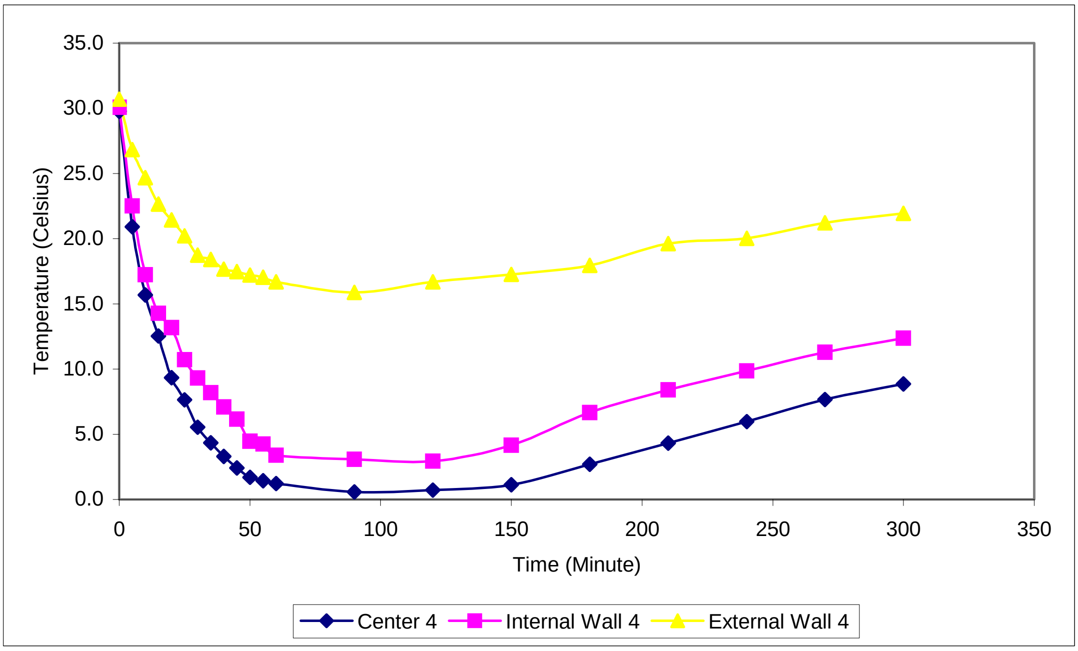


Figure A16: Temperature Profile at Difference Sensor Location of Level 4 Probe of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

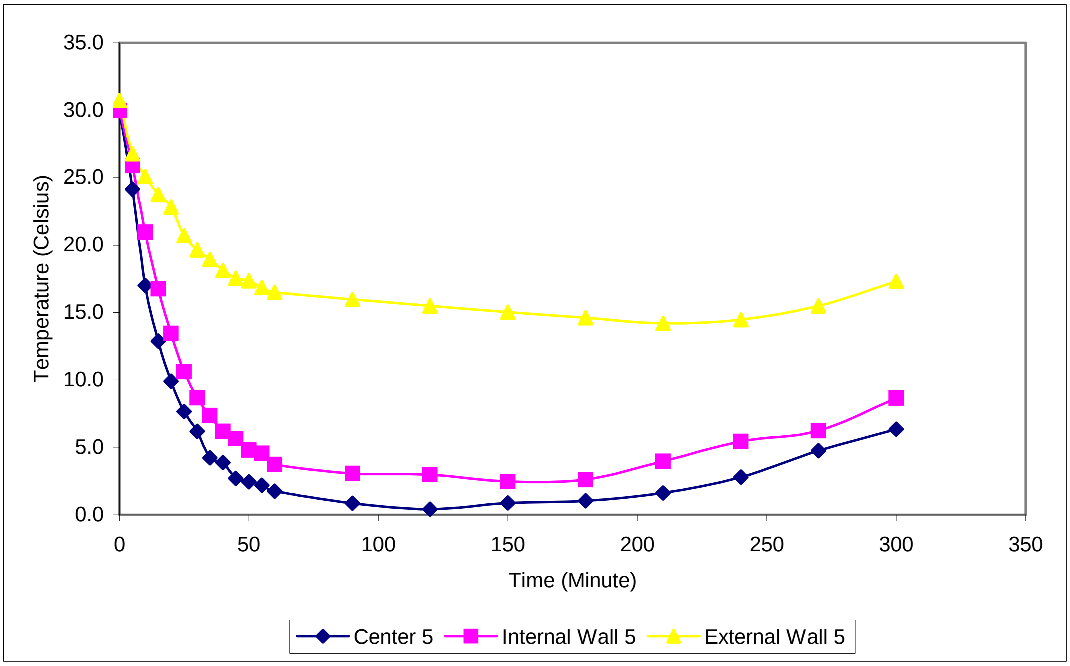


Figure A17: Temperature Profile at Difference Sensor Location of Level 5 Probe of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

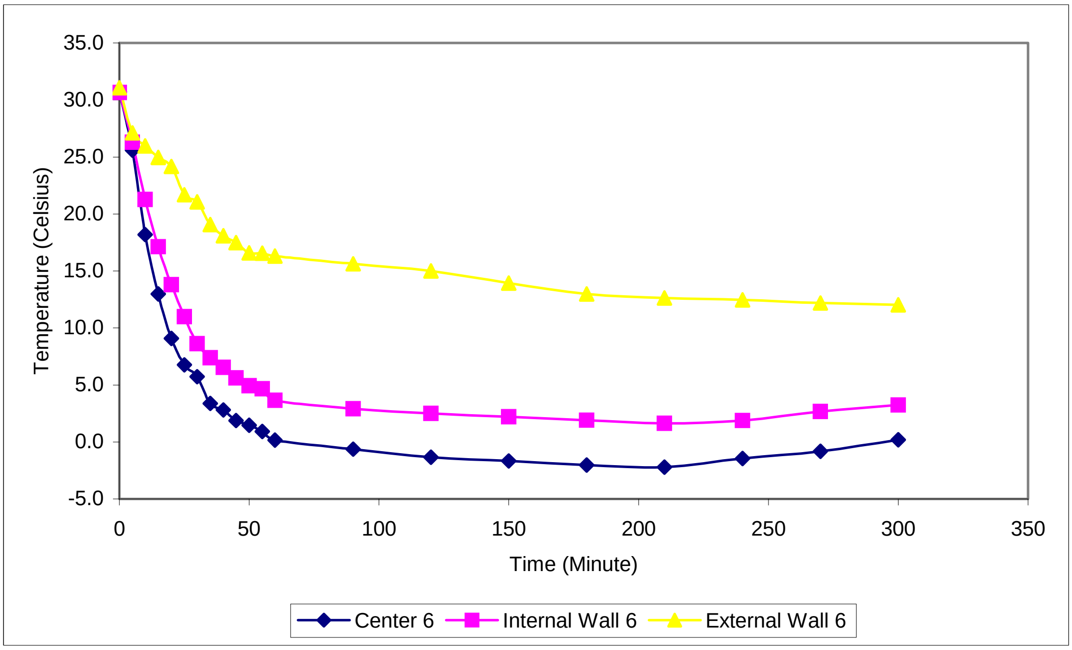


Figure A18: Temperature Profile at Difference Sensor Location of Level 6 Probe of Commercial Butane at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

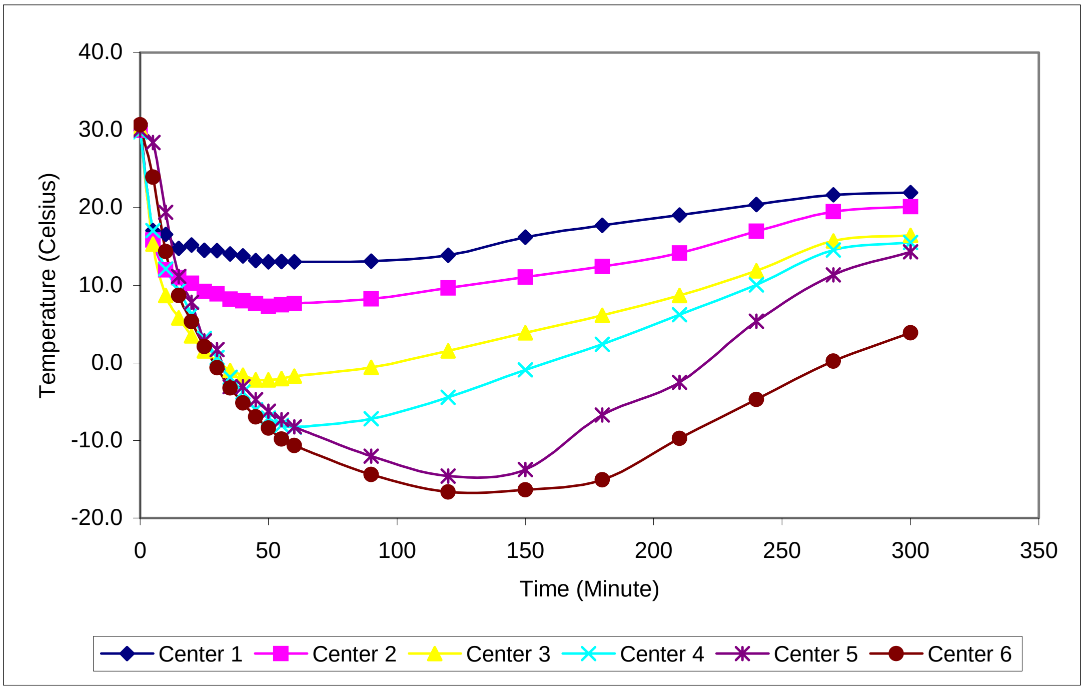


Figure A19: Temperature Profile at Center of the Cylinder of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

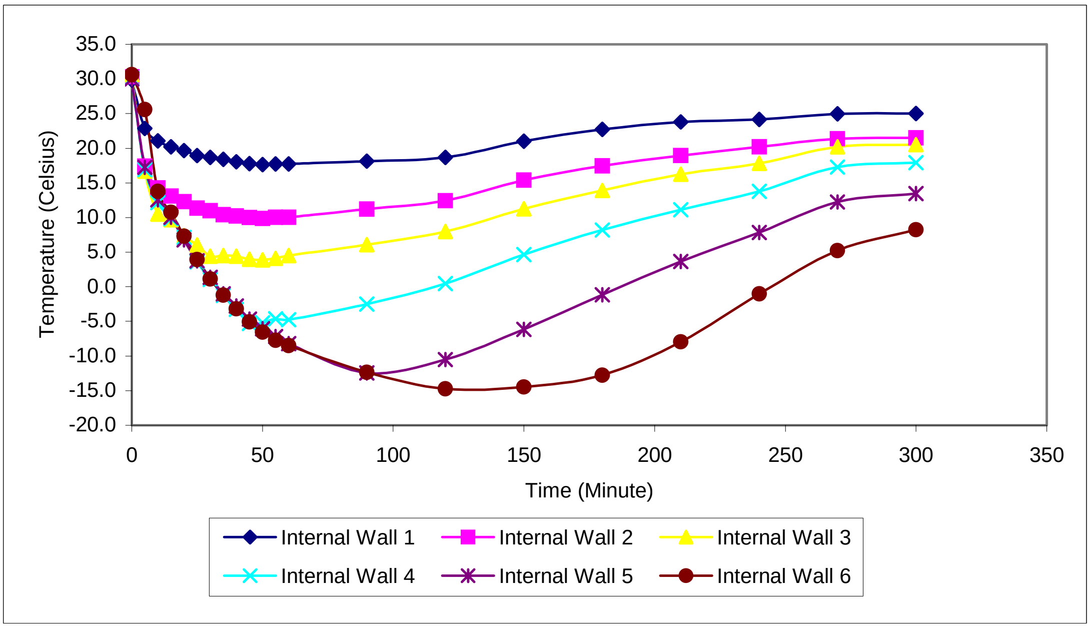


Figure A20: Temperature Profile at Internal Wall of the Cylinder of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

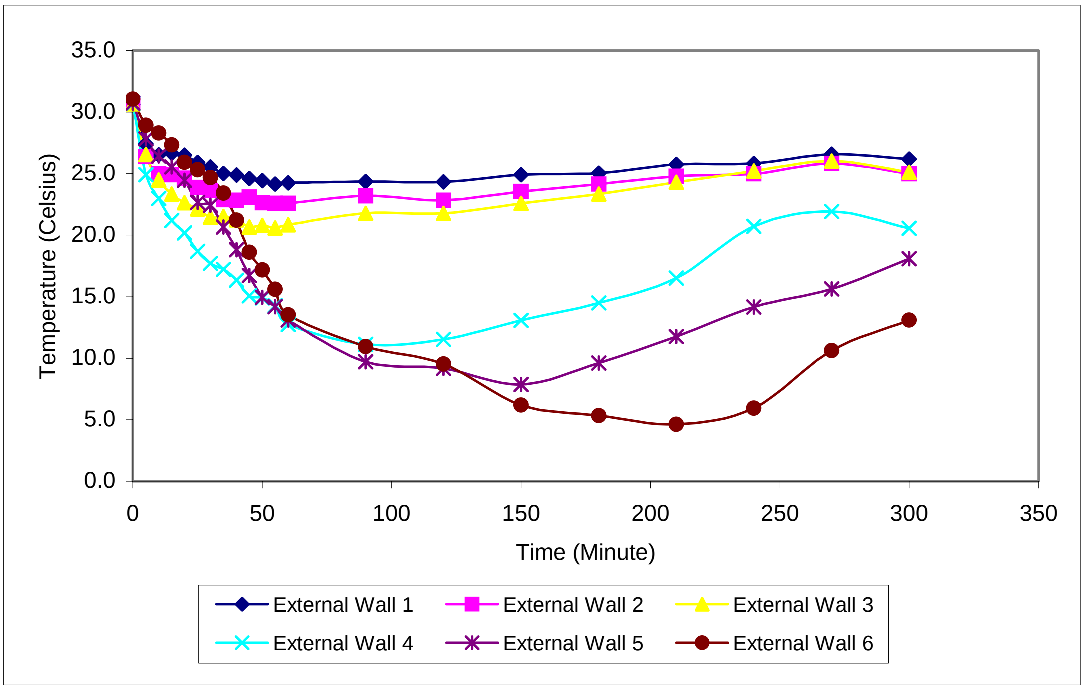


Figure A21: Temperature Profile at External Wall of the Cylinder of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

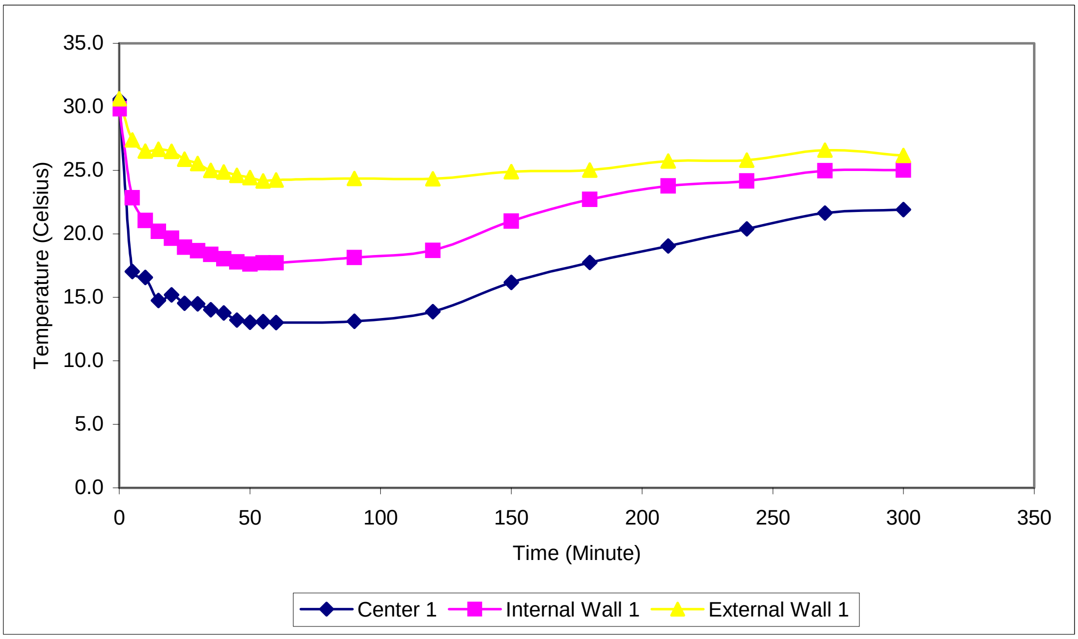


Figure A22: Temperature Profile at Difference Sensor Location of Level 1 Probe of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

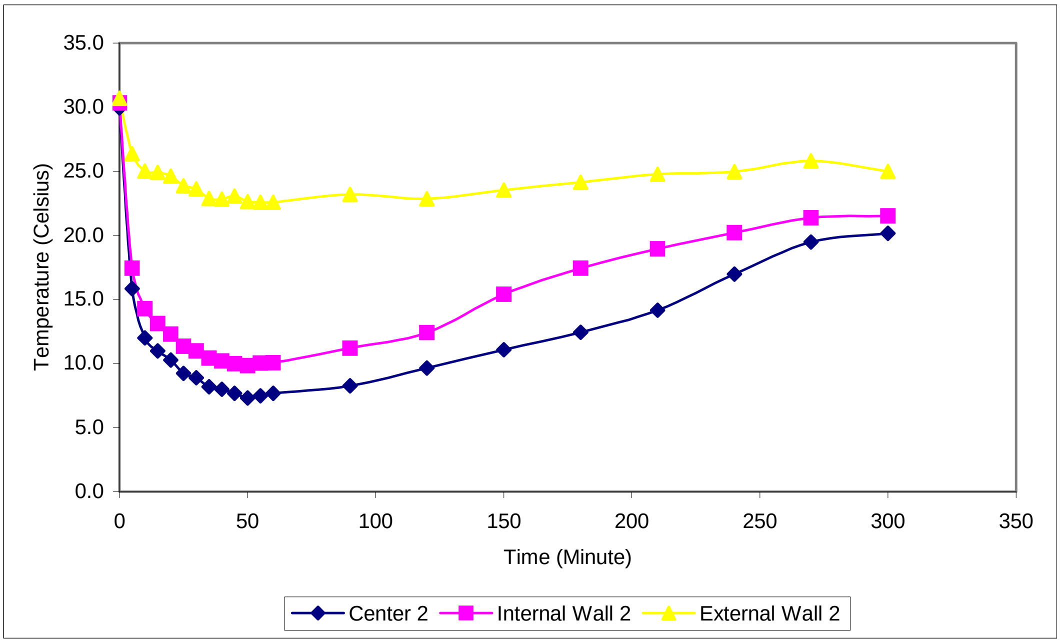


Figure A23: Temperature Profile at Difference Sensor Location of Level 2 Probe of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

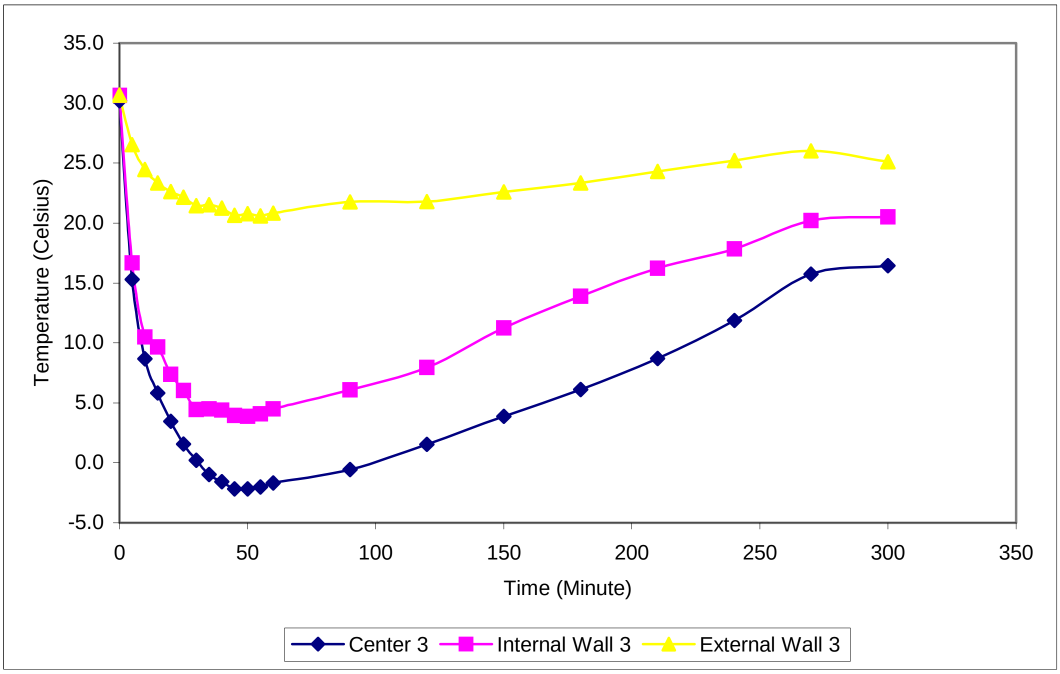


Figure A24: Temperature Profile at Difference Sensor Location of Level 3 Probe of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

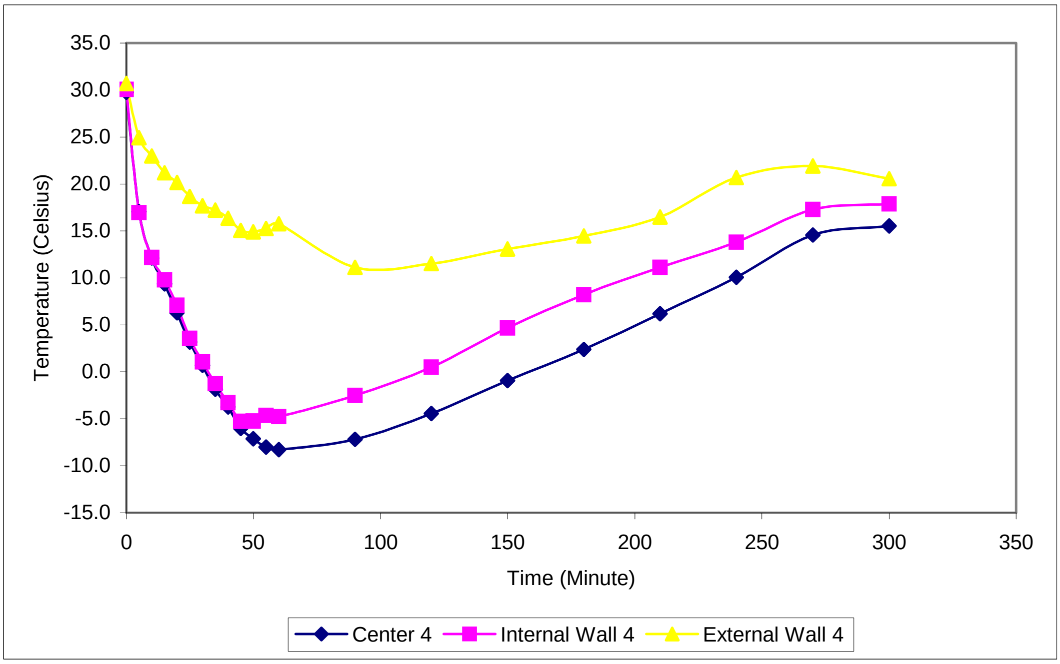


Figure A25: Temperature Profile at Difference Sensor Location of Level 4 Probe of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

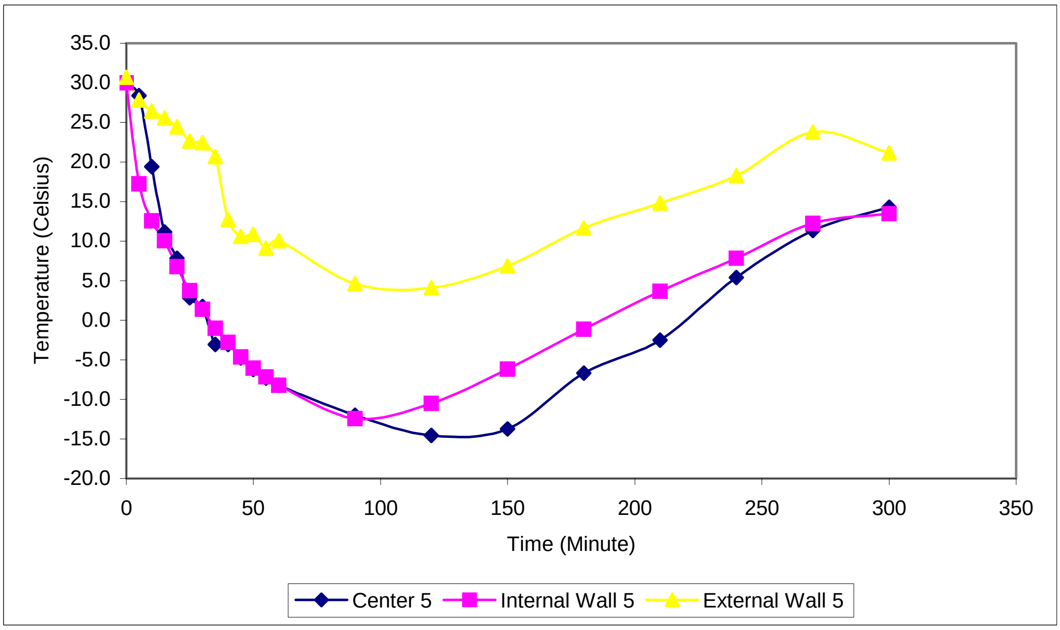


Figure A26: Temperature Profile at Difference Sensor Location of Level 5 Probe of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

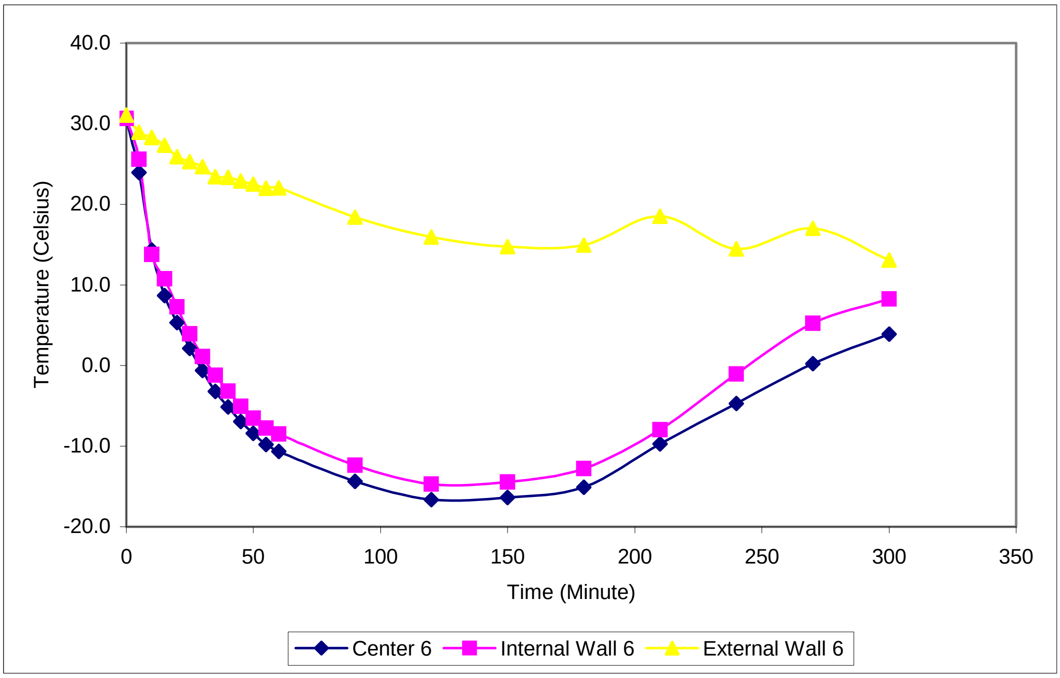


Figure A27: Temperature Profile at Difference Sensor Location of Level 6 Probe of 8020 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

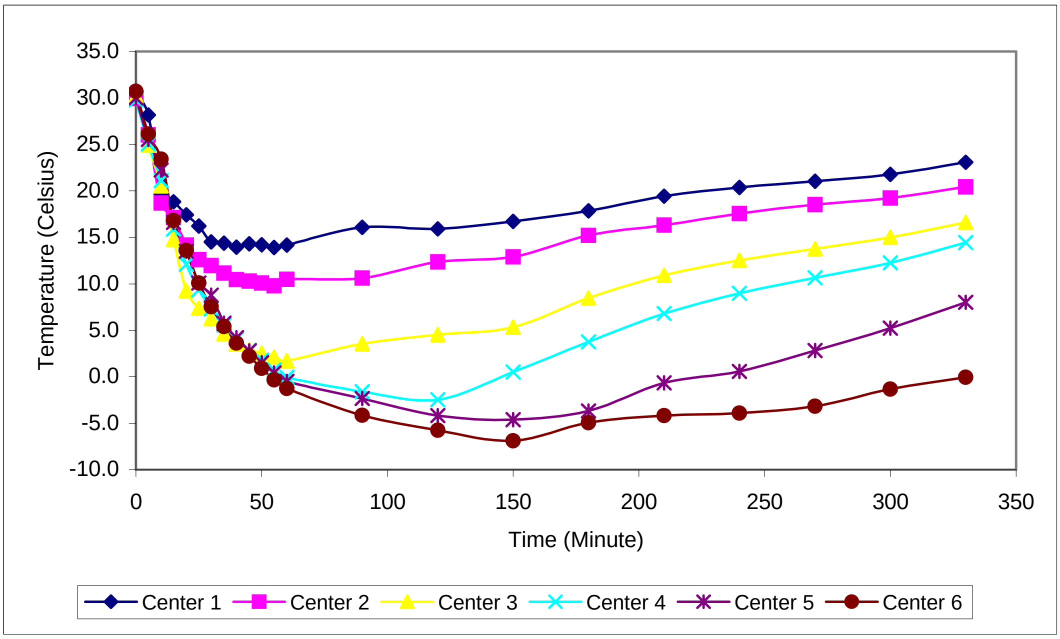


Figure A28: Temperature Profile at Center of the Cylinder of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

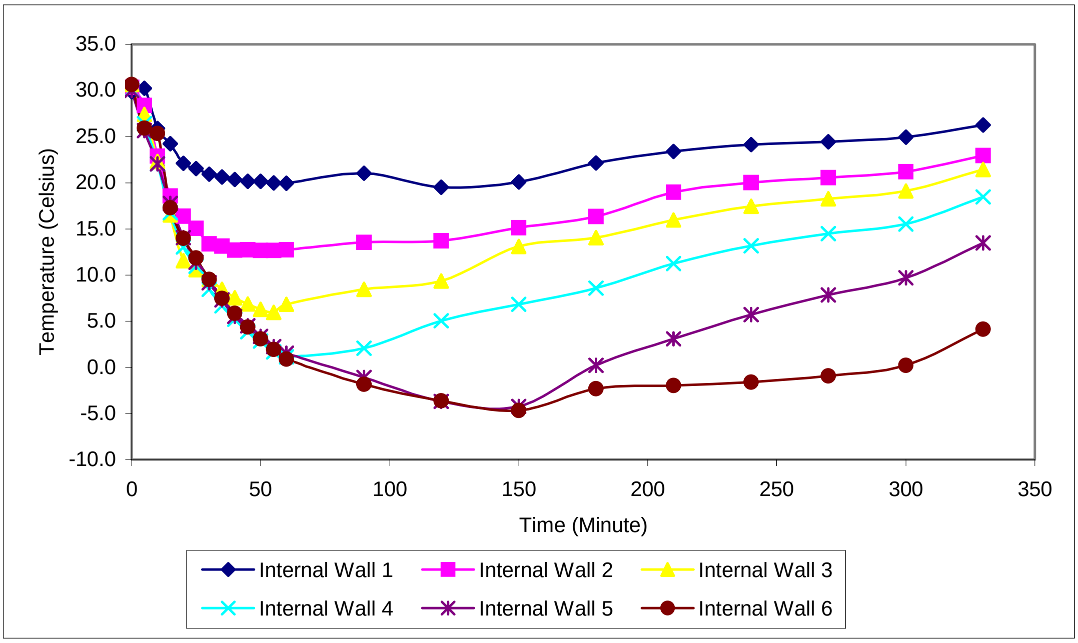


Figure A29: Temperature Profile at Internal Wall of the Cylinder of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

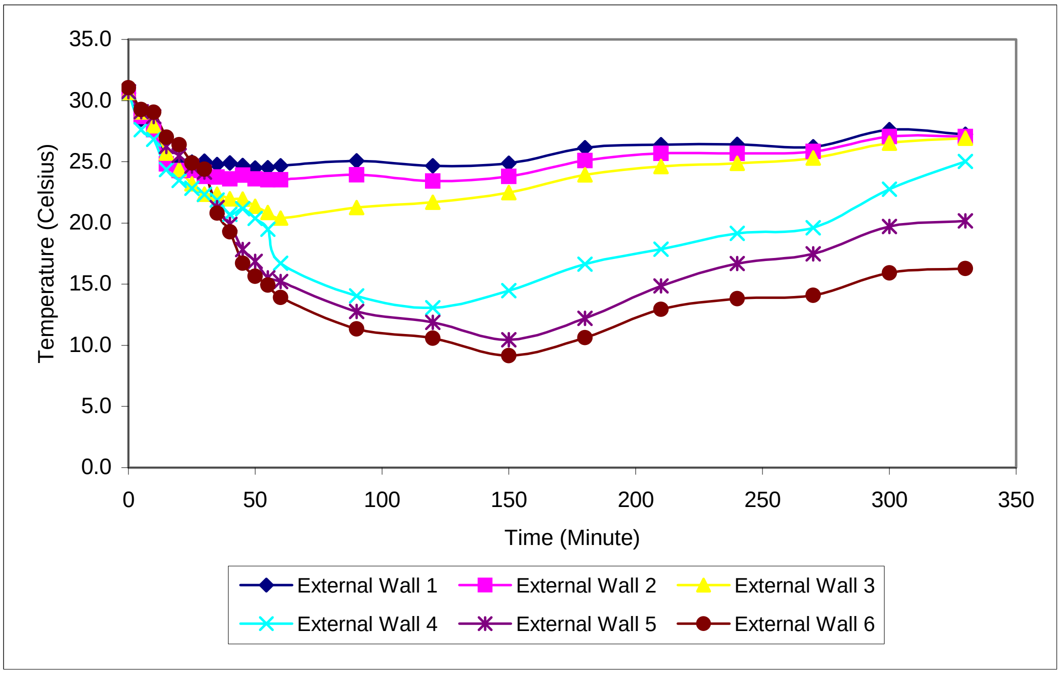


Figure A30: Temperature Profile at External Wall of the Cylinder of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

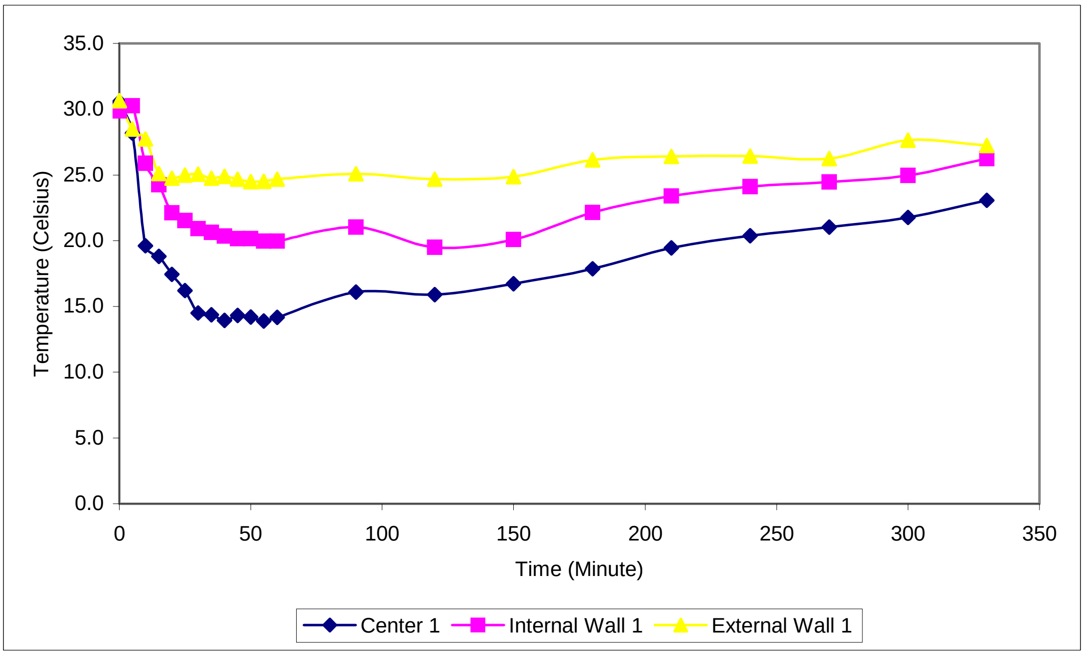


Figure A31: Temperature Profile at Difference Sensor Location of Level 1 Probe of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

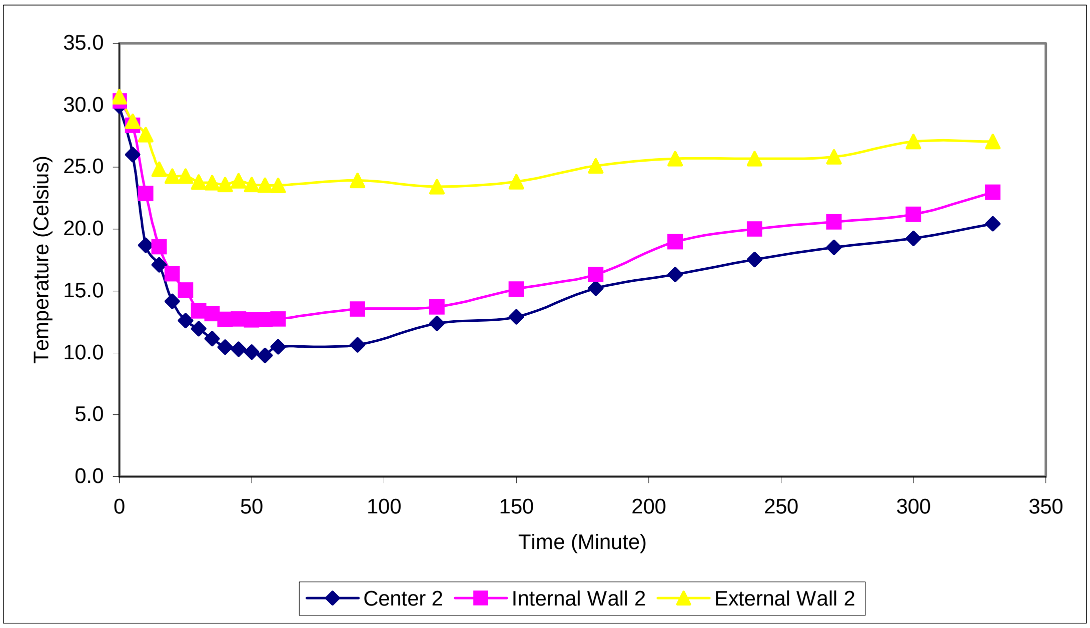


Figure A32: Temperature Profile at Difference Sensor Location of Level 2 Probe of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

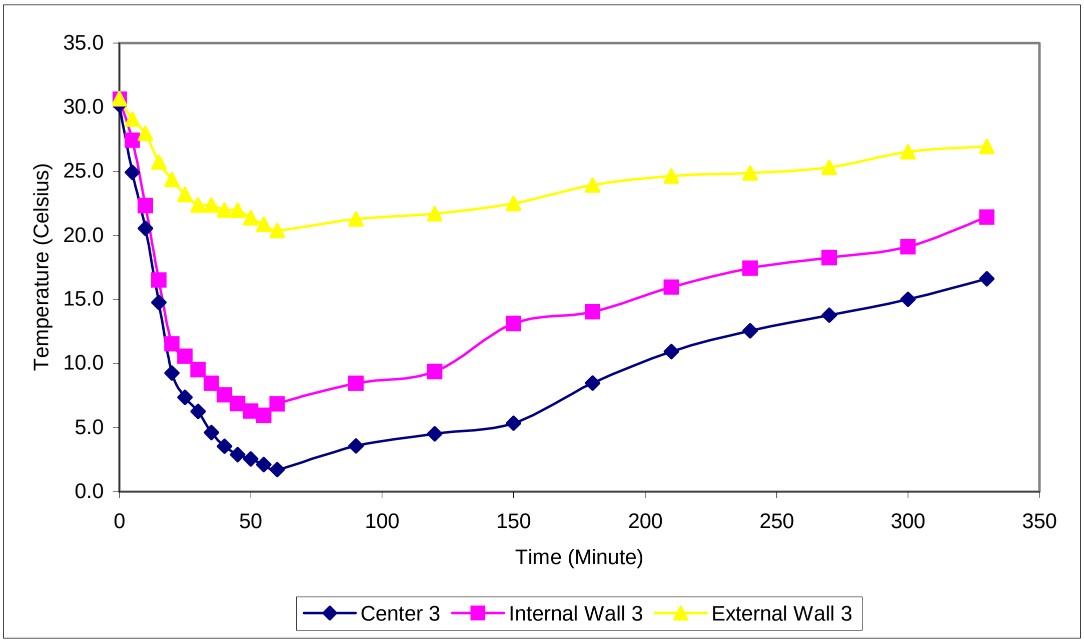


Figure A33: Temperature Profile at Difference Sensor Location of Level 3 Probe of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

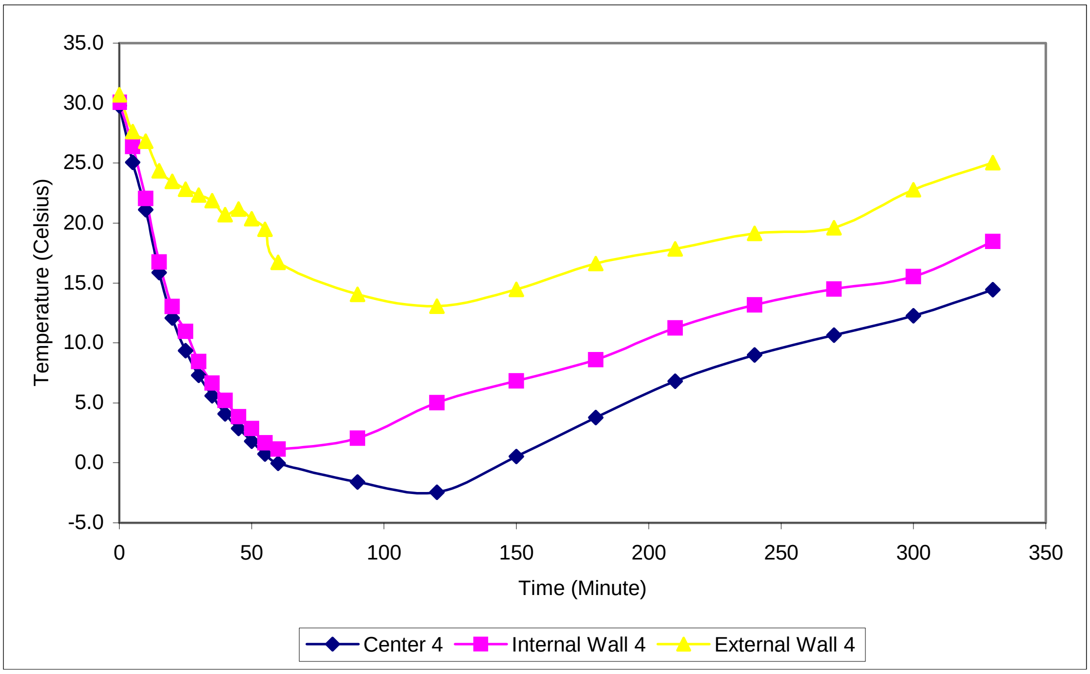


Figure A34: Temperature Profile at Difference Sensor Location of Level 4 Probe of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

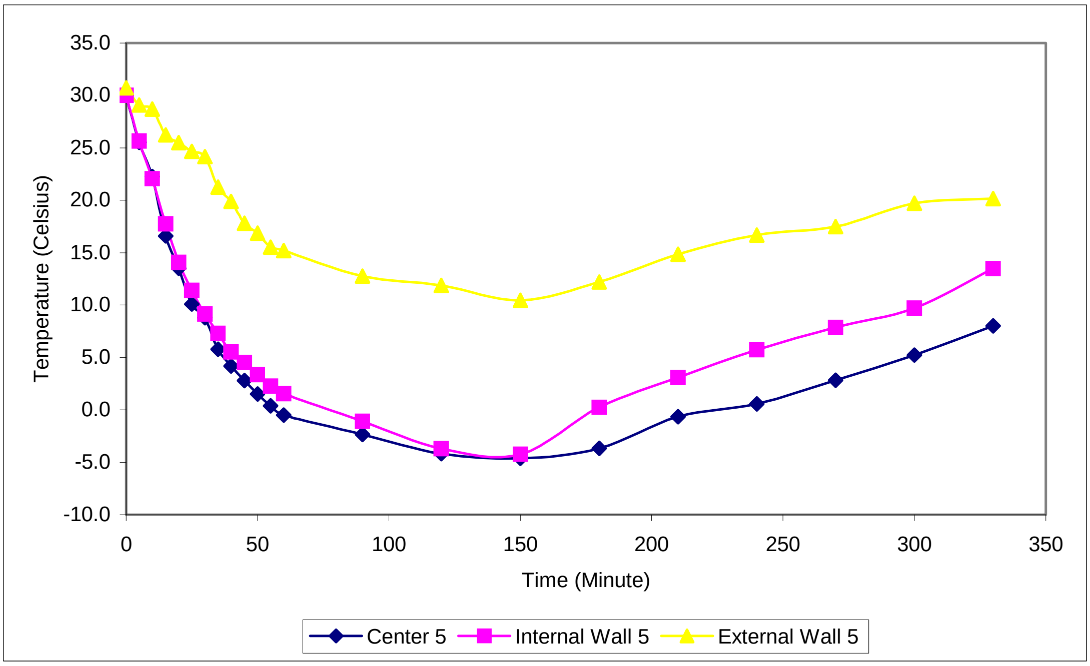


Figure A35: Temperature Profile at Difference Sensor Location of Level 5 Probe of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

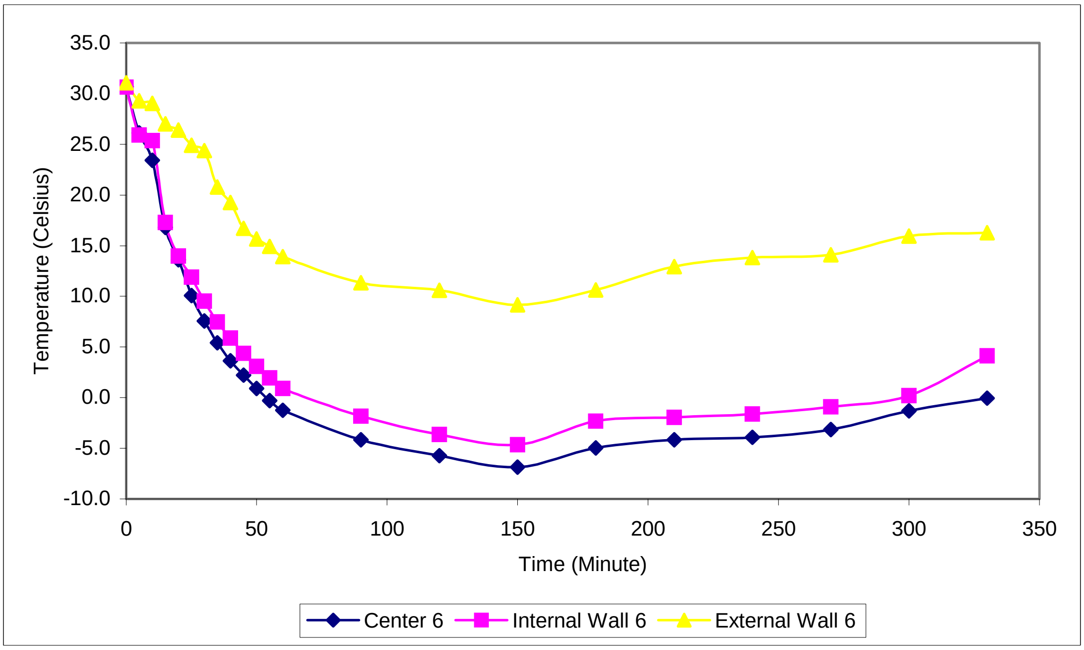


Figure A36: Temperature Profile at Difference Sensor Location of Level 6 Probe of 6040 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30°C and Weight of 6 kg

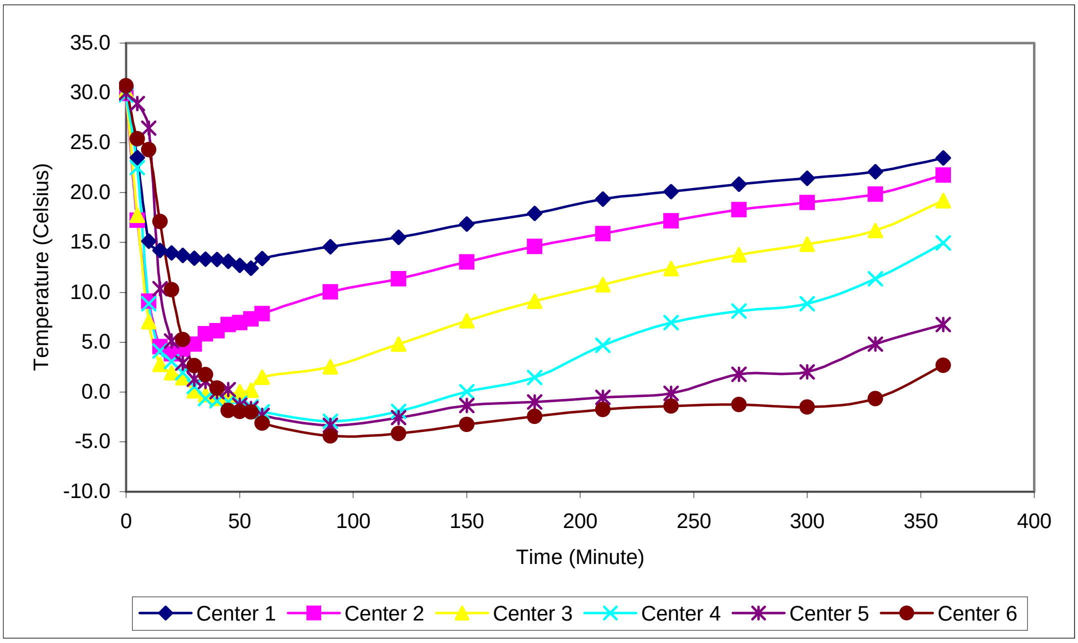


Figure A37: Temperature Profile at Center of the Cylinder of 4060 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

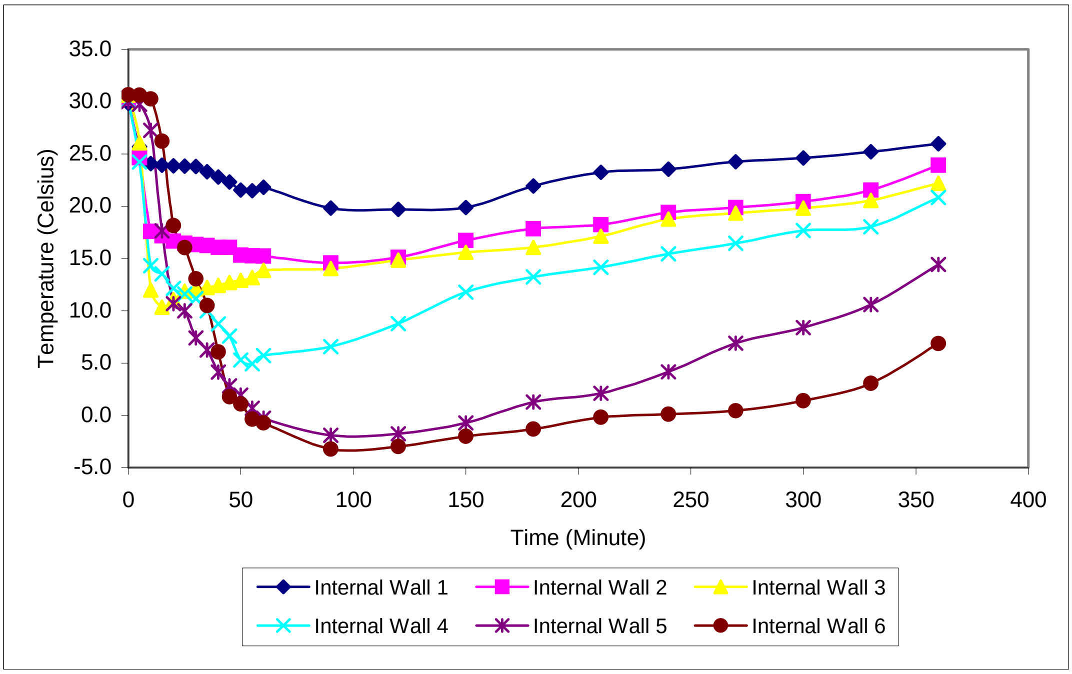


Figure A38: Temperature Profile at Internal Wall of the Cylinder of 4060 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

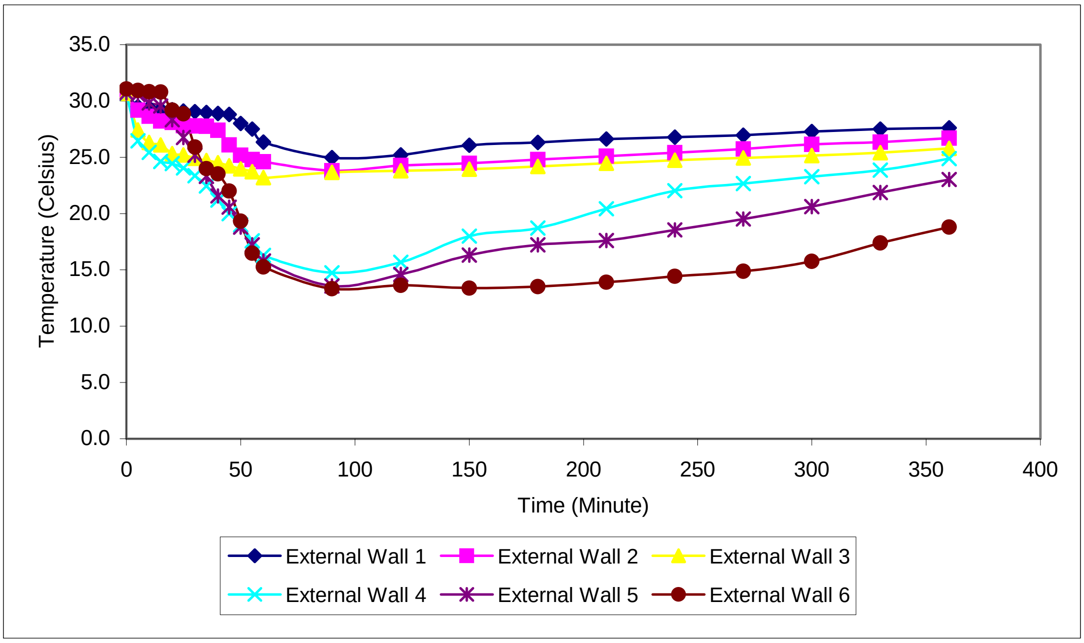


Figure A39: Temperature Profile at External Wall of the Cylinder of 4060 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

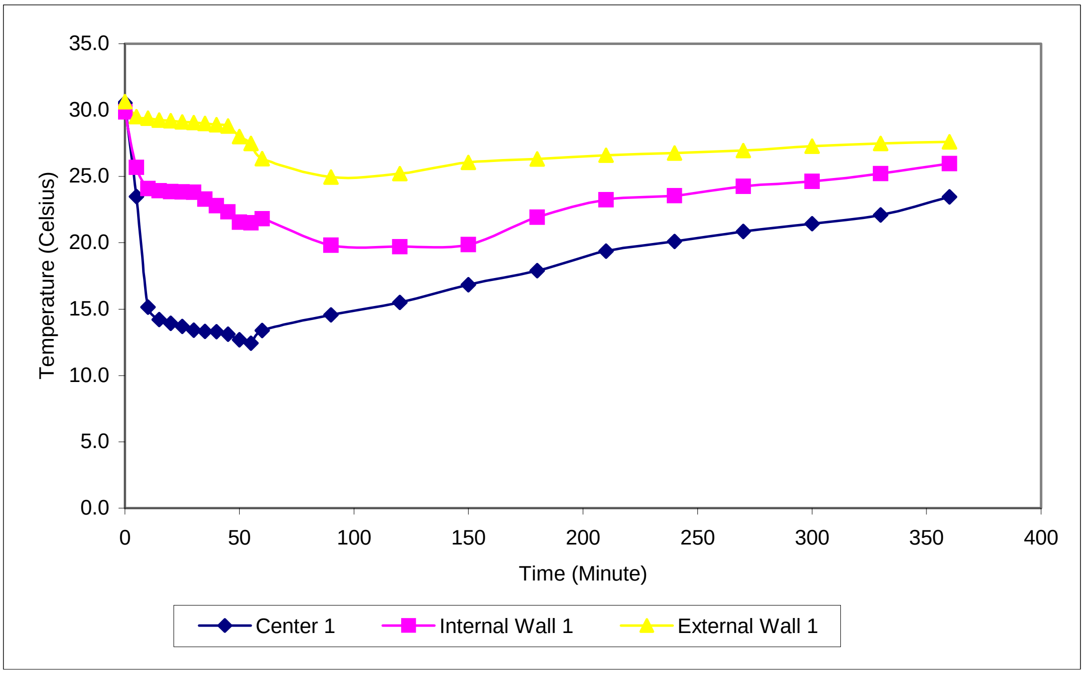


Figure A40: Temperature Profile at Difference Sensor Location of Level 1 Probe of 4060 Composition at Flow rate of 48 liter/minute Surrounding Temperature of 30^{o}C and Weight of 6 kg

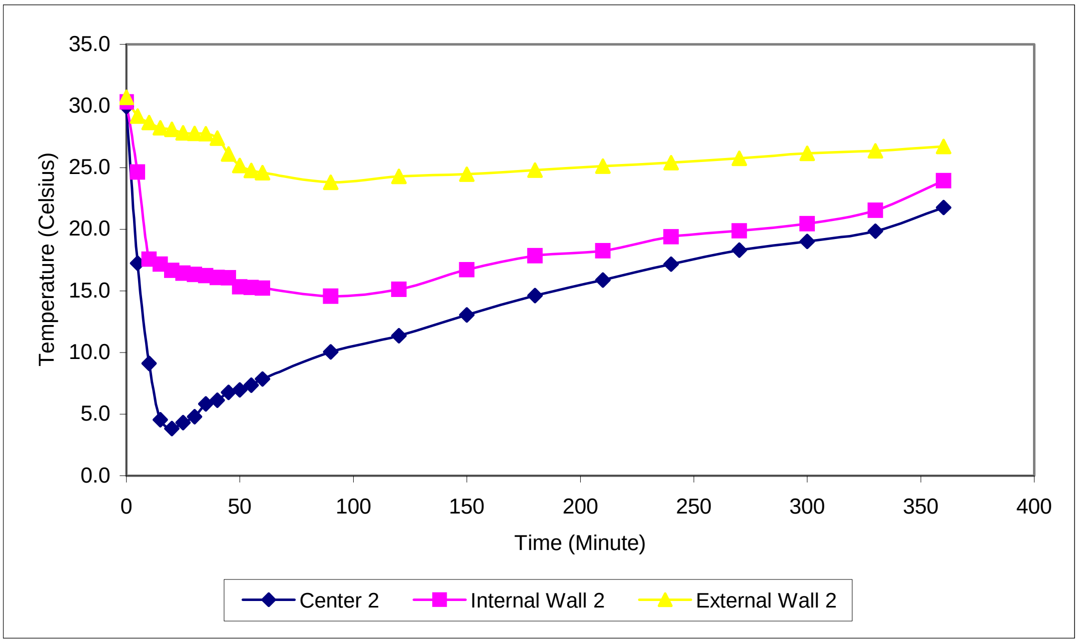


Figure A41: Temperature Profile at Difference Sensor Location of Level 2 Probe of 4060 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

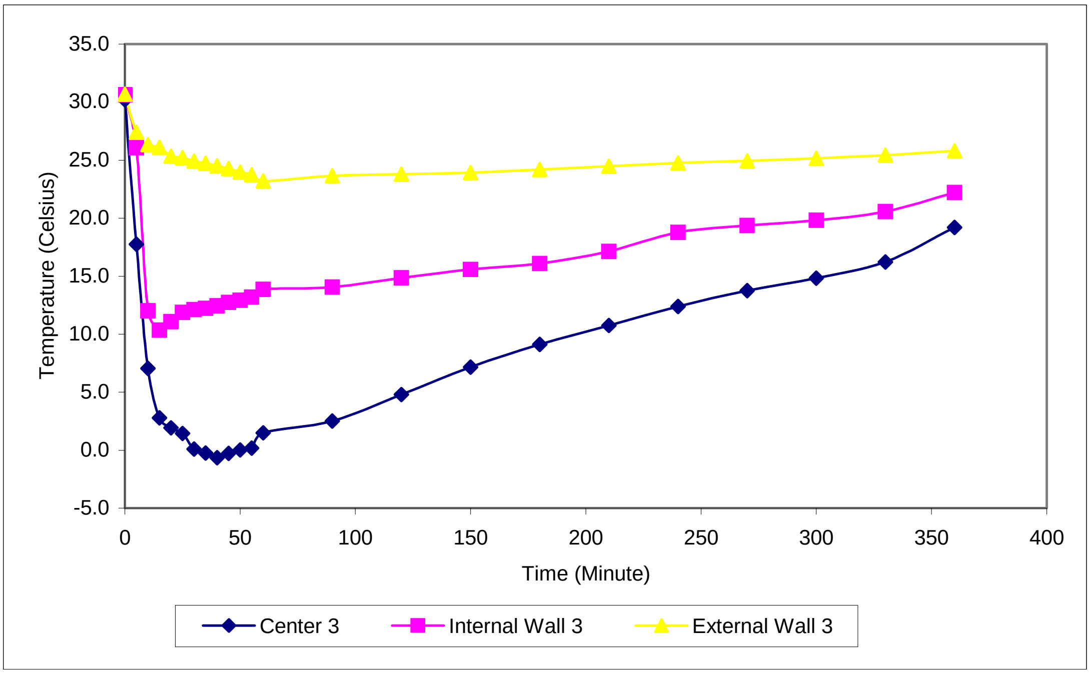


Figure A42: Temperature Profile at Difference Sensor Location of Level 3 Probe of 4060 Composition at Flow rate of 48 liter/minute Surrounding Temperature of 30^{o}C and Weight of 6 kg

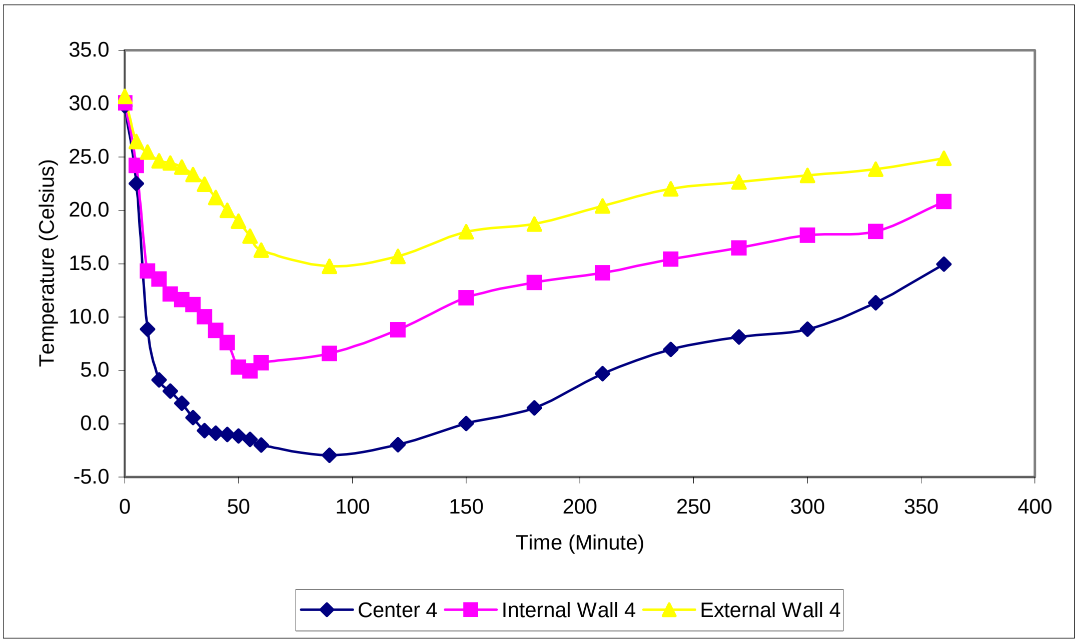


Figure A43: Temperature Profile at Difference Sensor Location of Level 4 Probe of 4060 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

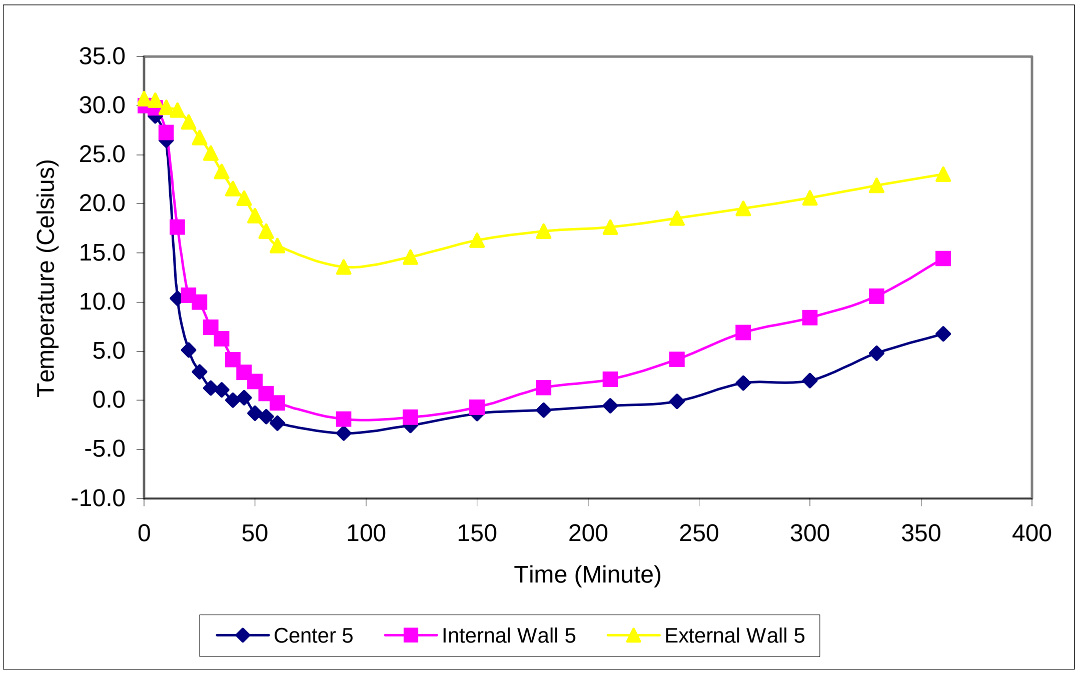


Figure A44: Temperature Profile at Difference Sensor Location of Level 5 Probe of 4060 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

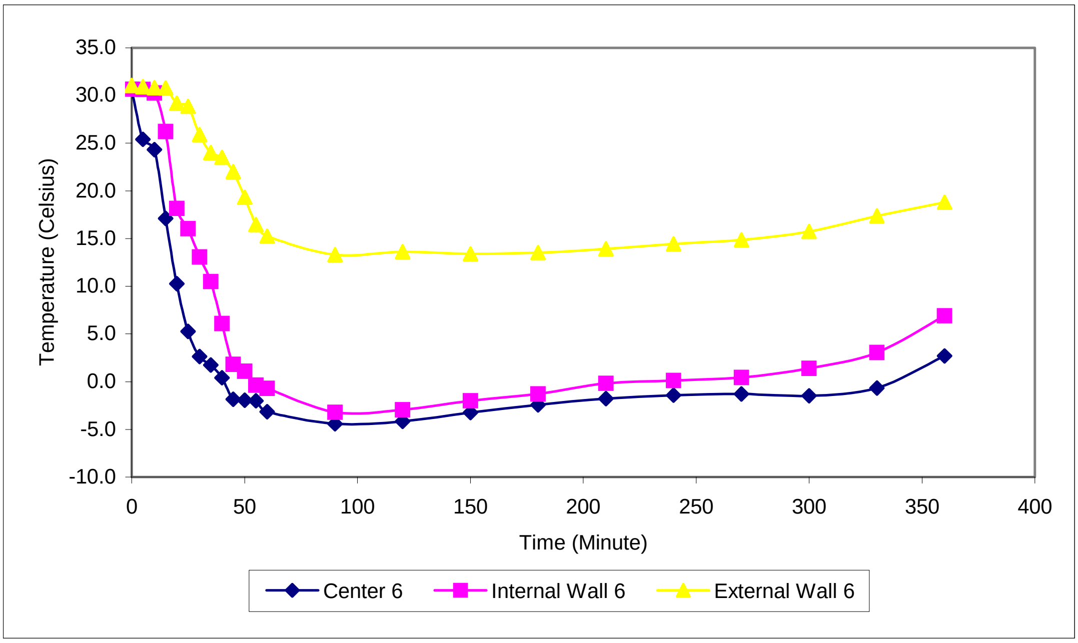


Figure A45: Temperature Profile at Difference Sensor Location of Level 6 Probe of 4060 Composition at Flow rate of 48 liter/minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

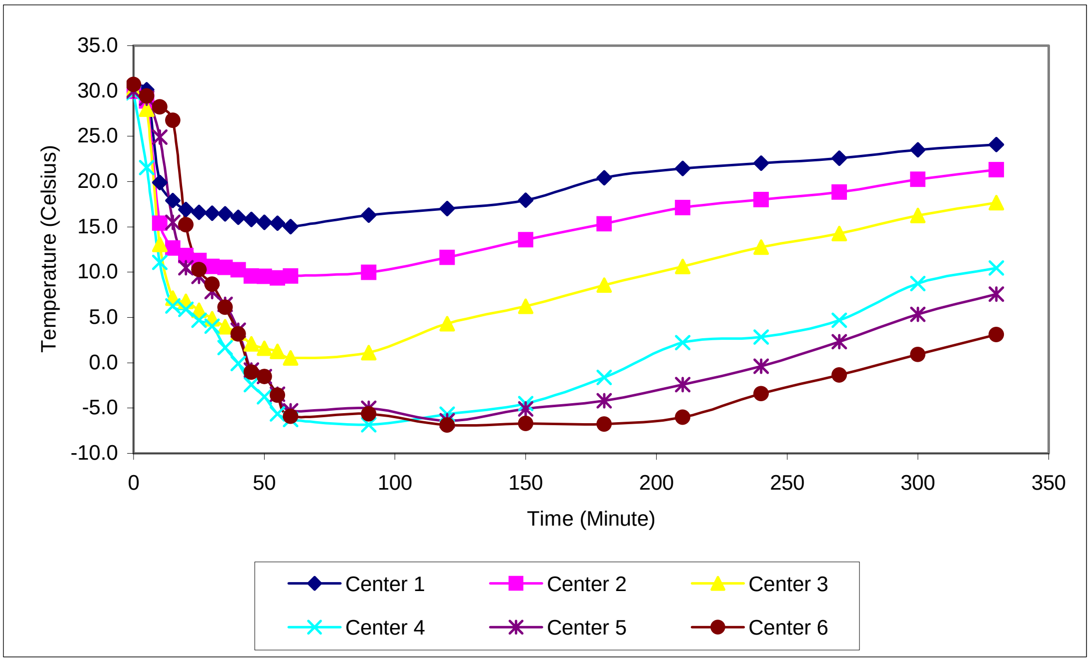


Figure A46: Temperature Profile at Center of the Cylinder for Flow rate 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

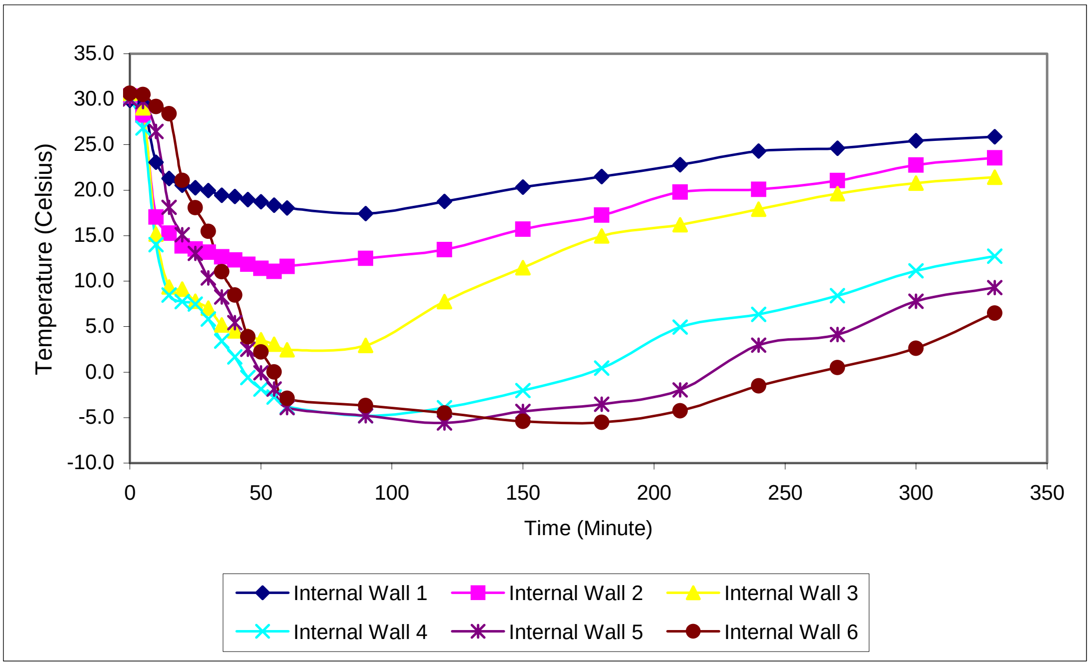


Figure A47: Temperature Profile at Internal Wall of the Cylinder for Flow rate 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

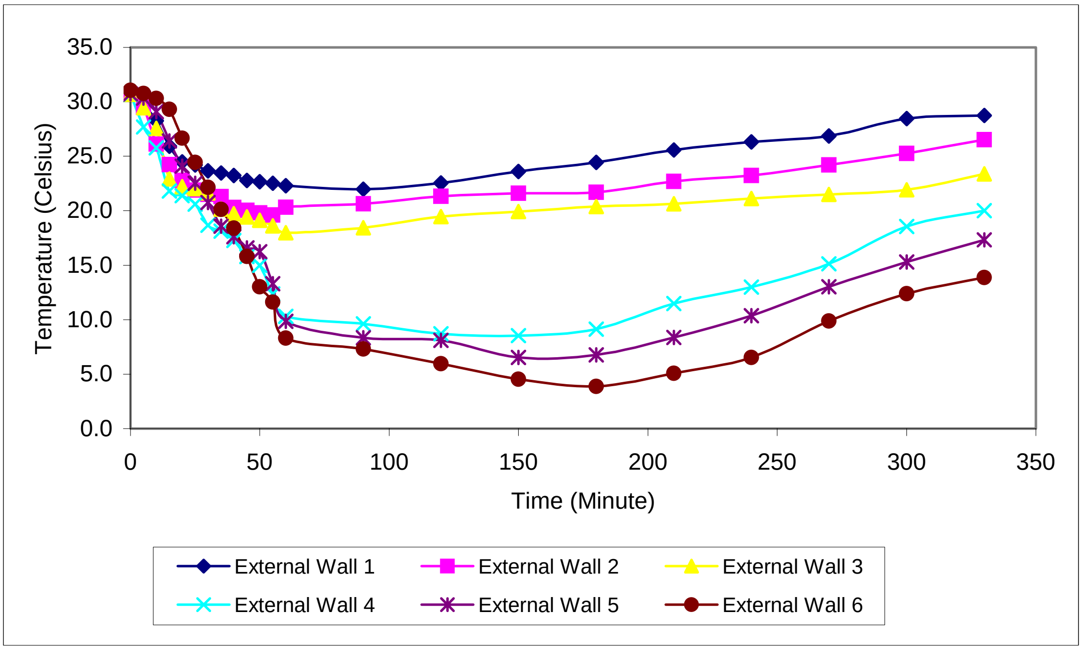


Figure A48: Temperature Profile at External Wall of the Cylinder for Flow rate 70 liter/minute at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

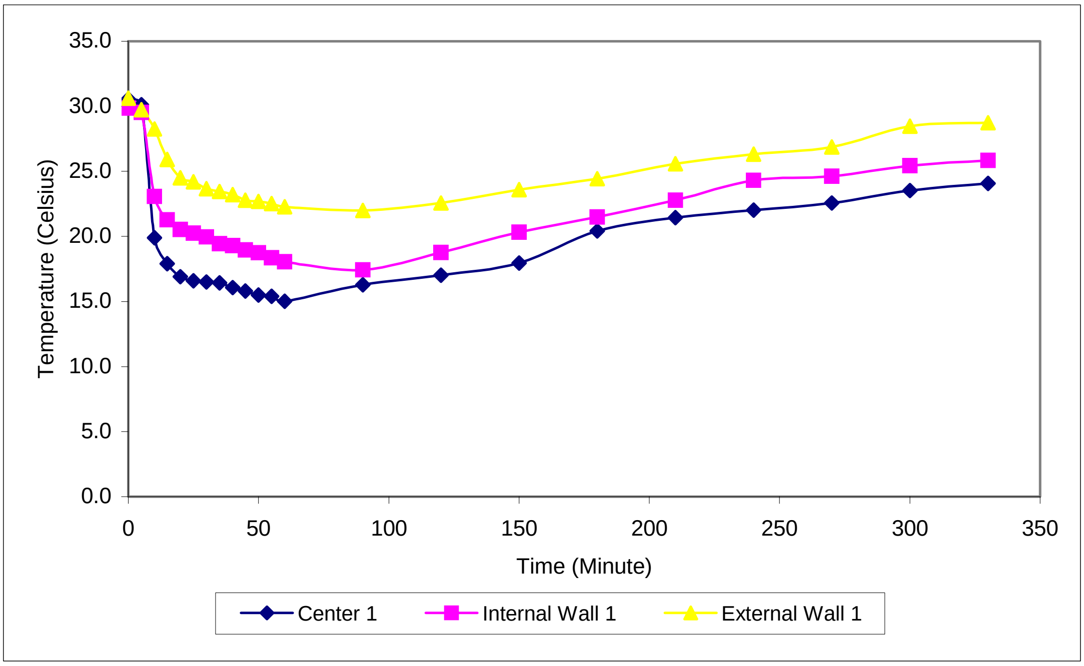


Figure A49: Temperature Profile at Difference Sensor Location of Level 1 Probe for Flow rate 70 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

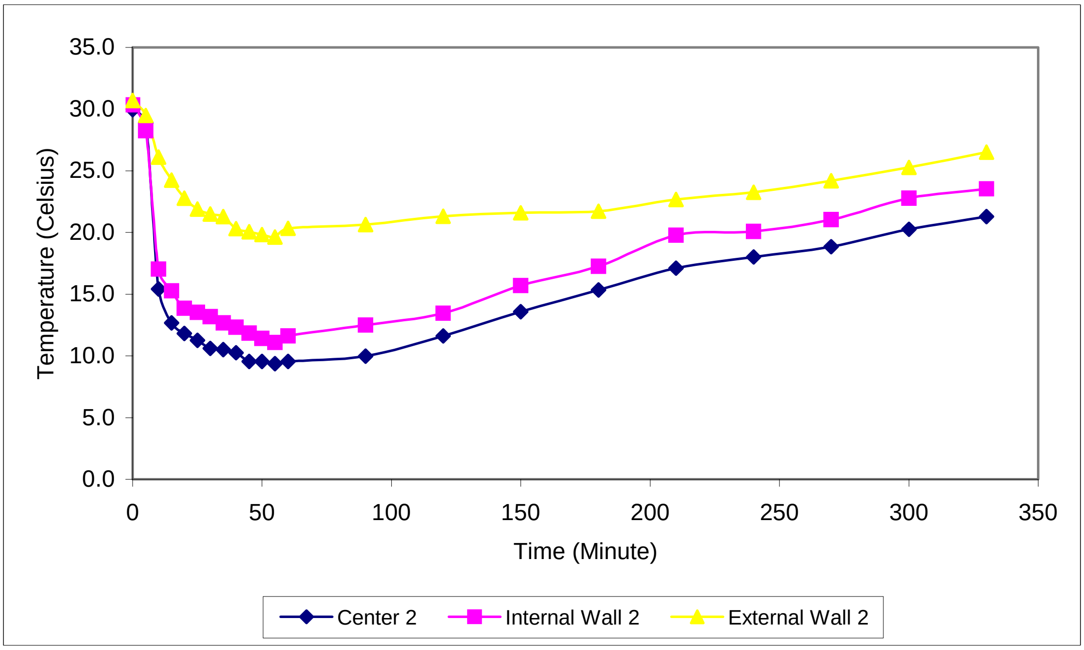


Figure A50: Temperature Profile at Difference Sensor Location of Level 2 Probe for Flow rate 70 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

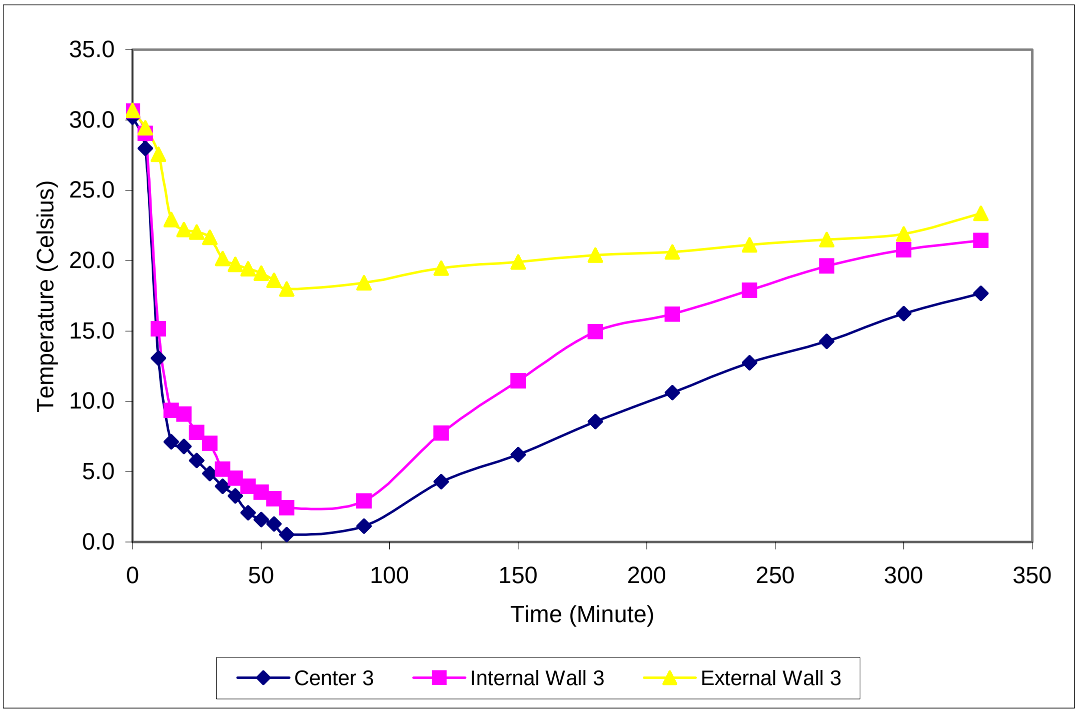


Figure A51: Temperature Profile at Difference Sensor Location of Level 3 Probe for Flow rate 70 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

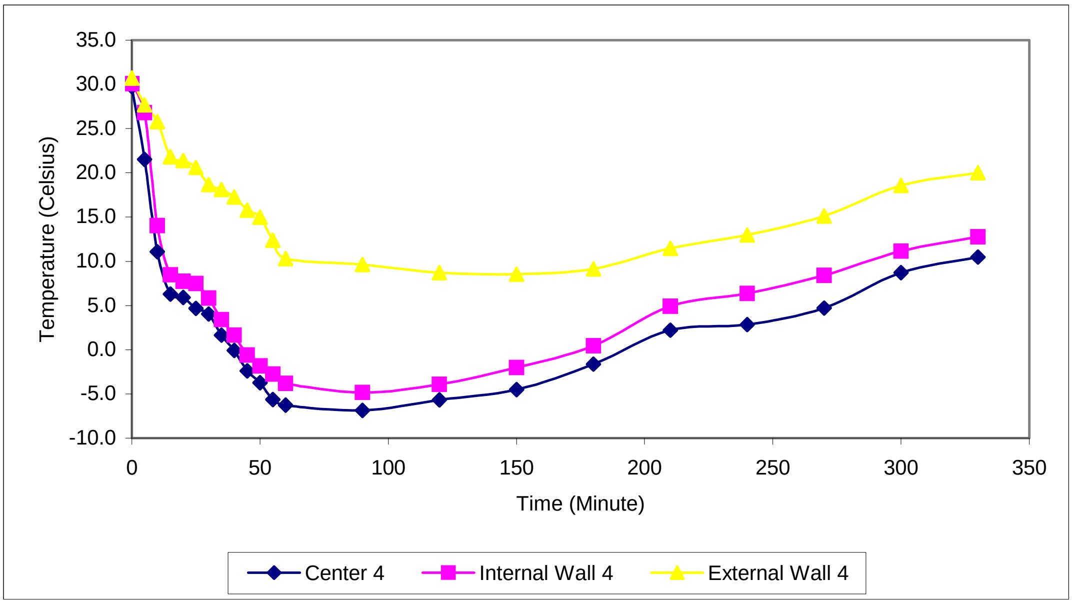


Figure A52: Temperature Profile at Difference Sensor Location of Level 4 Probe for Flow rate 70 liter/minute at Composition of 4060 Surrounding Temperature of 30^{o}C and Weight of 6 kg

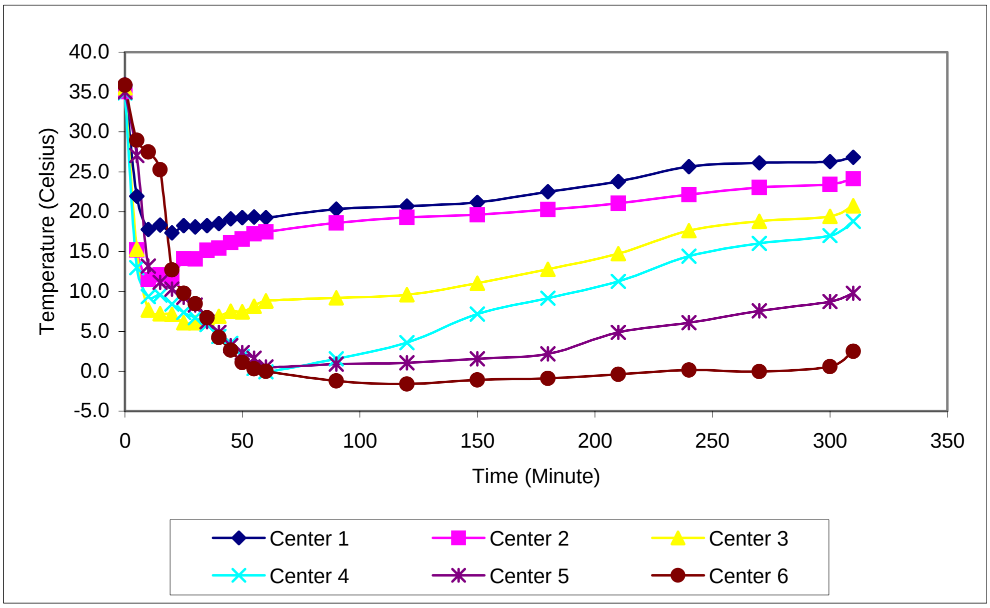


Figure A91: Temperature Profile at Center of the Cylinder for Surrounding Temperature of 35°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

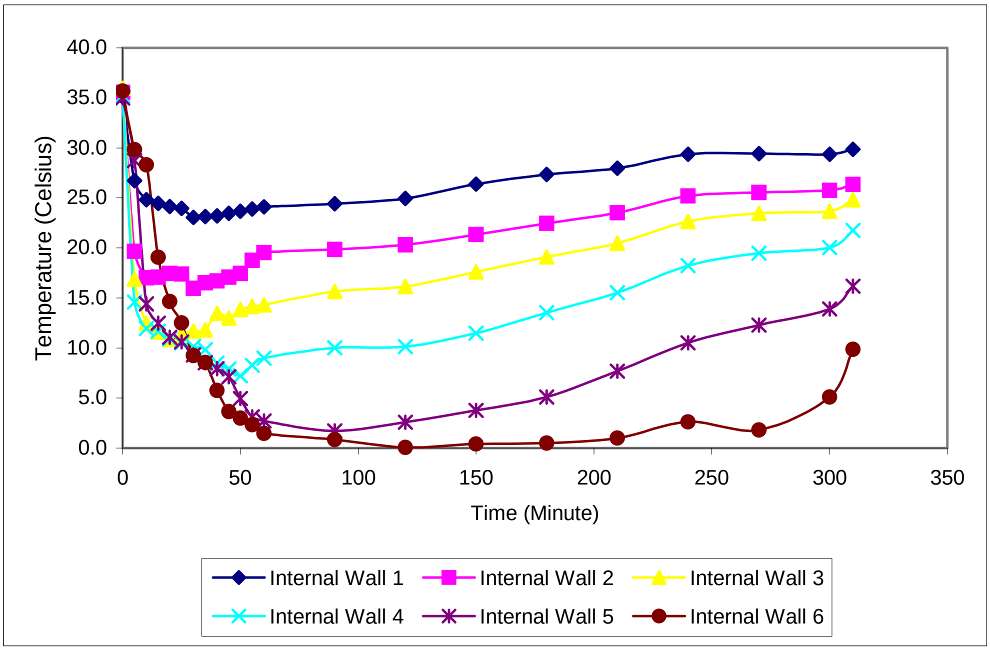


Figure A92: Temperature Profile at Internal Wall of the Cylinder for Surrounding Temperature of 35°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

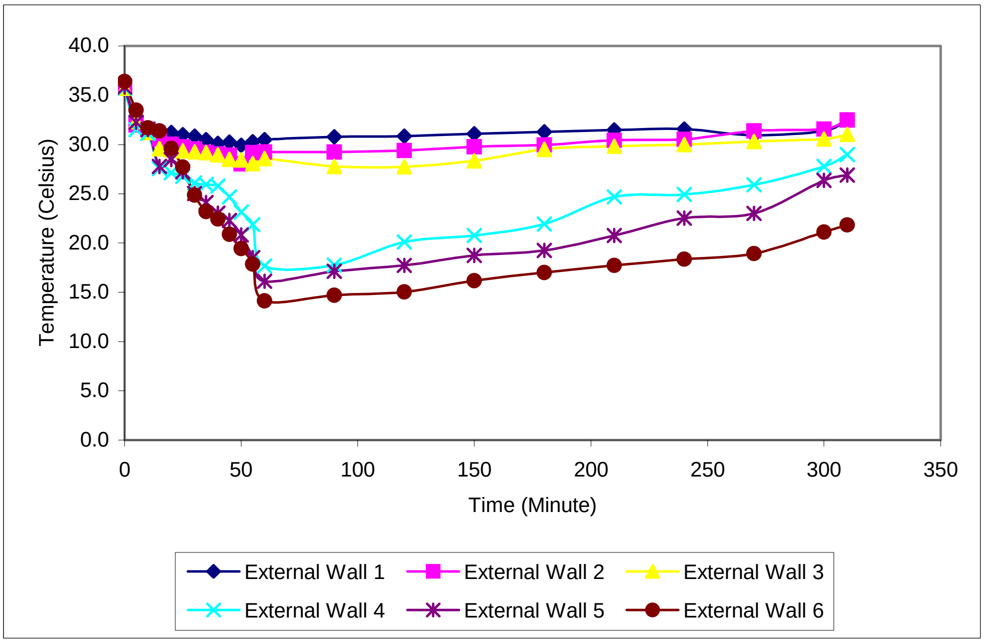


Figure A93: Temperature Profile at External Wall of the Cylinder for Surrounding Temperature of 35°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

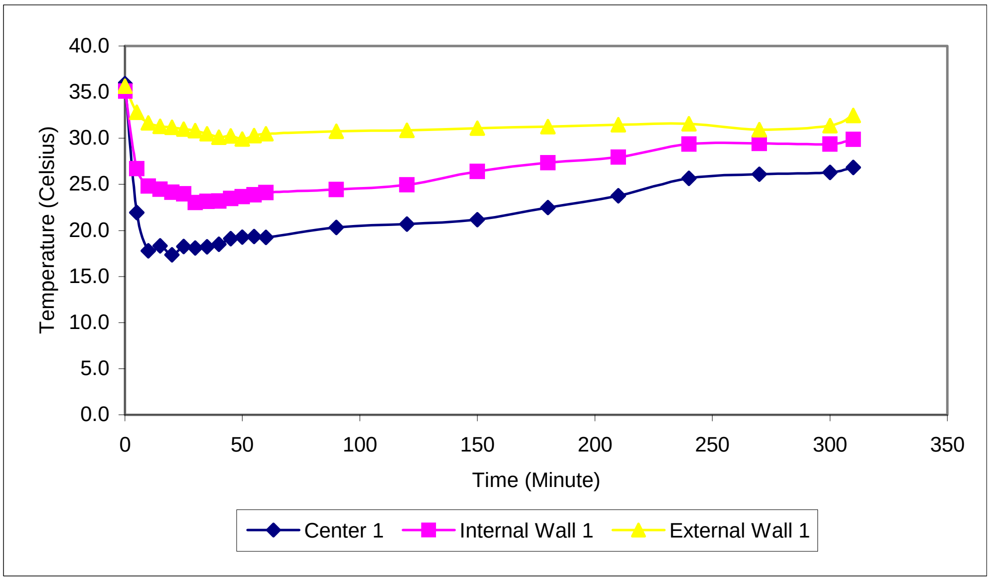


Figure A94: Temperature Profile at Difference Sensor Location of Level 1 Probe for Surrounding Temperature of 35°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

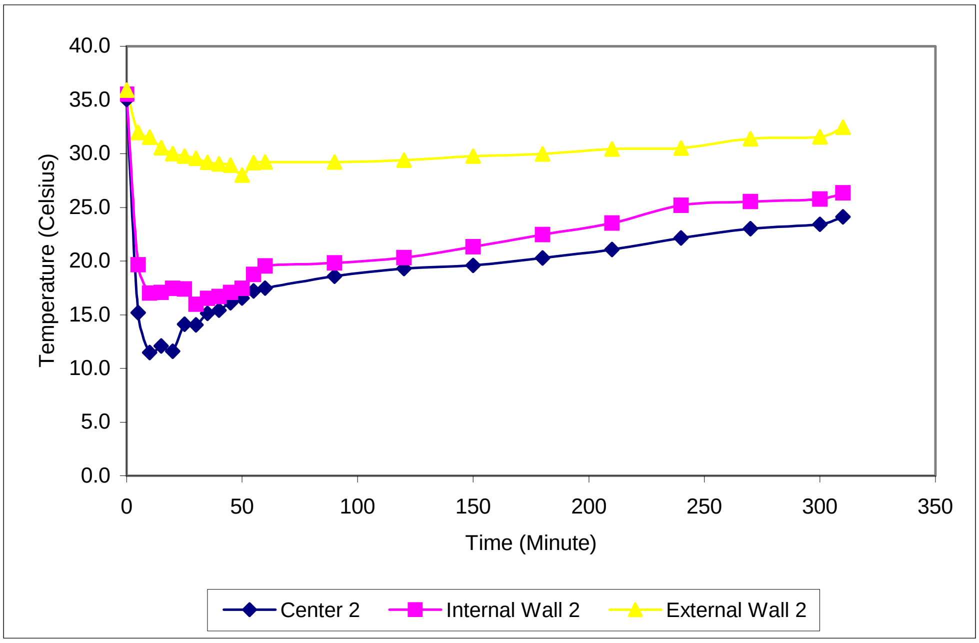


Figure A95: Temperature Profile at Difference Sensor Location of Level 2 Probe for Surrounding Temperature of 35°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

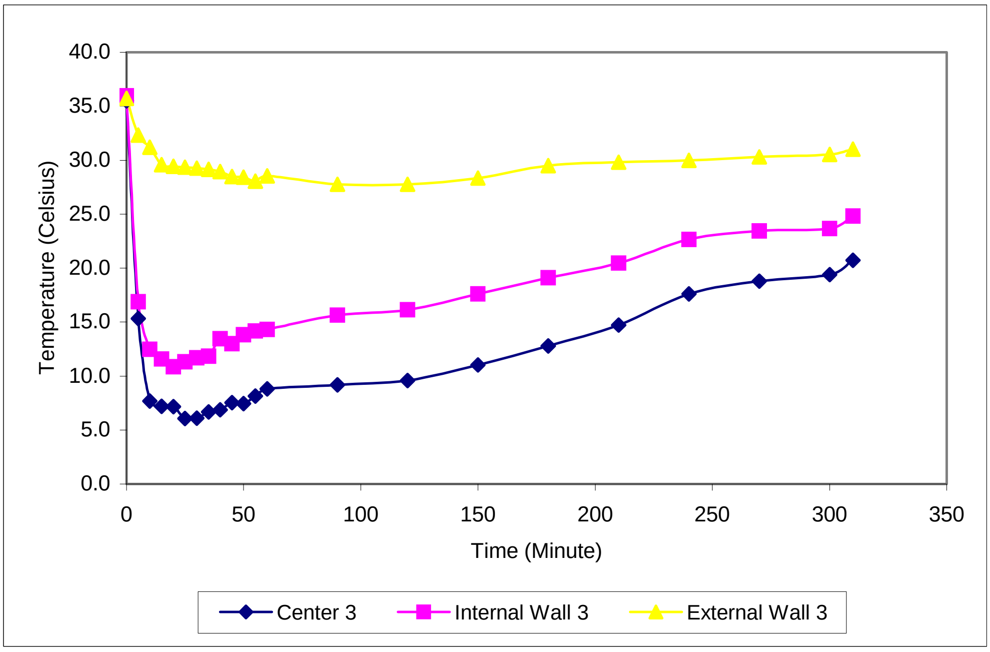


Figure A96: Temperature Profile at Difference Sensor Location of Level 3 Probe for Surrounding Temperature of 35°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

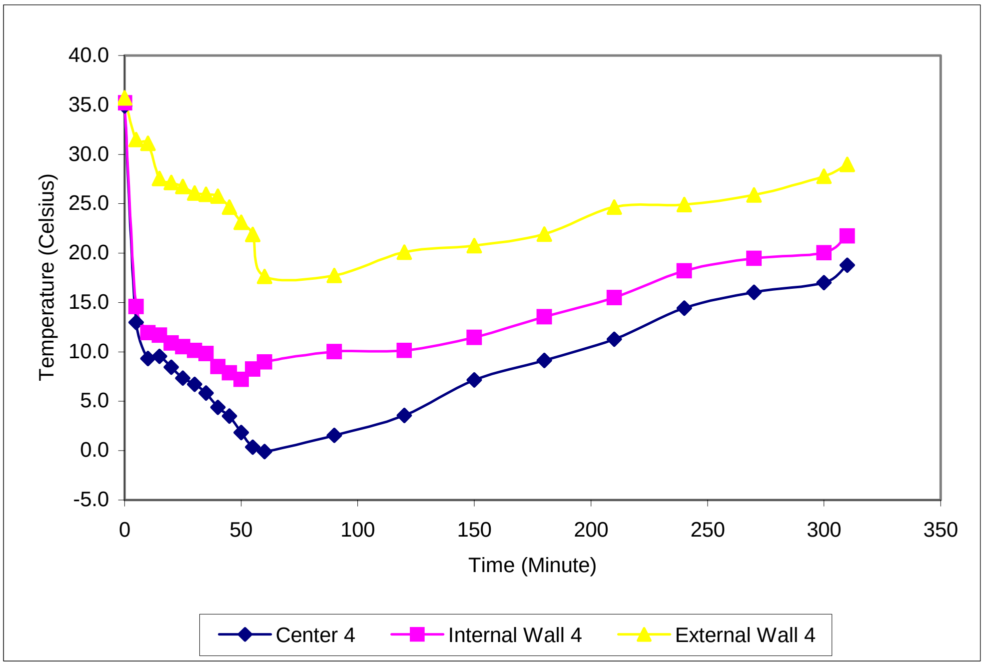


Figure A97: Temperature Profile at Difference Sensor Location of Level 4 Probe for Surrounding Temperature of 35^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

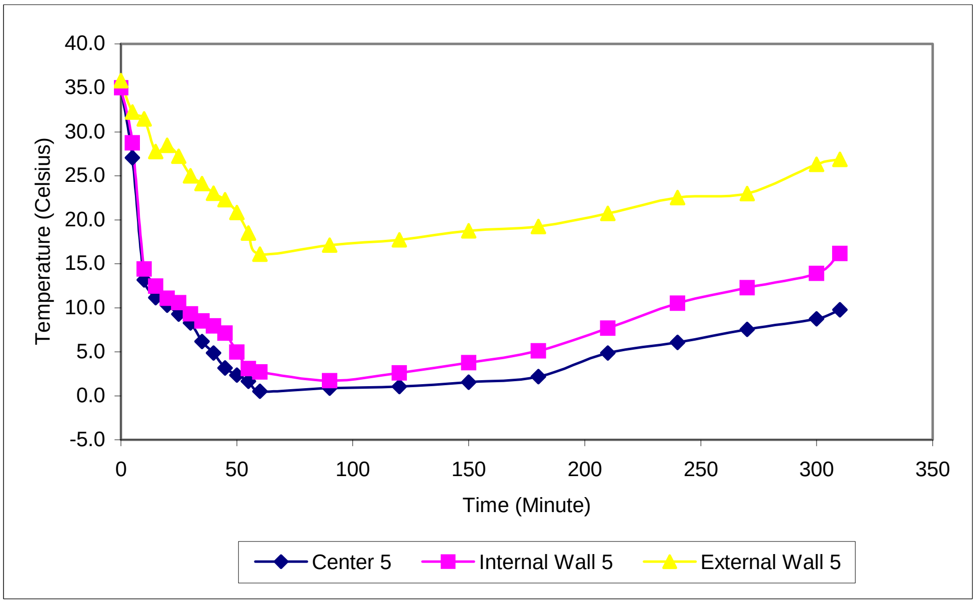


Figure A98: Temperature Profile at Difference Sensor Location of Level 5 Probe for Surrounding Temperature of 35^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

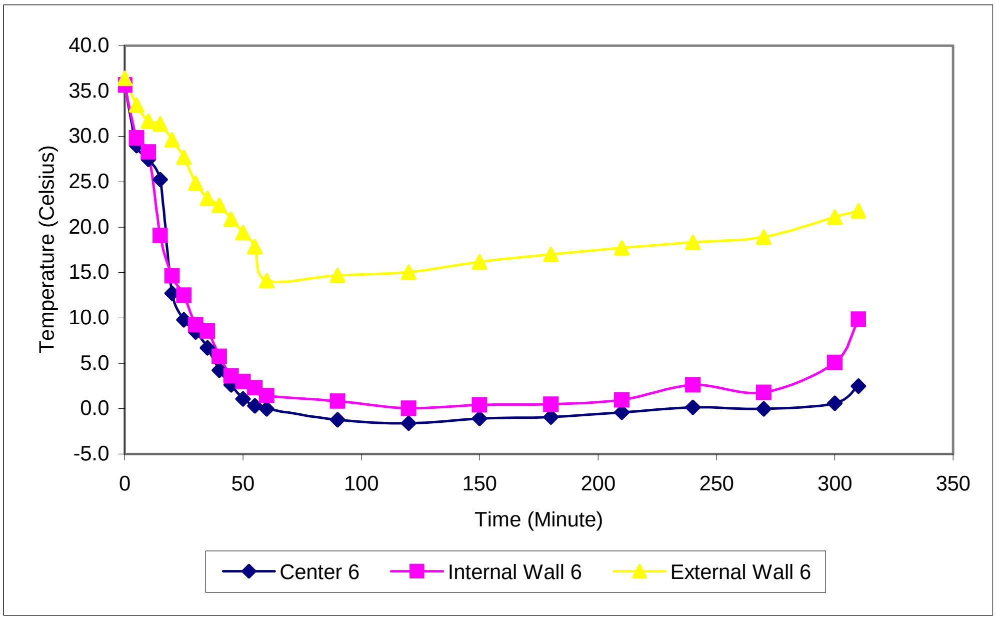


Figure A99: Temperature Profile at Difference Sensor Location of Level 6 Probe for Surrounding Temperature of 35°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

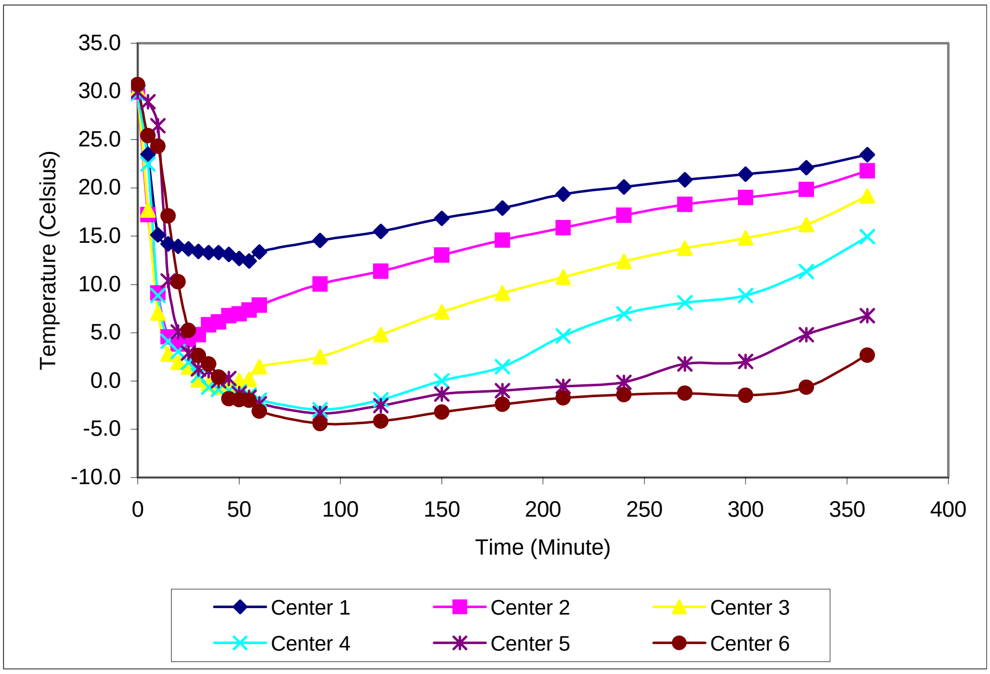


Figure A100: Temperature Profile at Center of the Cylinder for Surrounding Temperature of 30°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

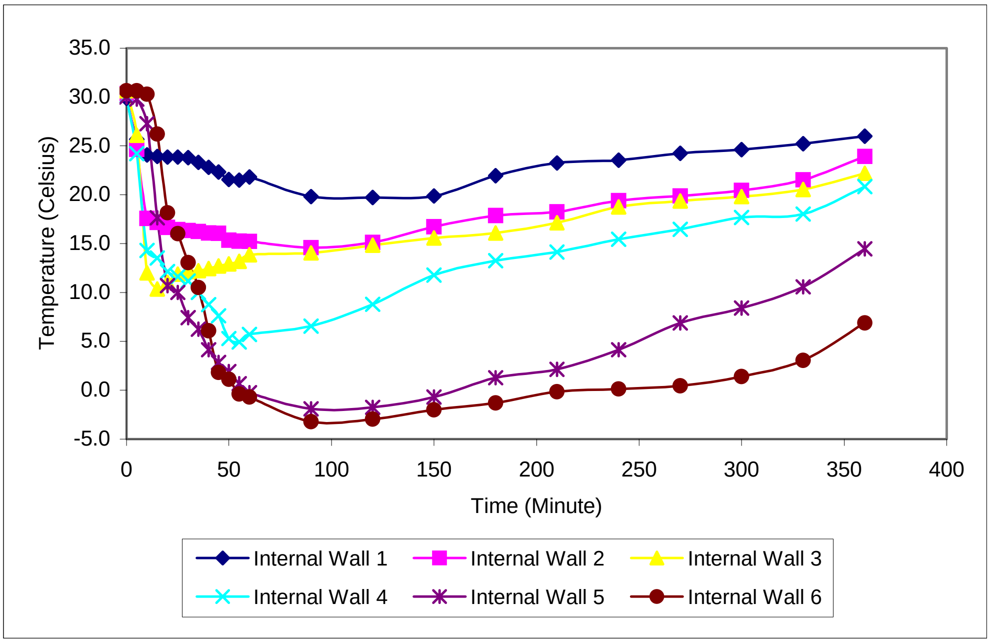


Figure A101: Temperature Profile at Internal Wall of the Cylinder for Surrounding Temperature of 30°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

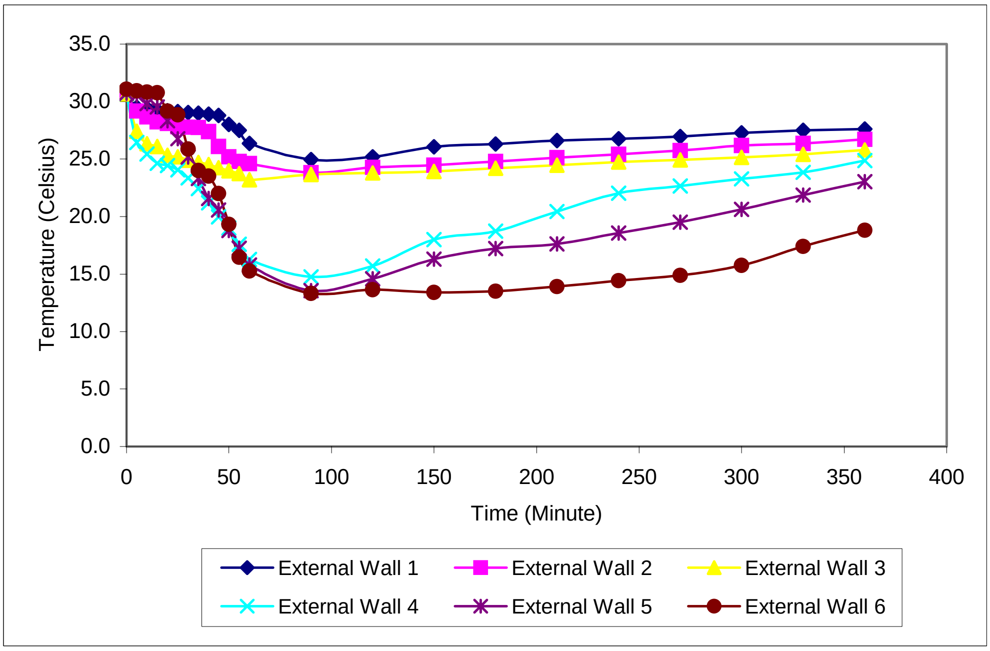


Figure A102: Temperature Profile at External Wall of the Cylinder for Surrounding Temperature of 30°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

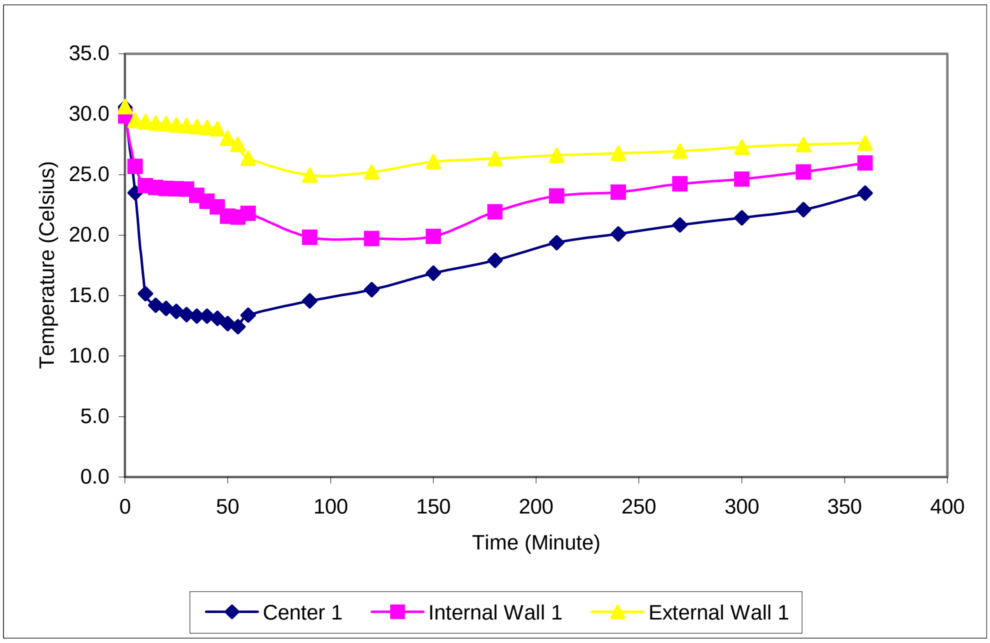


Figure A103: Temperature Profile at Difference Sensor Location of Level 1 Probe for Surrounding Temperature of 30^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

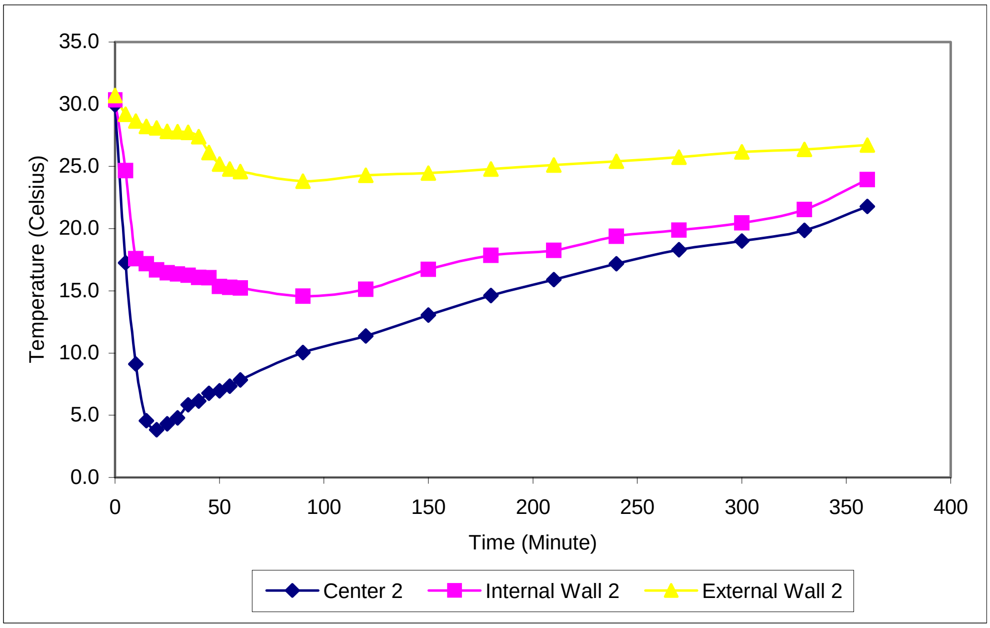


Figure A104: Temperature Profile at Difference Sensor Location of Level 2 Probe for Surrounding Temperature of 30^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

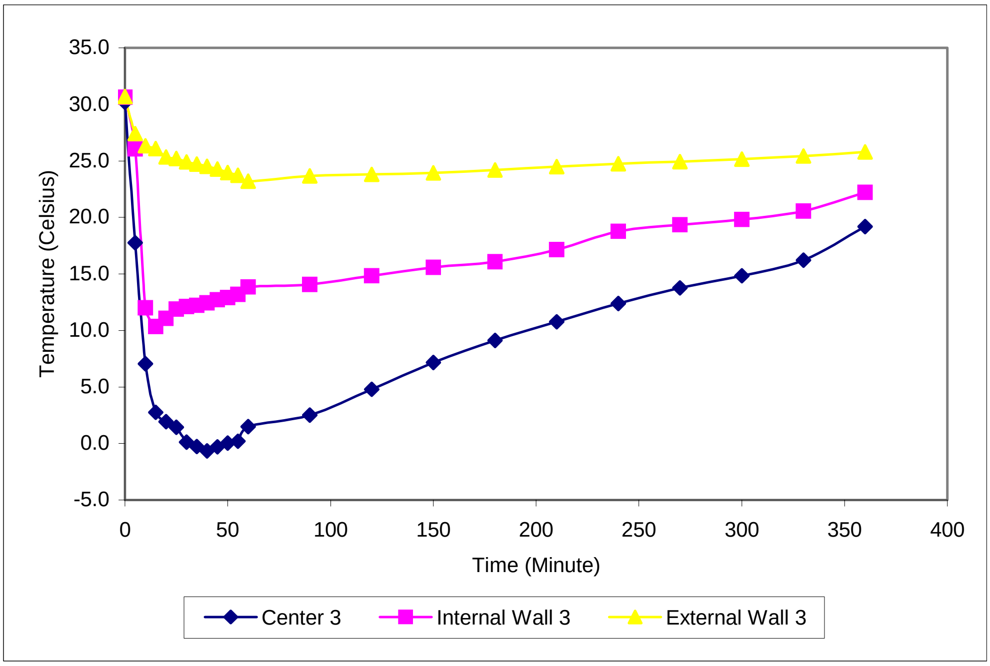


Figure A105: Temperature Profile at Difference Sensor Location of Level 3 Probe for Surrounding Temperature of 30^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

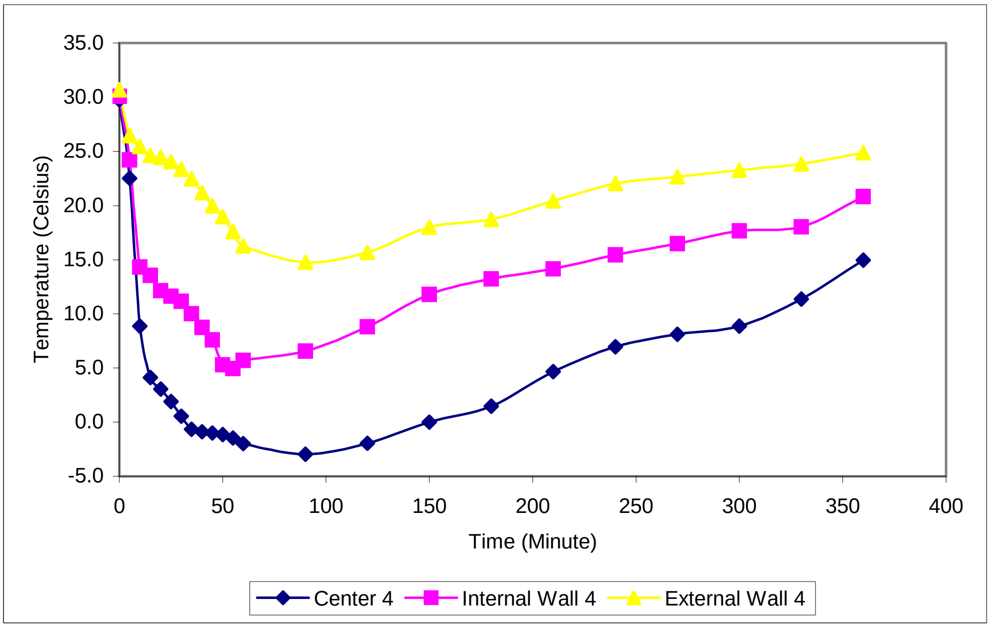


Figure A106: Temperature Profile at Difference Sensor Location of Level 4 Probe for Surrounding Temperature of 30^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

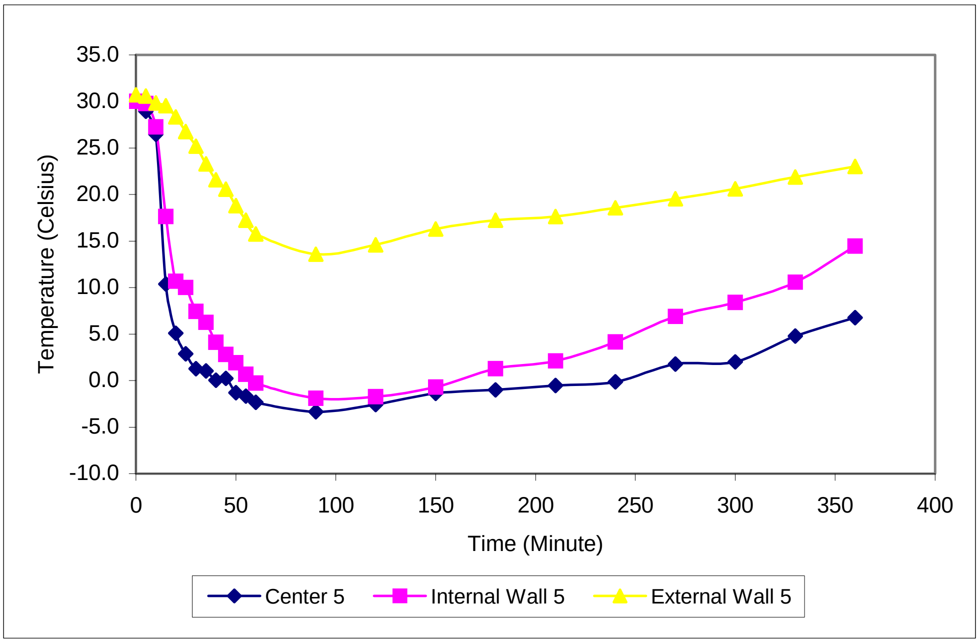


Figure A107: Temperature Profile at Difference Sensor Location of Level 5 Probe for Surrounding Temperature of 30^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

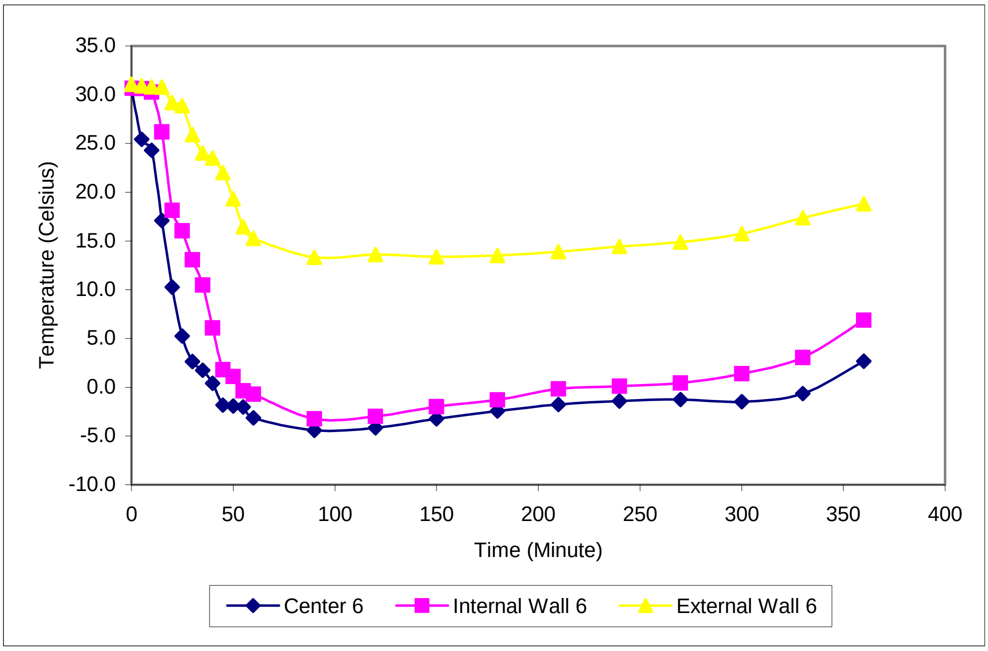


Figure A108: Temperature Profile at Difference Sensor Location of Level 6 Probe for Surrounding Temperature of 30^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

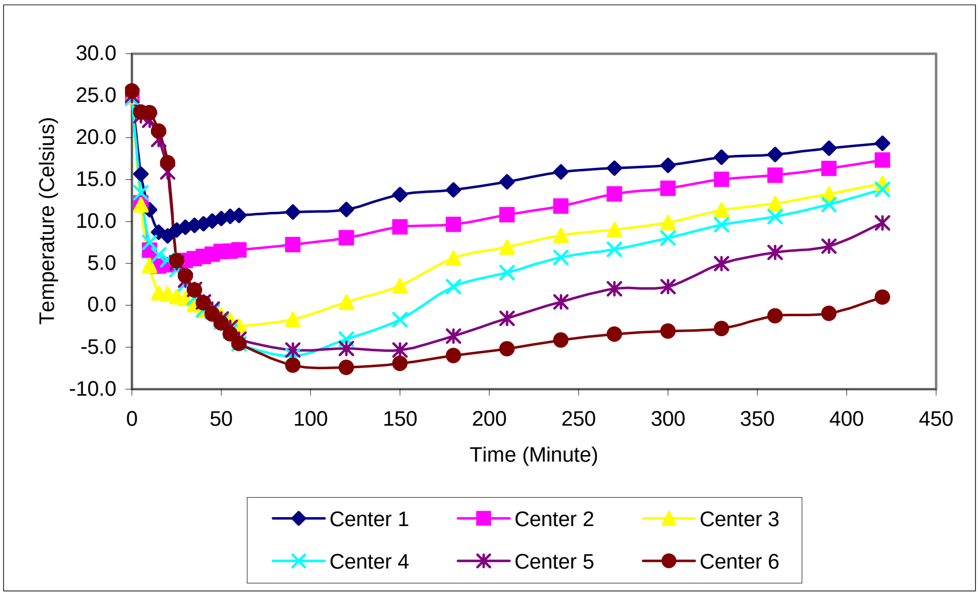


Figure A109: Temperature Profile at Center of the Cylinder for Surrounding Temperature of 25^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

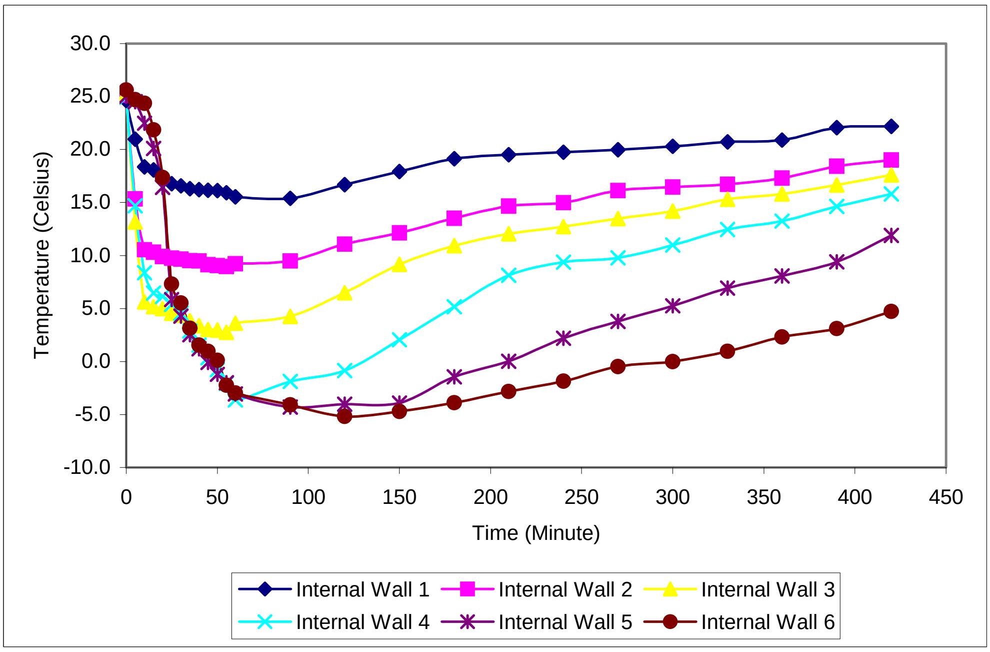


Figure A110: Temperature Profile at Internal Wall of the Cylinder for Surrounding Temperature of 25^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

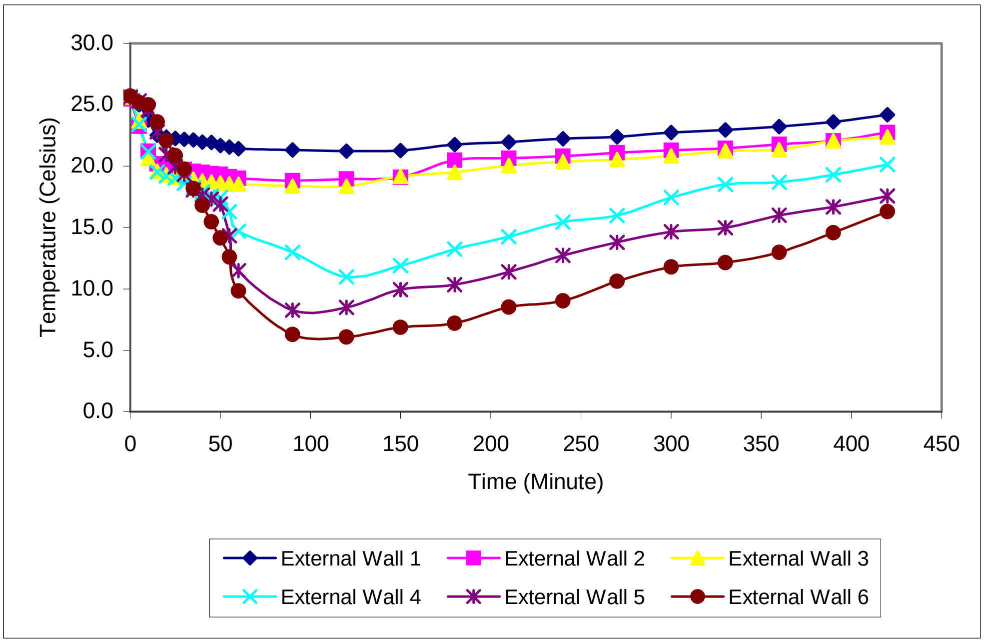


Figure A111: Temperature Profile at External Wall of the Cylinder for Surrounding Temperature of 25°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

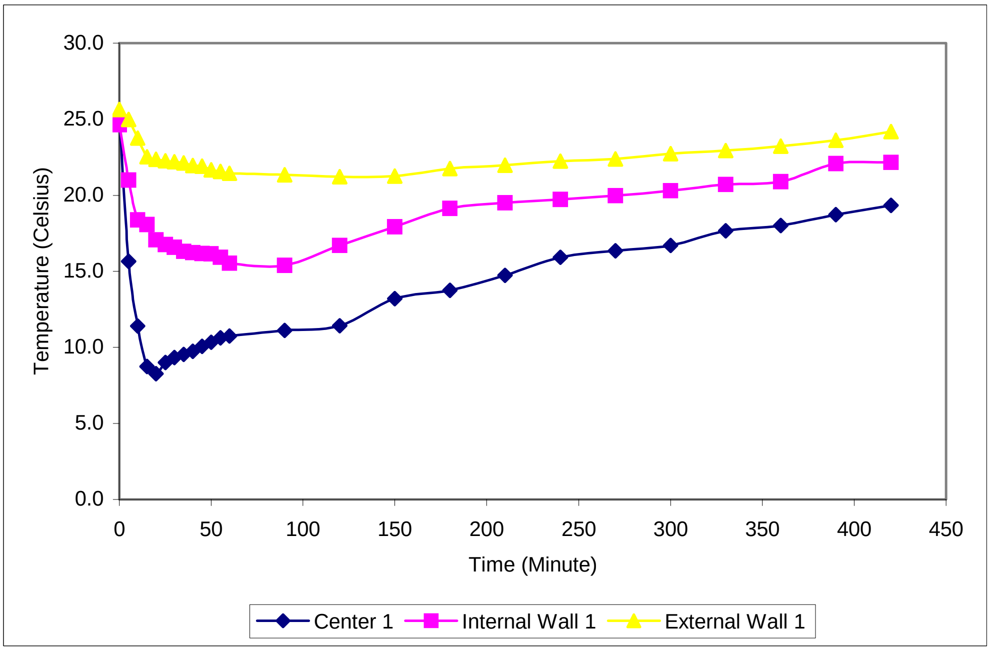


Figure A112: Temperature Profile at Difference Sensor Location of Level 1 Probe for Surrounding Temperature of 25°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

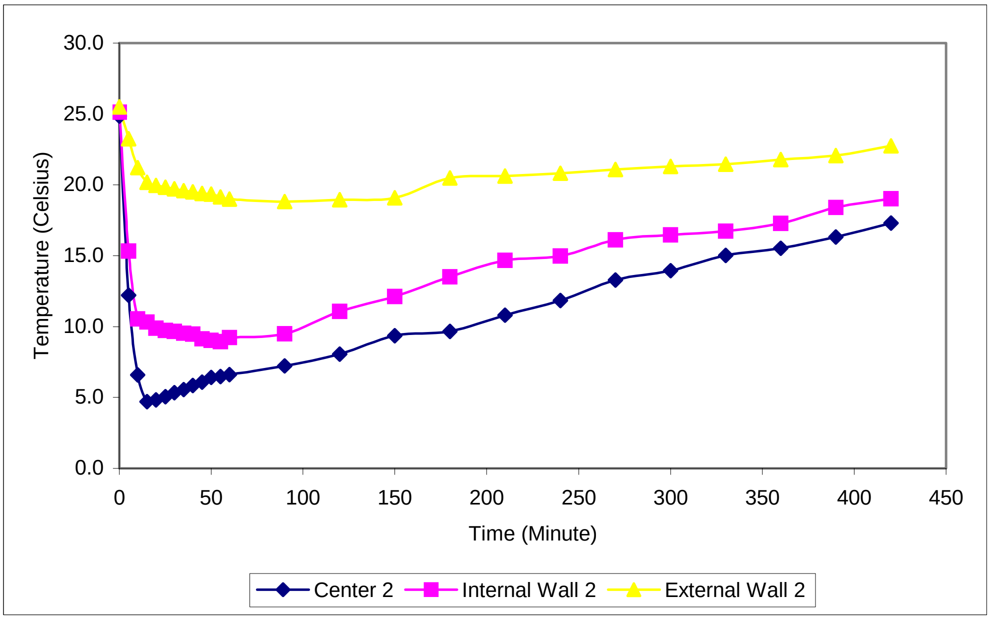


Figure A113: Temperature Profile at Difference Sensor Location of Level 2 Probe for Surrounding Temperature of 25^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

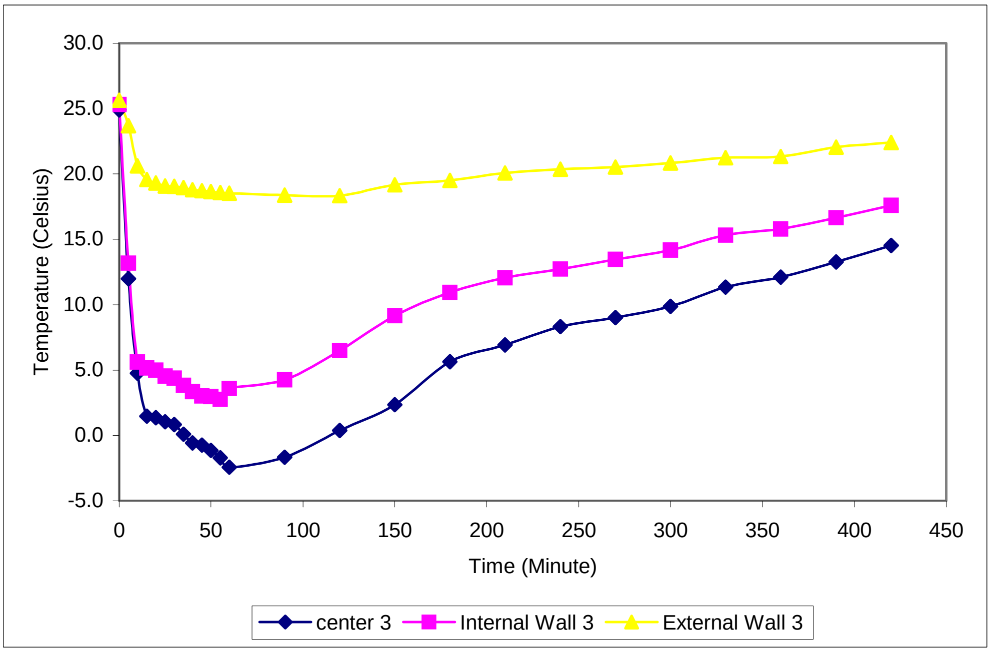


Figure A114: Temperature Profile at Difference Sensor Location of Level 3 Probe for Surrounding Temperature of 25^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

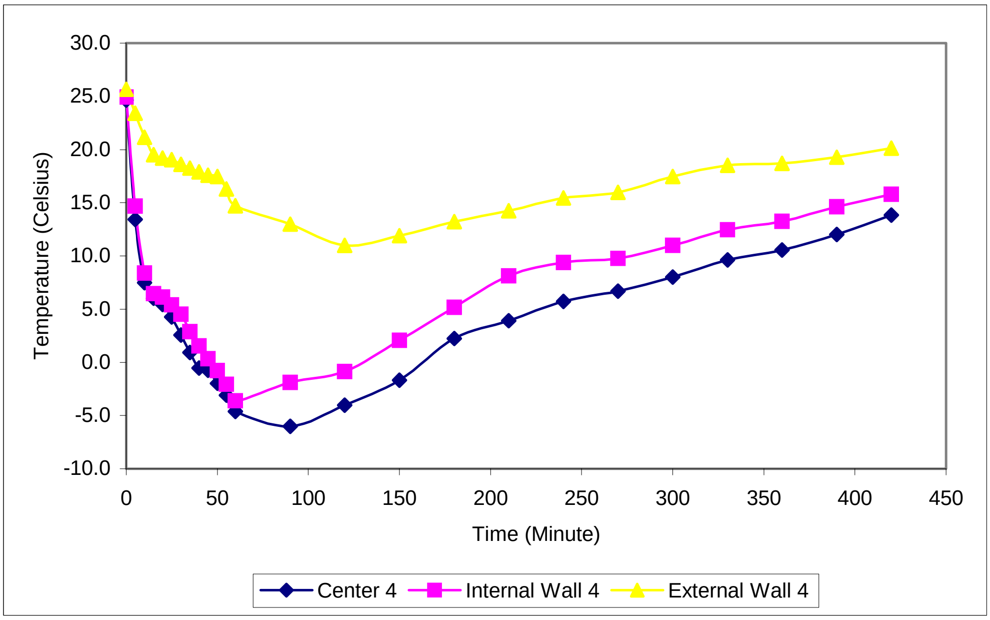


Figure A115: Temperature Profile at Difference Sensor Location of Level 4 Probe for Surrounding Temperature of 25^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

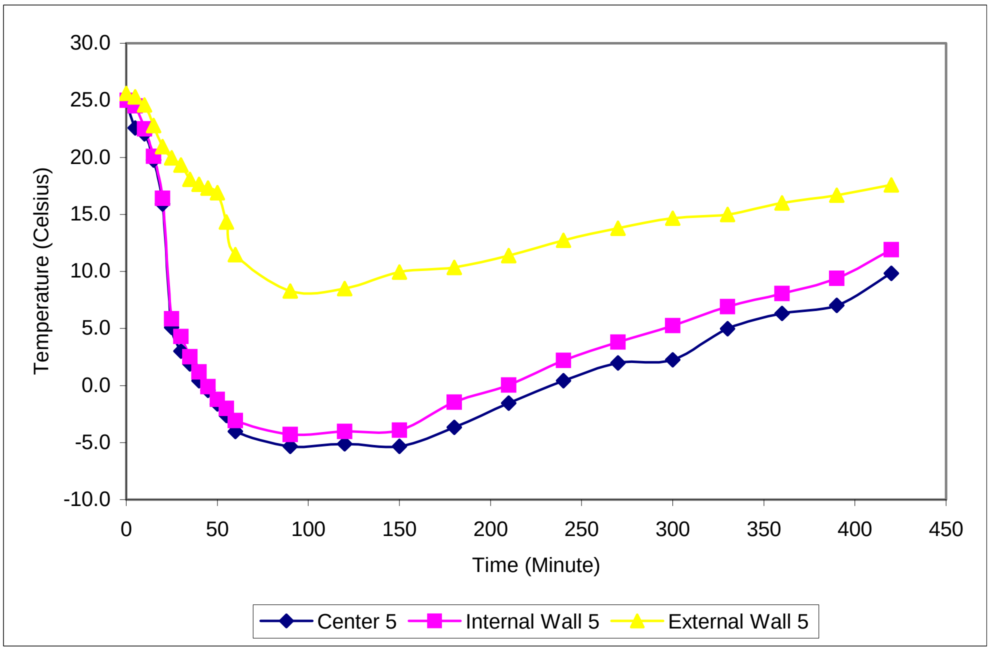


Figure A116: Temperature Profile at Difference Sensor Location of Level 5 Probe for Surrounding Temperature of 25^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

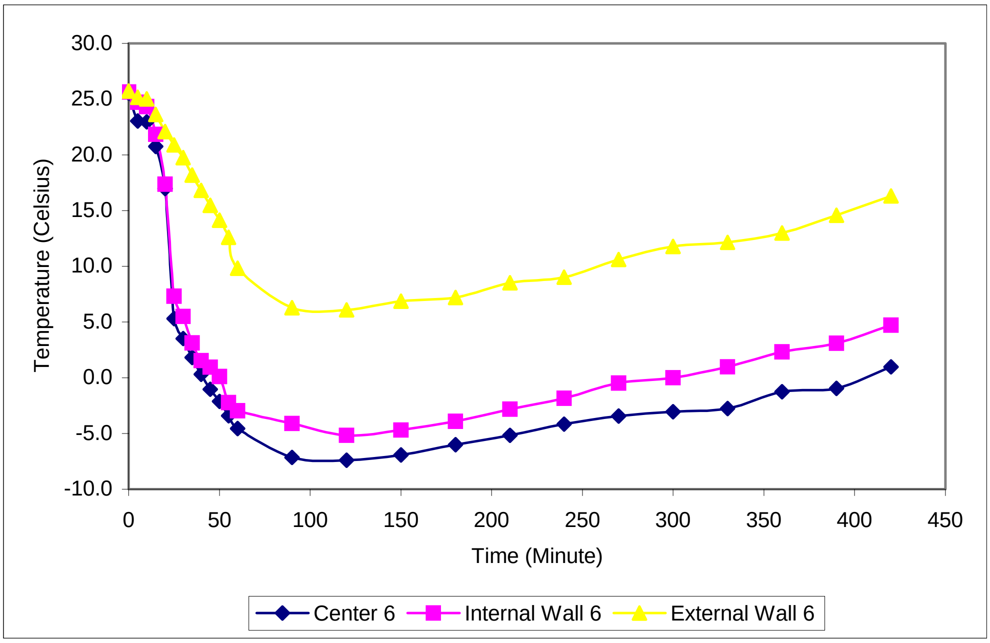


Figure A117: Temperature Profile at Difference Sensor Location of Level 6 Probe for Surrounding Temperature of 25°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

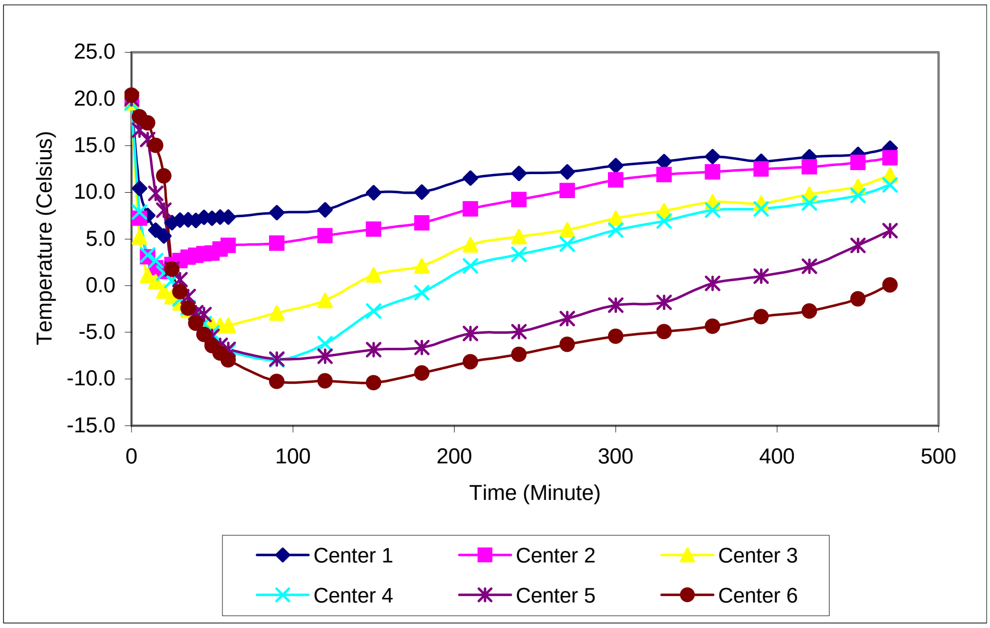


Figure A118: Temperature Profile at Center of the Cylinder for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

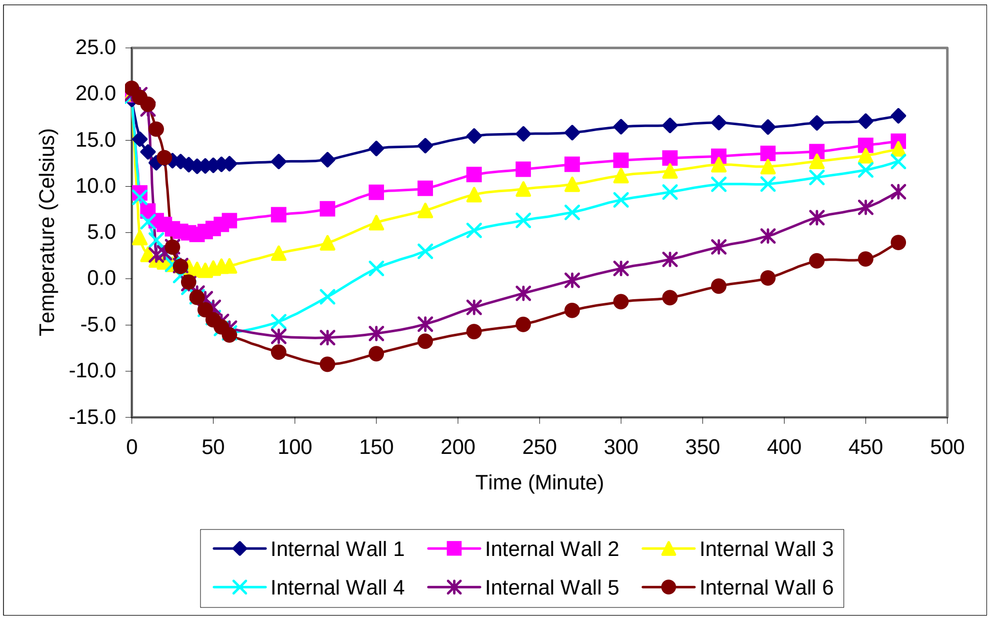


Figure A119: Temperature Profile at Internal Wall of the Cylinder for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

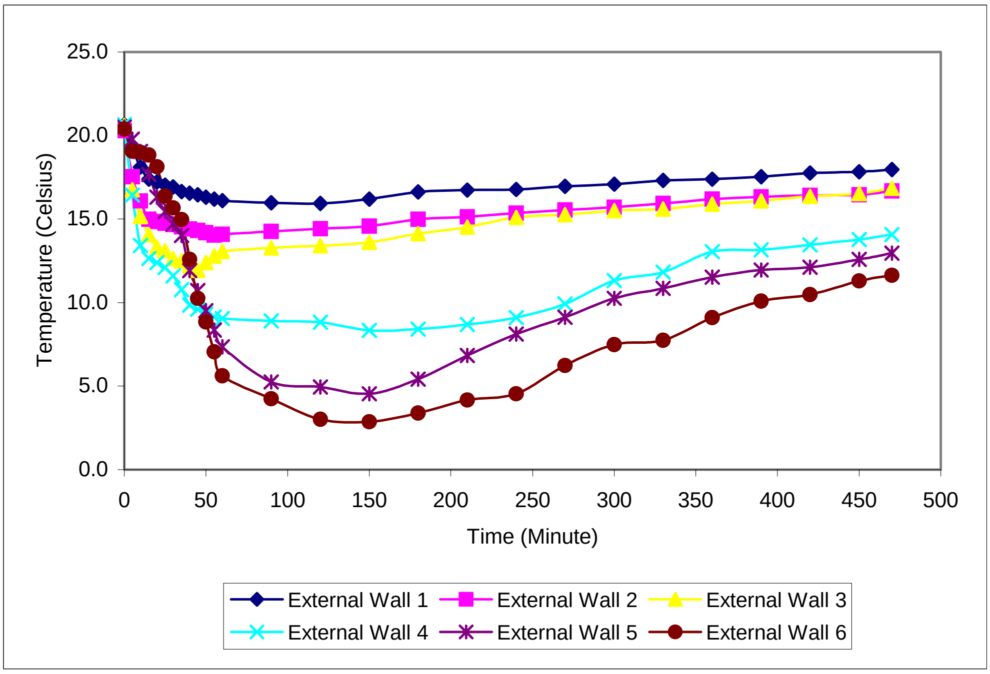


Figure A120: Temperature Profile at External Wall of the Cylinder for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

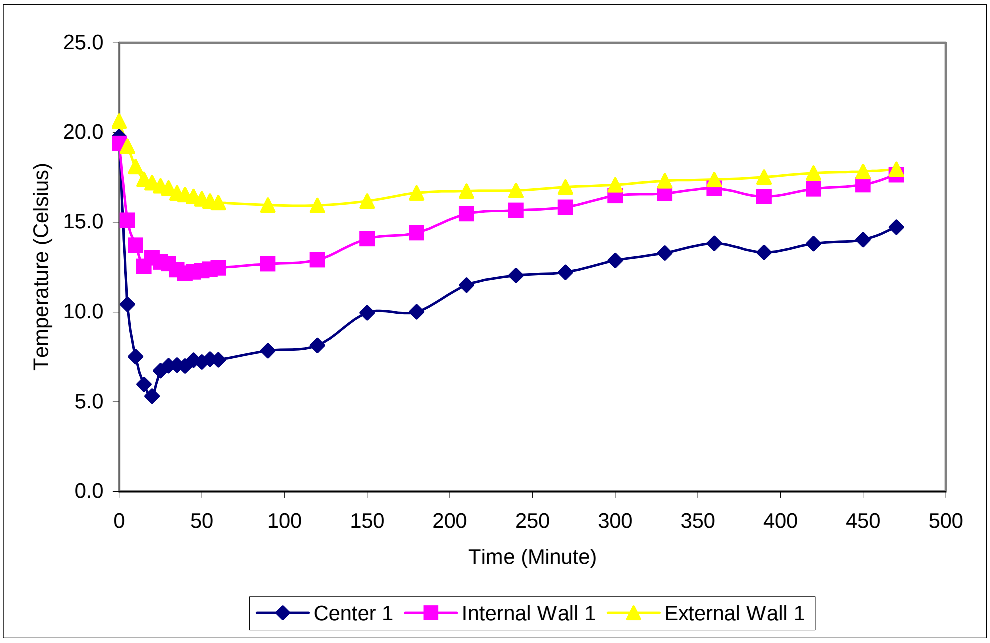


Figure A121: Temperature Profile at Difference Sensor Location of Level 1 Probe for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

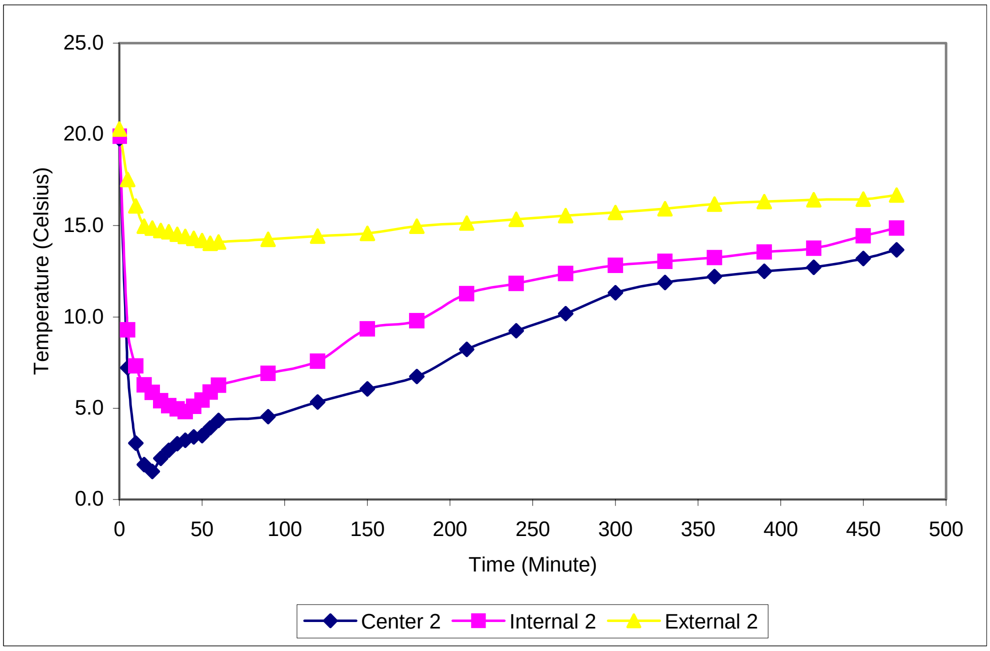


Figure A122: Temperature Profile at Difference Sensor Location of Level 2 Probe for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

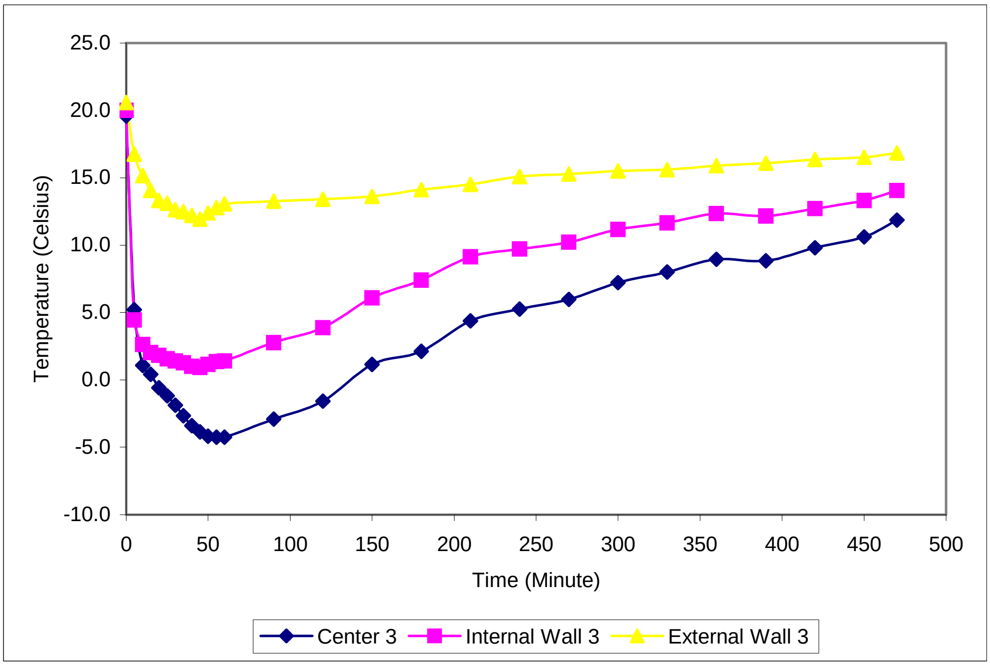


Figure A123: Temperature Profile at Difference Sensor Location of Level 3 Probe for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

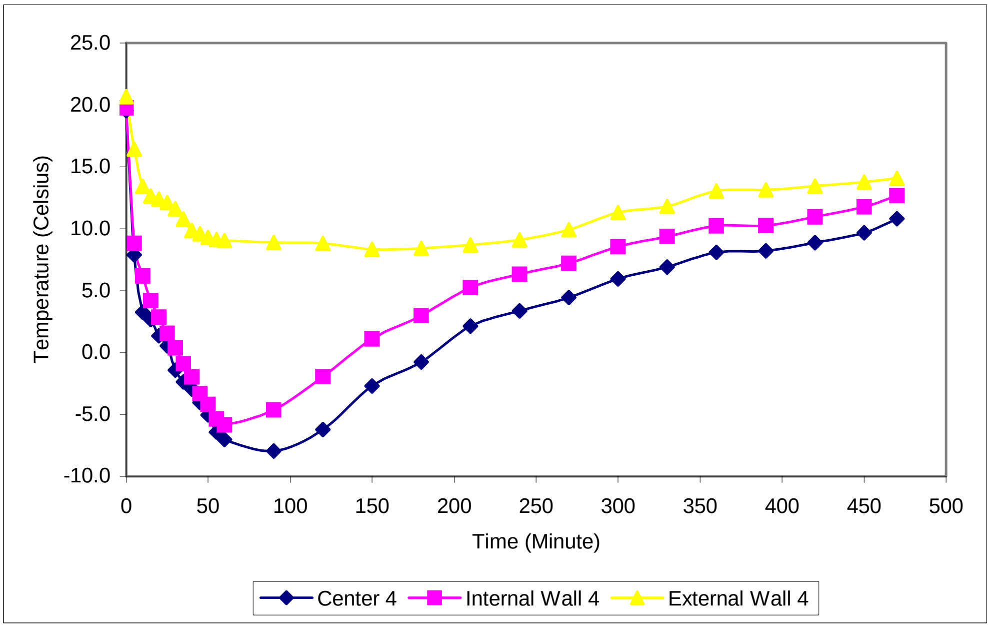


Figure A124: Temperature Profile at Difference Sensor Location of Level 4 Probe for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

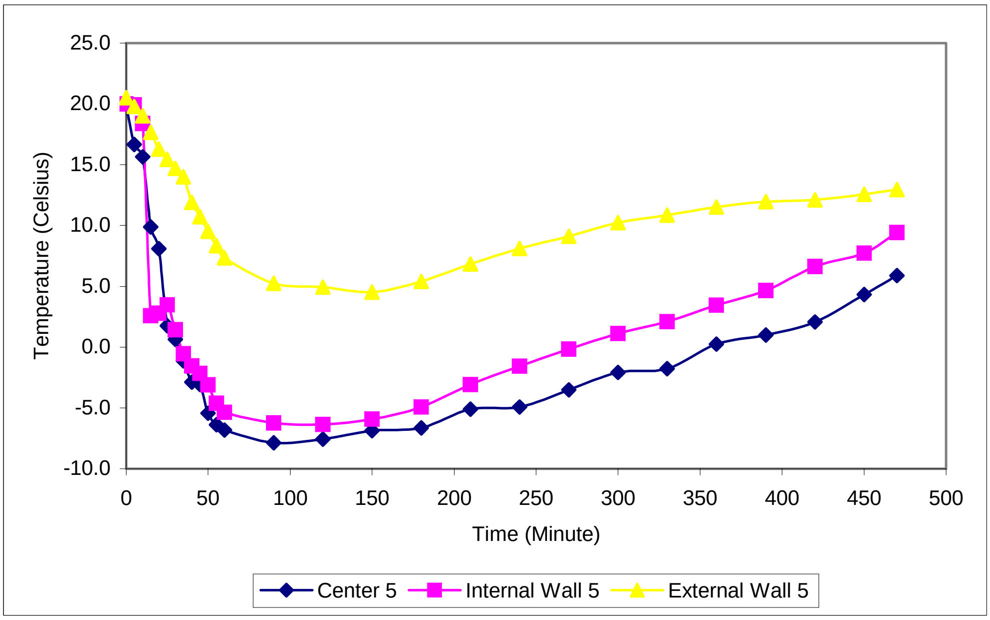


Figure A125: Temperature Profile at Difference Sensor Location of Level 5 Probe for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

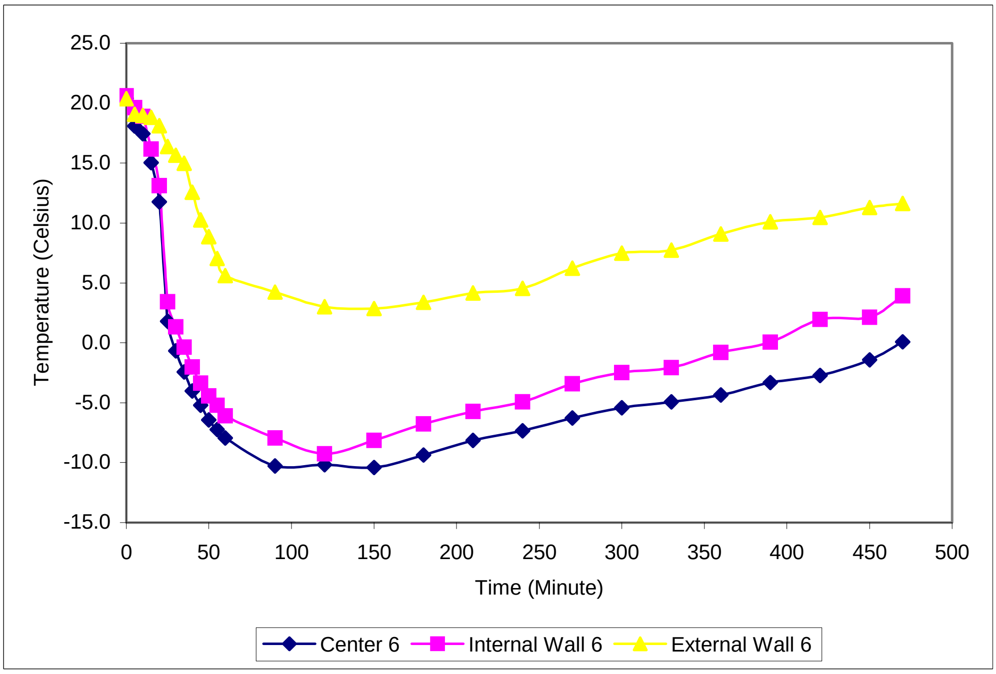


Figure A126: Temperature Profile at Difference Sensor Location of Level 6 Probe for Surrounding Temperature of 20°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

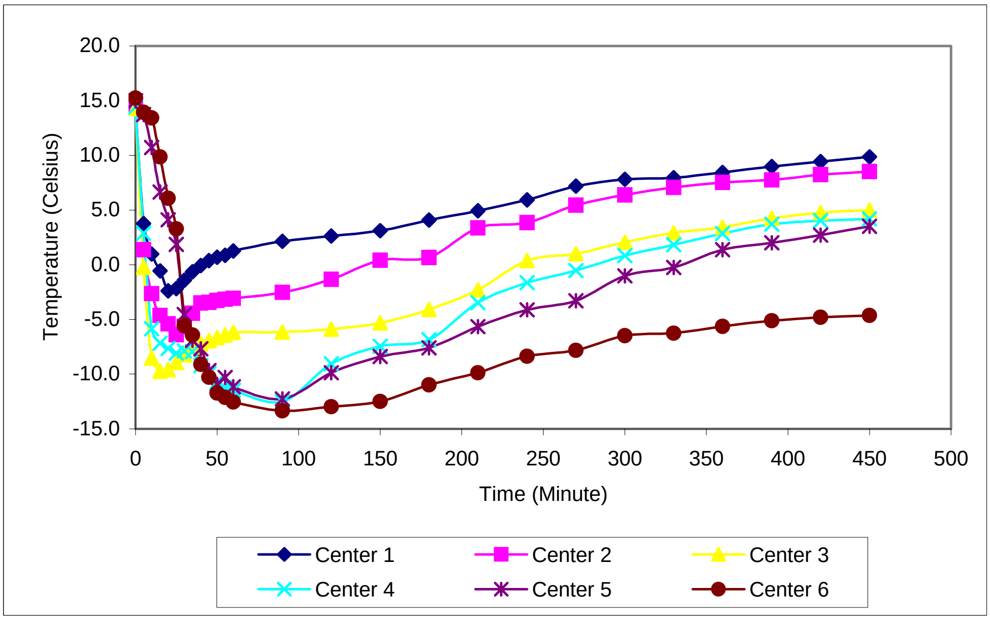


Figure A127: Temperature Profile at Center of the Cylinder for Surrounding Temperature of 15^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

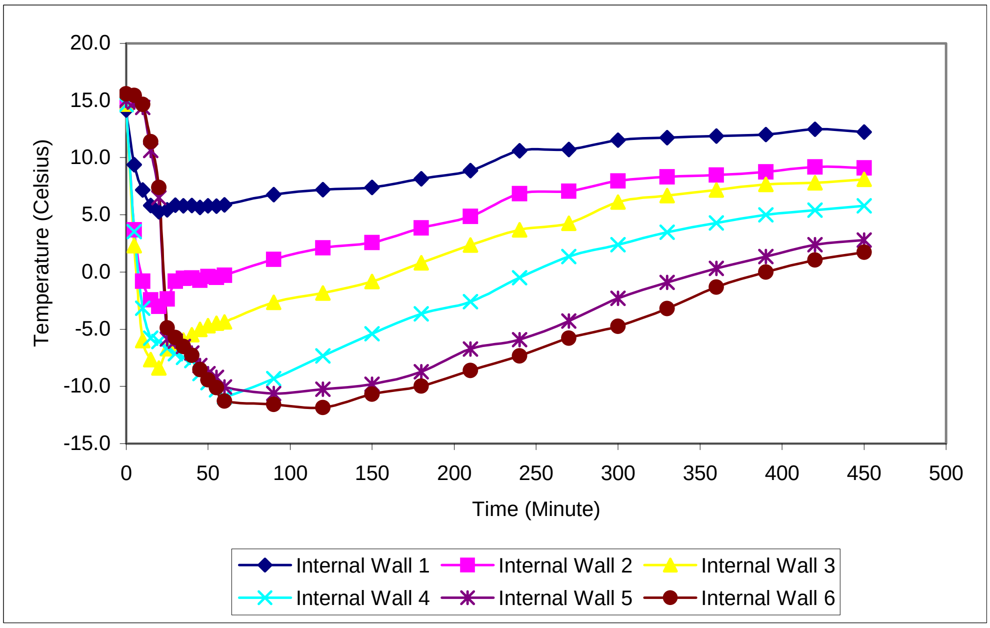


Figure A128: Temperature Profile at Internal Wall of the Cylinder for Surrounding Temperature of 15^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

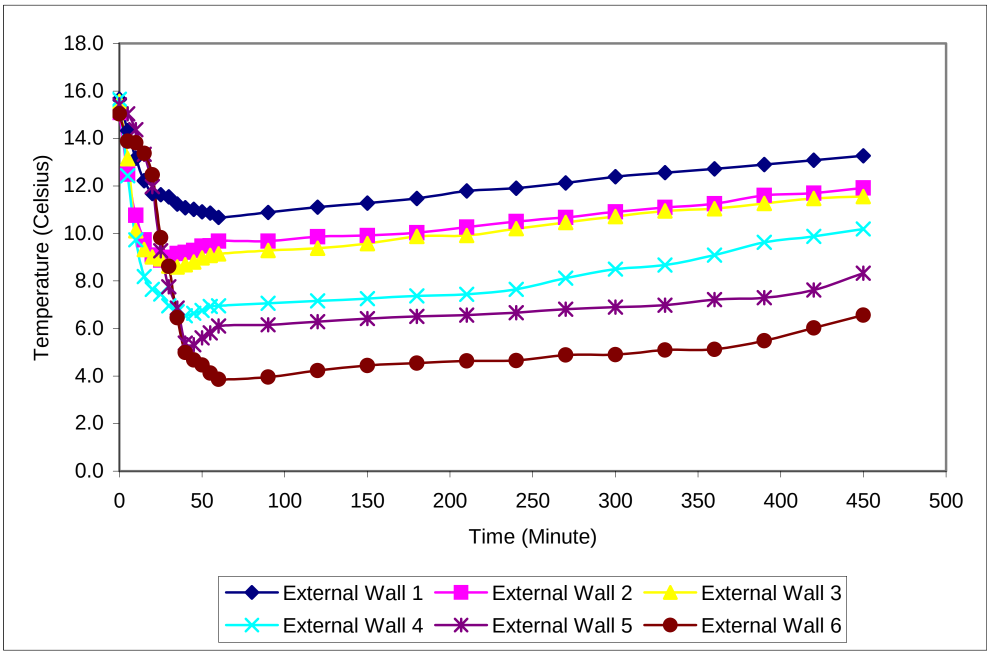


Figure A129: Temperature Profile at External Wall of the Cylinder for Surrounding Temperature of 15^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

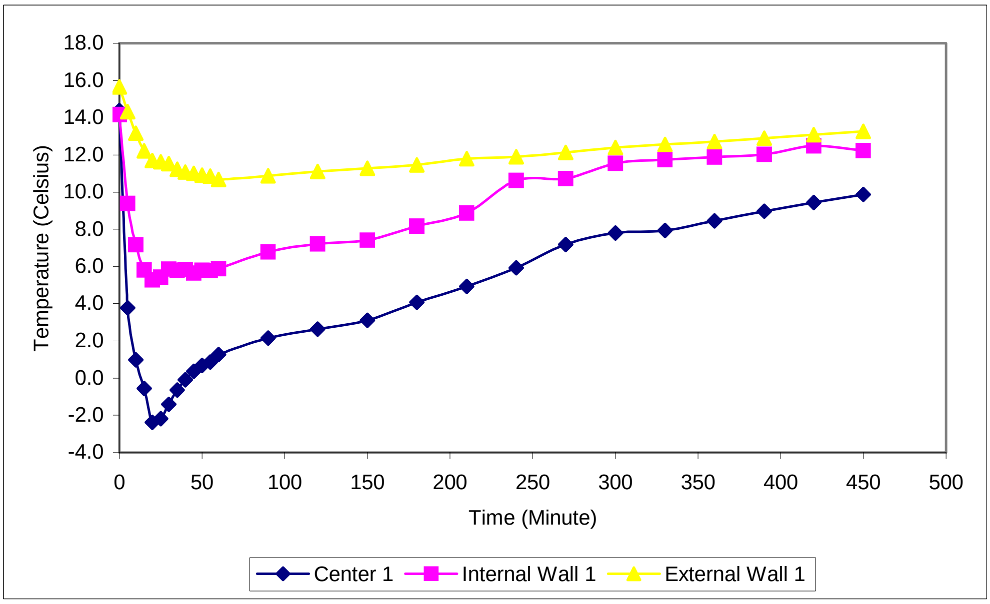


Figure A130: Temperature Profile at Difference Sensor Location of Level 1 Probe for Surrounding Temperature of 15^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

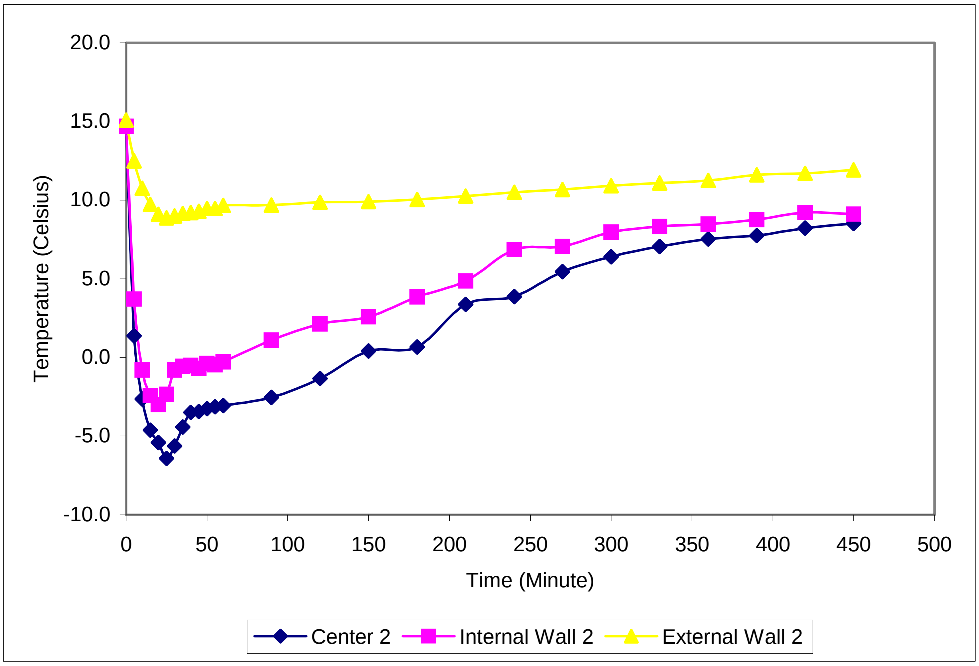


Figure A131: Temperature Profile at Difference Sensor Location of Level 2 Probe for Surrounding Temperature of 15°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

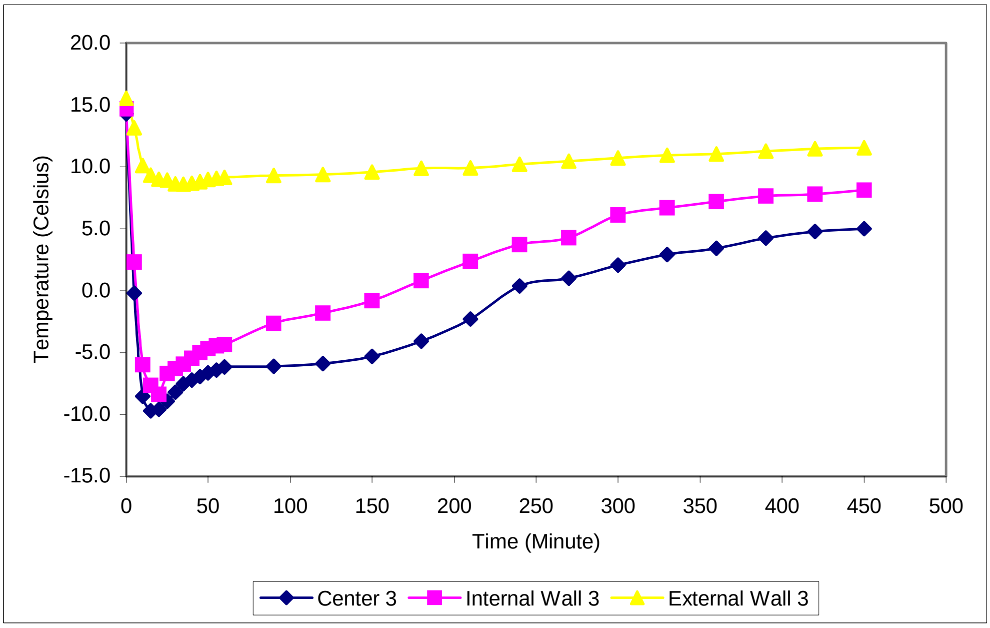


Figure A132: Temperature Profile at Difference Sensor Location of Level 3 Probe for Surrounding Temperature of 15°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

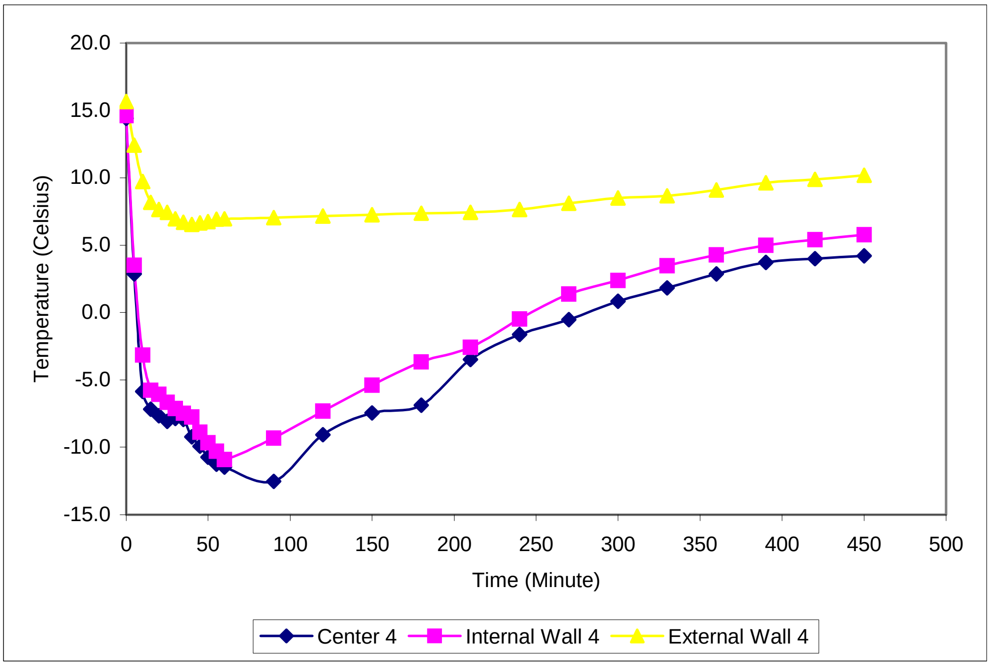


Figure A133: Temperature Profile at Difference Sensor Location of Level 4 Probe for Surrounding Temperature of 15°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

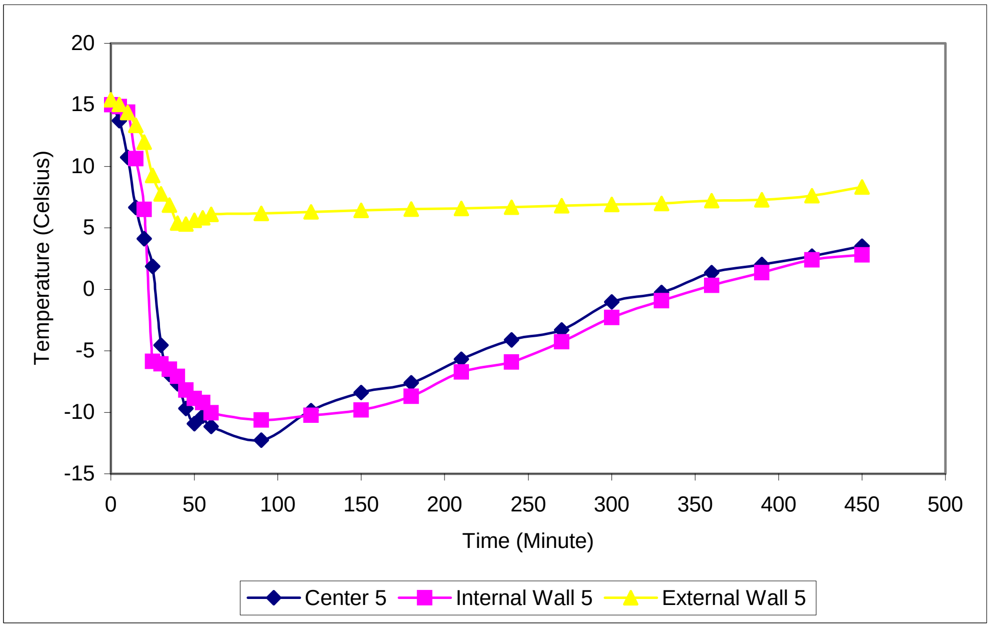


Figure A134: Temperature Profile at Difference Sensor Location of Level 5 Probe for Surrounding Temperature of 15°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

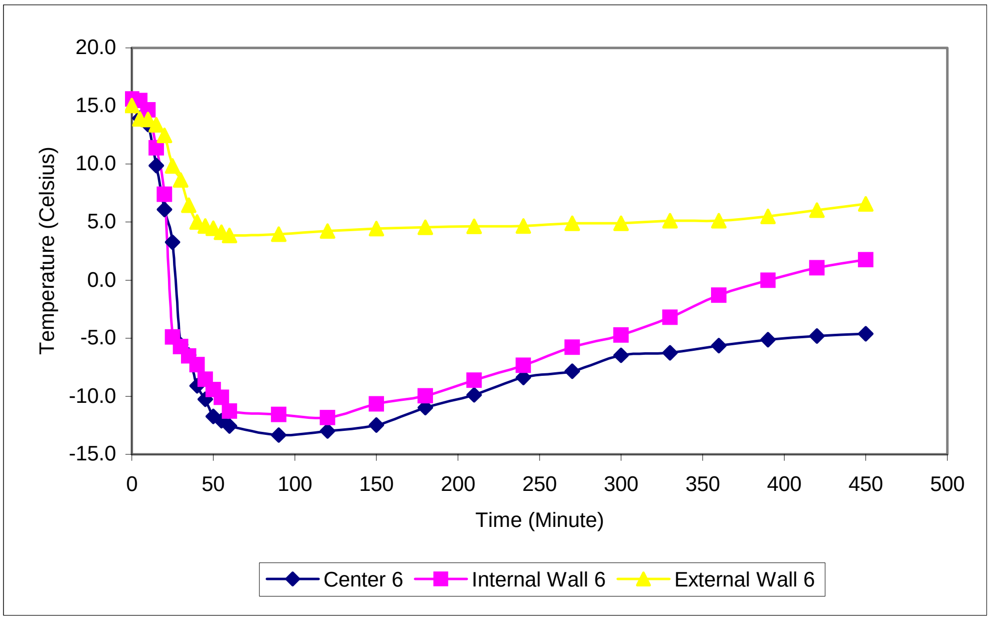


Figure A135: Temperature Profile at Difference Sensor Location of Level 6 Probe for Surrounding Temperature of 15°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

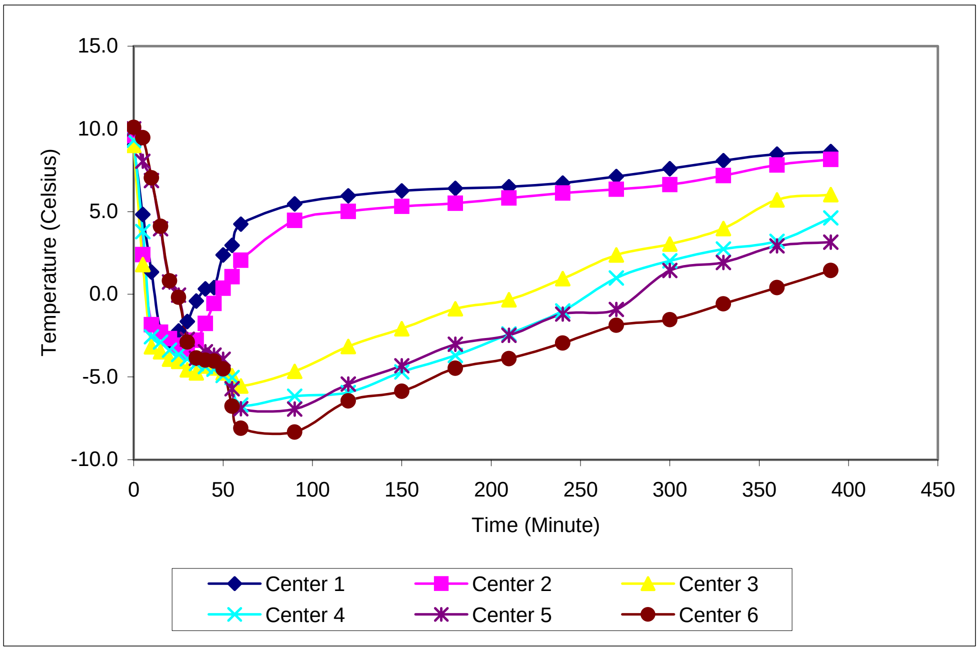


Figure A136: Temperature Profile at Center of the Cylinder for Surrounding Temperature of 10°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

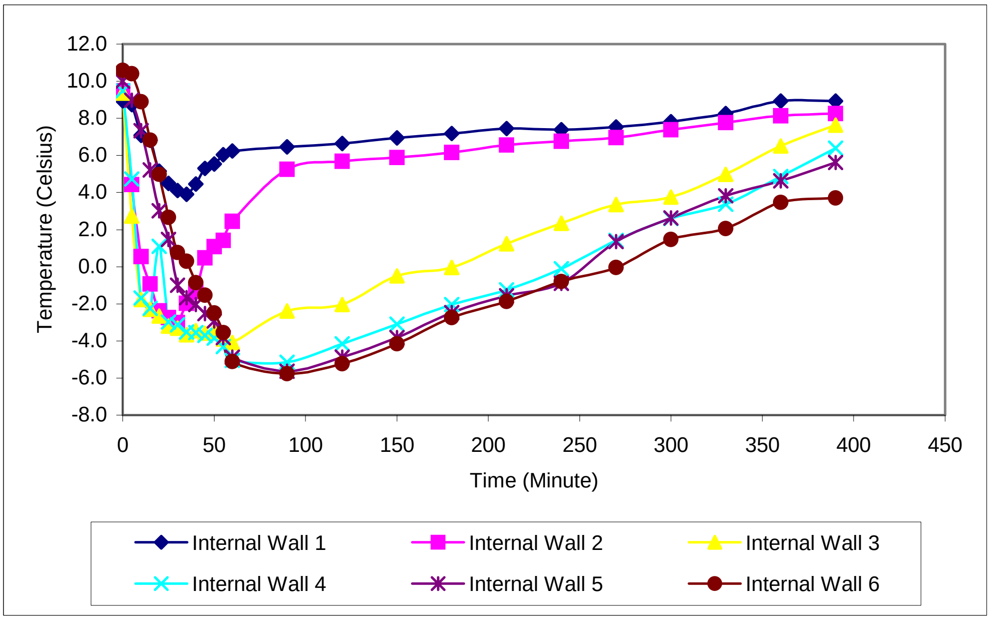


Figure A137: Temperature Profile at Internal Wall of the Cylinder for Surrounding Temperature of 10°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

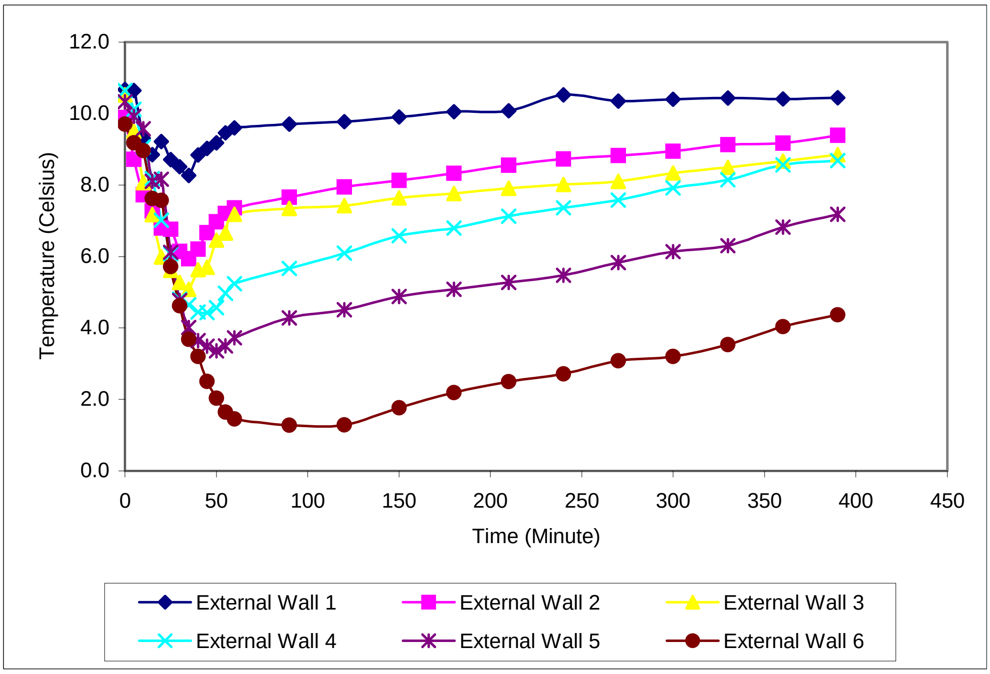


Figure A138: Temperature Profile at External Wall of the Cylinder for Surrounding Temperature of 10°C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

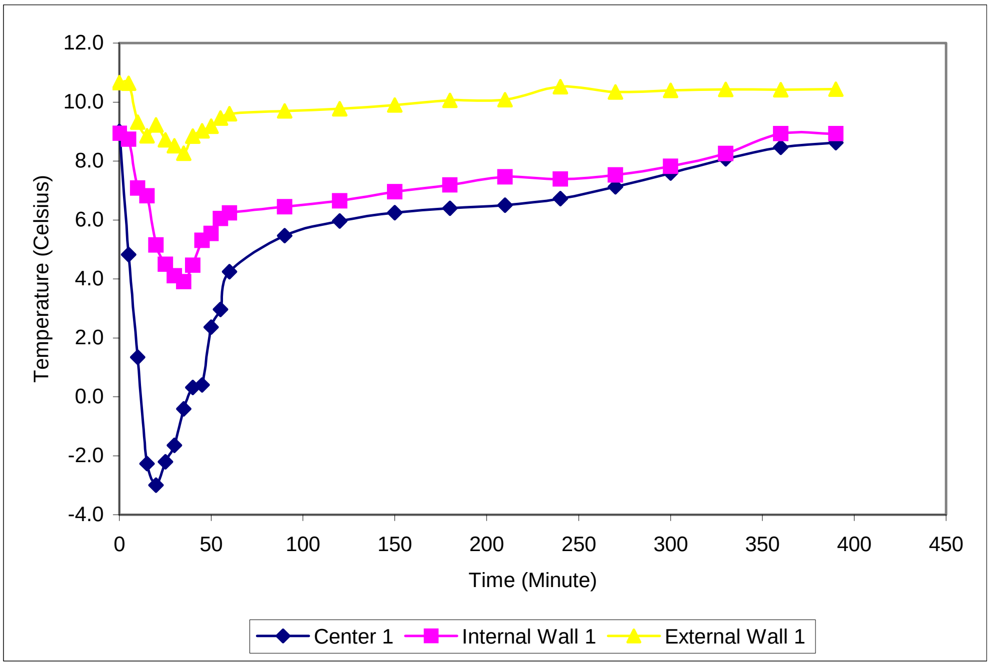


Figure A139: Temperature Profile at Difference Sensor Location of Level 1 Probe for Surrounding Temperature of 10^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

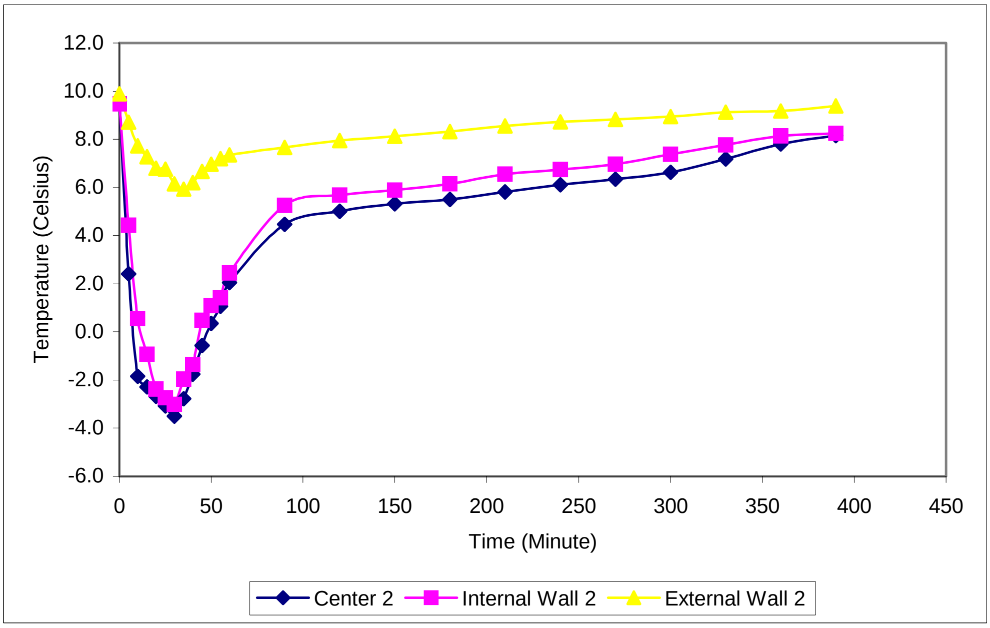


Figure A140: Temperature Profile at Difference Sensor Location of Level 2 Probe for Surrounding Temperature of 10^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

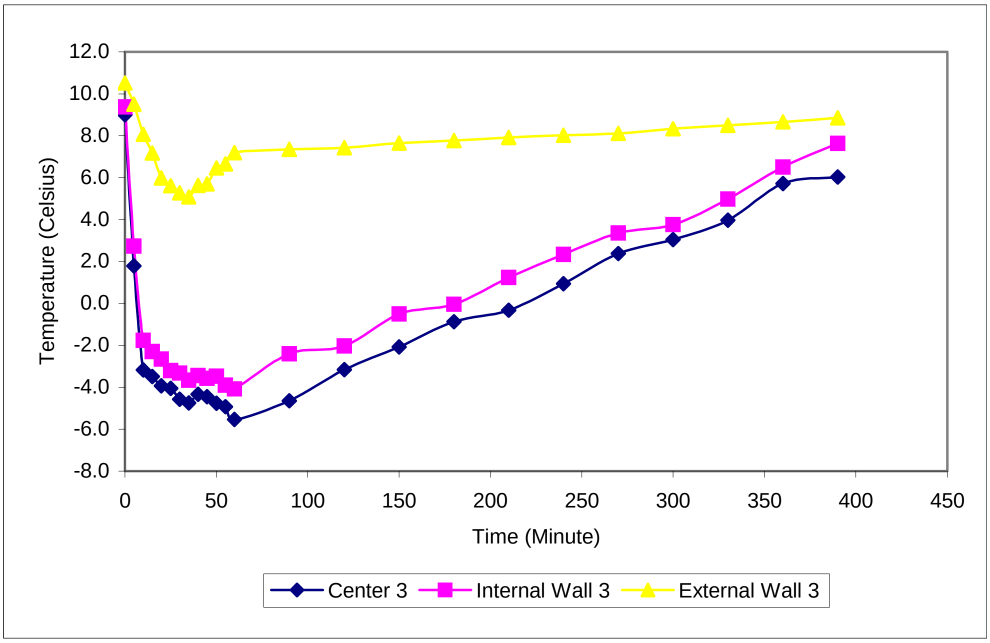


Figure A141: Temperature Profile at Difference Sensor Location of Level 3 Probe for Surrounding Temperature of 10^oC at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

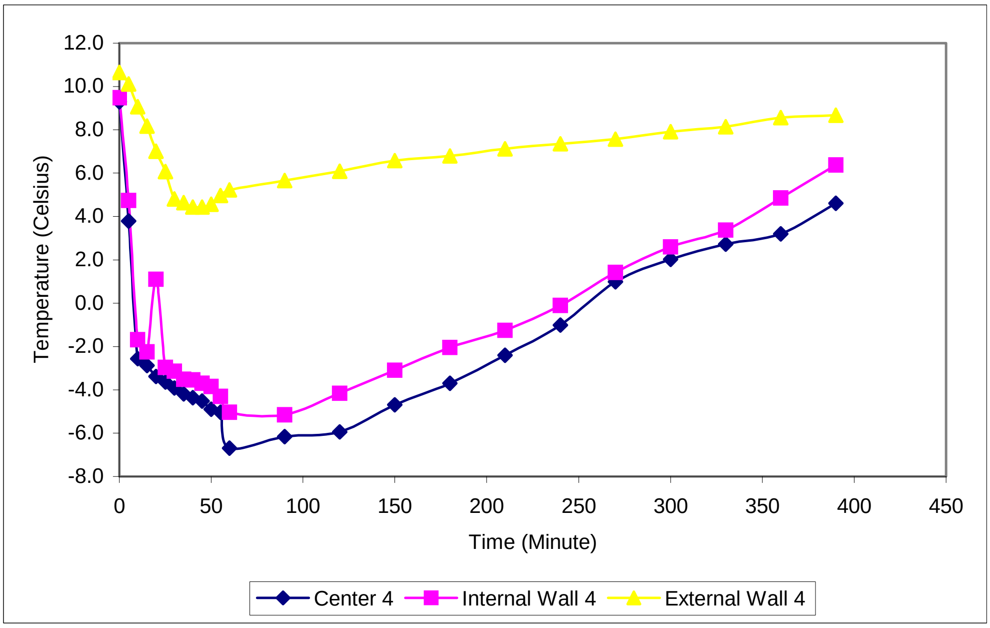


Figure A142: Temperature Profile at Difference Sensor Location of Level 4 Probe for Surrounding Temperature of 10^oC at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

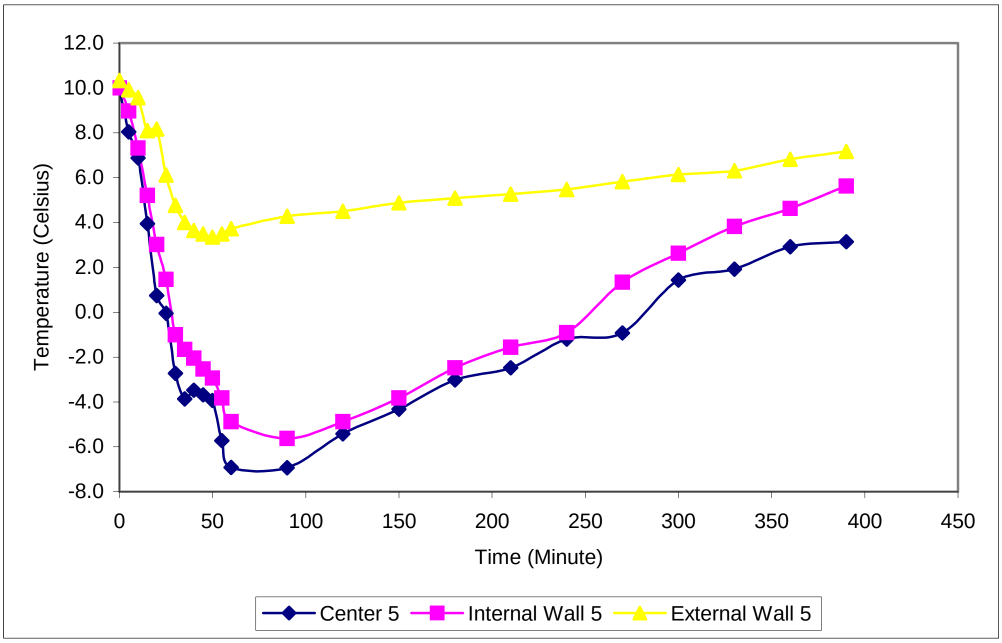


Figure A143: Temperature Profile at Difference Sensor Location of Level 5 Probe for Surrounding Temperature of 10^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

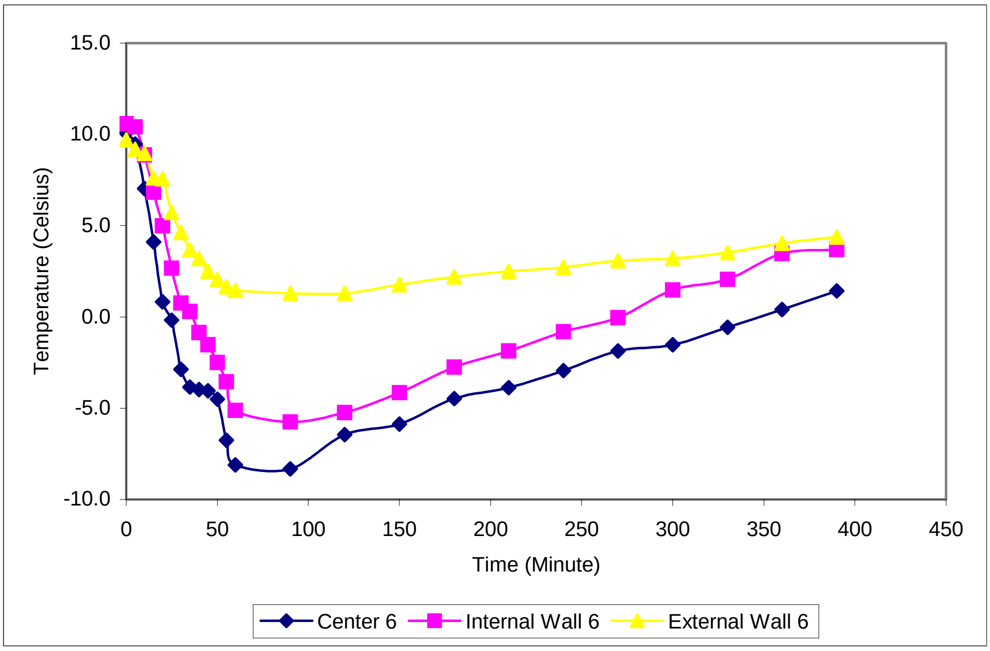


Figure A144: Temperature Profile at Difference Sensor Location of Level 6 Probe for Surrounding Temperature of 10^{o}C at Composition of 4060, Flow rate of 48 liter/minute and Weight of 6 kg

Table A23: Others Data of Commercial Propane for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	161.66	100.00	0.00	100.00	0.00
5	5.58	30.00	35.90	122.11	100.00	0.00		
10	5.18	28.50	30.00	104.15	100.00	0.00		
15	4.85	26.00	26.20	89.89	100.00	0.00		
20	4.55	25.00	22.20	79.14	100.00	0.00		
25	4.29	24.00	19.20	70.68	100.00	0.00		
30	4.06	23.00	17.50	64.04	100.00	0.00		
35	3.85	22.10	16.10	58.65	100.00	0.00		
40	3.65	20.30	14.20	54.39	100.00	0.00		
45	3.47	19.30	13.10	50.73	100.00	0.00		
50	3.30	18.20	12.60	48.12	100.00	0.00	100.00	0.00
55	3.18	17.00	12.40	45.71	100.00	0.00		
60	3.02	16.20	12.20	43.49	100.00	0.00		
90	2.22	13.00	9.60	34.49	100.00	0.00		
120	1.55	10.50	8.10	29.05	100.00	0.00		
150	0.97		7.10	25.01	100.00	0.00	100.00	0.00
180	0.45		6.20	21.77	100.00	0.00		
210	0.17		3.70	15.07	100.00	0.00		
213	0.01		0.00	1.47	100.00	0.00	100.00	0.00

Table A24: Others Data of 8020 Composition for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	158.90	100.00	0.00	78.73	21.27
5	5.58	30.00	33.80	102.81	100.00	0.00		
10	5.21	28.50	27.80	81.28	100.00	0.00		
15	4.91	26.00	23.80	70.27	100.00	0.00		
20	4.65	25.00	21.00	62.90	100.00	0.00		
25	4.41	24.00	18.70	56.18	100.00	0.00		
30	4.20	23.00	16.50	51.07	100.00	0.00	70.74	29.26
35	3.97	22.50	15.00	47.02	100.00	0.00		
40	3.78	20.50	13.60	43.37	100.00	0.00		
45	3.61	19.50	12.90	40.41	100.00	0.00		
50	3.45	18.50	12.30	37.92	100.00	0.00	61.56	38.44
55	3.31	17.50	11.90	35.64	100.00	0.00		
60	3.16	16.50	11.50	33.85	100.00	0.00	57.23	42.77
90	2.42	13.50	9.20	26.47	100.00	0.00	49.02	50.98
120	1.79	11.00	7.50	21.24	82.55	17.45		
150	1.28		5.30	16.97	75.03	24.97	39.79	60.21
180	0.84		4.40	12.21	60.11	39.89		
210	0.52		3.30	8.91	37.63	62.37		
240	0.25		2.30	7.45	19.95	80.05	28.56	71.44
270	0.05		0.00	1.40	4.49	95.51		

Table A25: Others Data of 6040 Composition for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	146.7	100.00	0.00	56.17	43.83
5	5.60	30.00	29.50	98.58	100.00	0.00		
10	5.33	29.00	25.50	74.77	100.00	0.00		
15	5.11	27.00	20.80	58.34	100.00	0.00		
20	4.92	26.00	19.70	47.85	100.00	0.00		
25	4.73	24.80	16.20	40.99	100.00	0.00		
30	4.56	24.00	14.60	36.83	85.87	14.13	50.45	49.55
35	4.41	22.30	13.20	33.41	80.09	19.91		
40	4.26	21.50	12.00	30.26	75.10	24.90		
45	4.12	20.00	11.30	28.48	70.56	29.44		
50	3.98	19.00	10.70	26.99	65.69	34.31	44.22	55.78
55	3.85	18.00	10.00	24.00	60.55	39.45		
60	3.72	17.00	9.70	22.75	55.48	44.52	42.76	57.24
90	3.15	14.00	7.70	18.79	45.56	54.44	39.65	60.35
120	2.60	12.00	6.80	15.98	37.46	62.54		
150	2.15	10.00	6.20	12.88	29.69	70.31	30.49	69.51
180	1.72		5.70	10.06	12.69	87.31		
210	1.32		5.20	9.59	8.38	91.62		
240	0.95		4.80	8.81	3.62	96.38	20.42	79.58
270	0.56		4.20	8.38	0.00	100.00		
300	0.24		3.50	7.39	0.00	100.00		
330	0.07		1.20	5.96	0.00	100.00	14.69	85.31

Table A26: Others Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	121.18	100.00	0.00	35.76	64.24
5	5.62	30.00	27.40	78.79	100.00	0.00		
10	5.33	29.00	22.00	54.06	100.00	0.00		
15	5.10	27.40	18.20	41.84	77.87	22.13		
20	4.91	26.40	17.40	35.23	66.77	33.23		
25	4.72	25.30	15.80	32.75	52.86	47.14		
30	4.56	24.60	13.00	29.75	51.72	48.28	24.09	75.91
35	4.41	22.90	11.50	26.83	50.79	49.21		
40	4.28	22.20	10.40	24.44	49.84	50.16		
45	4.14	21.90	9.80	22.47	48.87	51.13		
50	4.02	21.00	9.00	20.90	47.80	52.20	21.23	78.77
55	3.90	20.50	8.30	19.23	46.79	53.21		
60	3.79	20.00	7.80	18.26	45.72	54.28	18.07	81.93
90	3.21	17.80	6.80	13.77	36.80	63.20	11.81	88.19
120	2.72	15.00	5.90	11.54	28.72	71.28		
150	2.37	13.00	5.40	10.26	20.64	79.36	4.85	95.15
180	1.99	11.00	4.90	9.46	13.65	86.35		
210	1.65	9.50	4.60	8.93	8.02	91.98		
240	1.33		4.40	8.41	4.25	95.75	1.17	98.83
270	1.06		4.20	8.11	1.87	98.13		
300	0.81		3.90	7.98	0.62	99.38		
330	0.54		3.7	7.74	0	100.00	0.00	100.00
360	0.18		0	2.22	0	100.00		

Table A27: Others Data of Commercial Butane for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	41.56	0.00	100.00	0.00	100.00
5	5.74	30.00	22.50	26.53	0.00	100.00		
10	5.41	29.00	20.60	20.96	0.00	100.00		
15	5.15	27.50	17.80	17.22	0.00	100.00		
20	4.92	26.60	16.80	14.51	0.00	100.00		
25	4.73	25.50	14.10	12.54	0.00	100.00		
30	4.57	24.80	12.20	11.05	0.00	100.00		
35	4.43	23.20	10.70	10.02	0.00	100.00		
40	4.32	22.50	9.50	9.40	0.00	100.00		
45	4.20	22.00	8.50	8.82	0.00	100.00		
50	4.10	21.50	7.80	8.42	0.00	100.00	0.00	100.00
55	4.00	21.00	7.30	8.14	0.00	100.00		
60	3.91	20.50	6.90	7.99	0.00	100.00		
90	3.43	18.20	5.80	7.51	0.00	100.00		
120	2.98	16.00	5.40	7.37	0.00	100.00		
150	2.57	14.30	5.10	7.06	0.00	100.00	0.00	100.00
180	2.19	12.40	4.80	6.99	0.00	100.00		
210	1.80	10.40	4.50	6.86	0.00	100.00		
240	1.46		4.30	6.85	0.00	100.00	0.00	100.00
270	1.13		4.20	6.96	0.00	100.00		
300	0.82		3.90	6.94	0.00	100.00		
330	0.64		3.70	6.77	0.00	100.00		
360	0.46		3.20	6.68	0.00	100.00		
390	0.26		0.00	1.37	0.00	100.00		

Table A28: Others Data of Flow Rate of 73 Liter/Minute for Surrounding Temperature of 30^{o}C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	73.00	146.41	100.00	0.00	35.76	64.24
5	5.62	29.00	34.60	70.53	100.00	0.00		
10	5.24	27.00	24.50	47.61	100.00	0.00		
15	4.97	25.50	19.40	36.53	66.91	33.09		
20	4.74	24.50	18.60	33.34	56.79	43.21		
25	4.53	23.00	15.60	29.29	52.86	47.14		
30	4.34	22.00	13.80	25.74	51.72	48.28	20.62	79.38
35	4.17	21.00	12.80	22.94	50.79	49.21		
40	4.01	20.50	12.20	21.14	49.84	50.16		
45	3.85	20.00	11.10	19.25	48.87	51.13		
50	3.72	19.50	10.30	17.85	47.80	52.20		
55	3.58	19.00	10.00	17.14	46.79	53.21		
60	3.45	18.50	9.40	16.35	45.72	54.28	14.90	85.10
90	2.88	15.50	7.80	12.29	36.80	63.20	8.50	91.50
120	2.41	13.50	6.40	10.58	28.72	71.28		
150	2.00	11.30	5.70	9.73	20.64	79.36	4.56	95.44
180	1.64		5.20	8.96	13.65	86.35		
210	1.31		4.90	8.57	8.94	91.06	1.56	98.44
240	1.01		4.50	8.22	4.79	95.21	0.00	100.00
270	0.74		4.00	8.05	0.00	100.00		
300	0.46		3.70	7.87	0.00	100.00		
330	0.24		2.80	1.01	0.00	100.00		

Table A29: Others Data of Flow Rate of 60 Liter/Minute for Surrounding Temperature of 30^{o}C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	60.00	146.41	100.00	0.00	35.76	64.24
5	5.45	29.00	30.70	72.95	100.00	0.00		
10	5.13	27.50	22.20	51.56	100.00	0.00		
15	4.88	26.00	18.70	40.26	75.76	24.24		
20	4.68	25.00	16.20	34.07	59.39	40.61		
25	4.51	24.00	14.30	31.37	54.76	45.24		
30	4.34	23.00	13.00	27.93	53.83	46.17	21.03	78.97
35	4.28	22.20	12.00	25.36	52.82	47.18		
40	4.13	21.50	11.10	23.33	51.88	48.12		
45	4.00	21.00	10.20	21.27	50.84	49.16		
50	3.88	20.20	9.80	19.51	49.77	50.23		
55	3.73	19.50	9.50	18.46	48.77	51.23		
60	3.61	19.00	8.80	17.81	47.84	52.16	15.12	84.88
90	3.06	16.00	7.50	13.07	38.34	61.66	10.03	89.97
120	2.58	14.00	6.30	10.90	29.72	70.28		
150	2.20	12.00	5.60	9.94	21.69	78.31	6.47	93.53
180	1.83	10.00	5.10	9.18	14.63	85.37		
210	1.49		4.80	8.78	8.02	91.98	3.96	96.04
240	1.18		4.40	8.45	4.25	95.75	0.00	100.00
270	0.89		4.00	8.23	1.37	98.63		
300	0.60		3.70	7.94	0.00	100.00		
330	0.34		3.50	7.78	0.00	100.00		
360	0.20		2.50	1.54	0.00	100.00		

Table A30: Others Data of Flow Rate of 48 Liter/Minute for Surrounding Temperature of 30°C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	48.00	146.41	100.00	0.00	35.76	64.24
5	5.62	29.00	27.40	88.79	100.00	0.00		
10	5.33	27.50	20.00	64.06	100.00	0.00		
15	5.10	26.30	16.20	51.84	77.87	22.13		
20	4.91	25.20	14.40	42.23	66.77	33.23		
25	4.72	24.30	12.80	37.75	55.55	44.45		
30	4.56	23.50	12.00	34.75	54.59	45.41	24.09	75.91
35	4.41	23.00	11.00	31.83	53.72	46.28		
40	4.28	22.50	10.30	29.44	52.89	47.11		
45	4.14	22.00	9.70	27.47	52.11	47.89		
50	4.02	21.50	9.50	25.90	51.17	48.83		
55	3.90	21.00	9.30	23.23	50.10	49.90		
60	3.79	20.60	8.80	21.56	49.18	50.82	18.07	81.93
90	3.21	17.00	6.80	19.77	40.42	59.58	13.81	86.19
120	2.72	15.00	5.90	17.54	32.44	67.56		
150	2.37	12.50	5.20	15.26	24.63	75.37	9.85	90.15
180	1.99	10.50	4.70	13.46	17.50	82.50		
210	1.55	8.50	4.30	12.93	11.55	88.45	5.85	94.15
240	1.21		4.00	11.41	6.69	93.31	1.17	98.83
270	0.97		3.80	10.11	1.87	98.13		
300	0.72		3.60	9.98	0.62	99.38	0.00	100.00
330	0.45		3.4	8.74	0.00	100.00		
360	0.18		2.8	1.52	0.00	100.00		

Table A31: Others Data of Flow Rate of 30 Liter/Minute for Surrounding Temperature of 30^{o}C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	30.00	146.41	100.00	0.00	35.76	64.24
5	5.71	31.00	22.20	93.24	100.00	0.00		
10	5.44	30.00	16.40	71.00	100.00	0.00		
15	5.23	29.00	14.10	57.99	100.00	0.00		
20	5.06	28.00	12.40	49.36	65.40	34.60		
25	4.91	27.00	11.80	45.57	54.73	45.27		
30	4.77	26.00	11.00	43.03	53.71	46.29	27.26	72.74
35	4.67	25.20	10.00	40.43	53.12	46.88		
40	4.53	24.50	9.00	38.06	52.57	47.43		
45	4.41	24.00	9.20	36.12	51.96	48.04		
50	4.29	23.30	8.60	34.29	51.38	48.62		
55	4.18	22.80	8.00	32.75	50.75	49.25		
60	4.04	22.00	7.50	31.23	50.12	49.88	24.22	75.78
90	3.46	19.00	6.00	26.96	46.34	53.66	20.74	79.26
120	2.95	16.40	5.20	22.98	41.26	58.74		
150	2.50	14.00	4.90	20.26	35.51	64.49	16.47	83.53
180	2.11	12.60	4.50	18.34	29.27	70.73		
210	1.70	10.50	4.20	16.41	22.96	77.04	11.70	88.30
240	1.36		3.90	14.59	16.14	83.86	6.38	93.62
270	1.06		3.70	13.02	10.05	89.95		
300	0.81		3.50	11.78	5.17	94.83	2.08	97.92
330	0.54		3.30	10.74	1.96	98.04		
360	0.15		2.30	1.63	0.00	100.00		

Table A32: Others Data of Flow Rate of 20 Liter/Minute for Surrounding Temperature of 30^{o}C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	20.00	146.98	100.00	0.00	35.76	64.24
5	5.84	32.00	15.00	106.34	100.00	0.00		
10	5.65	31.00	12.40	89.45	100.00	0.00		
15	5.49	30.00	10.60	77.83	100.00	0.00		
20	5.36	29.50	9.40	69.80	100.00	0.00		
25	5.23	29.00	8.70	63.93	100.00	0.00		
30	5.12	28.40	8.00	59.91	100.00	0.00	28.58	71.42
35	4.99	27.50	7.30	55.32	75.79	24.21		
40	4.90	27.00	6.80	51.16	70.72	29.28		
45	4.80	26.50	6.30	47.92	65.65	34.35		
50	4.72	26.00	6.10	45.34	60.60	39.40		
55	4.63	25.50	5.70	42.57	54.47	45.53		
60	4.56	25.00	5.50	42.23	50.76	49.24	26.92	73.08
90	4.11	22.50	5.30	37.69	47.97	52.03	25.08	74.92
120	3.73	20.40	4.90	34.69	45.40	54.60		
150	3.36	18.40	4.70	32.95	42.37	57.63	21.90	78.10
180	2.96	16.50	4.40	30.66	38.86	61.14		
210	2.64	14.80	4.10	28.75	35.04	64.96	16.71	83.29
240	2.29	13.20	3.90	26.90	31.02	68.98	12.58	87.42
270	1.98	11.50	3.70	25.09	26.77	73.23		
300	1.69	10.00	3.50	23.09	22.27	77.73	8.93	91.07
330	1.39		3.30	21.54	17.82	82.18		
360	1.13		3.10	19.85	13.4	86.60		
390	0.88		3.00	18.64	9.37	90.63		
420	0.64		2.80	17.48	5.90	94.10		
450	0.41		2.70	16.19	3.12	96.88		
480	0.20		2.40	14.79	1.20	98.80		
510	0.10		2.00	1.45	0.00	100.00		

Table A33: Others Data of Surrounding Temperature of 35°C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample Propane (%)	Gas Sample Butane (%)	Liquid Sample Propane (%)	Liquid Sample Butane (%)
0	6.00	32.50	48.00	147.66	100.00	0.00	33.09	66.91
5	5.61	30.00	29.50	83.67	100.00	0.00		
10	5.29	28.50	22.60	61.27	100.00	0.00		
15	5.04	27.00	18.80	50.03	74.02	25.98		
20	4.83	25.00	16.50	42.51	65.83	34.17		
25	4.64	24.00	15.40	40.04	57.26	42.74		
30	4.46	23.00	14.00	36.21	56.30	43.70	23.93	76.07
35	4.24	22.00	12.90	33.21	55.23	44.77		
40	4.09	21.00	12.00	30.67	49.84	50.16		
45	3.95	20.50	11.20	28.65	48.87	51.13		
50	3.82	20.00	10.60	26.87	47.80	52.20		
55	3.69	19.50	10.00	25.28	46.79	53.21		
60	3.57	19.00	9.50	23.88	45.72	54.28	19.67	80.33
90	2.94	15.00	7.90	18.97	36.80	63.20	10.88	89.12
120	2.34	13.00	6.60	16.53	28.72	71.28		
150	1.85	11.00	5.80	14.39	20.64	79.36	6.04	93.96
180	1.42	9.00	5.10	13.80	13.65	86.35		
210	1.07		4.50	12.89	8.02	91.98	1.69	98.31
240	0.74		4.20	12.29	4.25	95.75	1.07	98.93
270	0.52		4.00	11.82	1.87	98.13	0.95	99.05
300	0.21		3.50	11.42	0.62	99.38		
310	0.04		0.00	2.72	0	100.00		

Table A34: Others Data of Surrounding Temperature of 30^{o}C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.20	48.30	131.18	100.00	0.00	33.76	66.24
5	5.62	29.00	27.40	80.79	100.00	0.00		
10	5.31	27.00	20.00	59.06	100.00	0.00		
15	5.07	26.00	16.20	47.84	77.87	22.13		
20	4.86	25.00	14.40	40.23	74.77	25.23		
25	4.69	24.00	13.80	36.75	66.86	33.14		
30	4.52	23.00	13.00	32.75	58.72	41.28	24.09	75.91
35	4.38	22.00	12.00	29.83	57.79	42.21		
40	4.24	21.50	11.10	26.44	54.25	45.75		
45	4.10	21.00	10.40	24.47	53.14	46.86		
50	3.97	20.00	9.80	23.90	52.02	47.98		
55	3.86	19.50	9.30	22.23	50.88	49.12		
60	3.75	19.00	8.80	21.26	49.60	50.40	20.07	79.93
90	3.16	16.00	6.80	17.77	41.86	58.14	11.81	88.19
120	2.67	14.00	5.90	15.54	32.22	67.78		
150	2.27	12.00	5.20	13.81	22.45	77.55	8.45	91.55
180	1.89	10.00	4.70	13.26	15.73	84.27		
210	1.56	8.50	4.30	12.23	10.09	89.91	1.97	98.03
240	1.25		4.00	11.99	5.88	94.12	1.17	98.83
270	0.98		3.80	11.71	2.87	97.13		
300	0.64		3.60	11.28	1.62	98.38		
330	0.40		3.4	10.34	0	100.00		
360	0.18		0	2.22	0	100.00		

Table A35: Others Data of Surrounding Temperature of 25°C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.00	127.12	100.00	0.00	33.83	66.17
5	5.62	29.00	29.00	77.50	100.00	0.00		
10	5.33	27.00	20.80	54.18	100.00	0.00		
15	5.10	26.00	16.70	42.60	76.20	23.80		
20	4.91	25.00	14.20	35.21	73.18	26.82		
25	4.72	24.00	12.90	31.30	65.65	34.35		
30	4.56	23.00	12.50	29.04	57.83	42.17	25.24	74.76
35	4.41	22.50	11.40	27.31	57.07	42.93		
40	4.28	22.00	10.70	24.74	56.19	43.81		
45	4.14	21.50	10.00	23.17	55.54	44.46		
50	4.02	21.00	9.40	21.49	54.62	45.38		
55	3.90	20.50	8.90	20.20	53.66	46.34		
60	3.79	20.00	8.50	18.83	52.57	47.43	21.06	78.94
90	3.21	17.00	6.60	16.11	45.74	54.26	12.77	87.23
120	2.72	15.00	5.40	14.89	38.17	61.83		
150	2.37	13.00	4.70	13.46	30.34	69.66	9.67	90.33
180	1.99	11.50	4.20	12.92	22.90	77.10		
210	1.65	10.00	3.90	12.03	16.15	83.85	2.36	97.64
240	1.33	9.00	3.60	11.79	10.38	89.62	2.05	97.95
270	1.06		3.40	11.50	6.07	93.93	1.96	98.04
300	0.81		3.20	11.19	3.17	96.83	1.15	98.85
330	0.54		3.10	10.18	1.4	98.60		
360	0.38		2.60	7.94	0.47	99.53		
390	0.25		0.00	2.49	0.00	100.00		

Table A36: Others Data of Surrounding Temperature of 20^{o}C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	31.80	48.00	122.59	100.00	0.00	34.05	65.95
5	5.54	30.00	26.60	65.01	100.00	0.00		
10	5.27	29.00	18.80	46.54	100.00	0.00		
15	5.06	28.00	15.00	36.43	73.68	26.32		
20	4.88	26.00	12.80	30.61	72.10	27.90		
25	4.71	25.00	12.30	28.62	63.23	36.77		
30	4.57	24.00	11.10	25.80	57.64	42.36	26.47	73.53
35	4.44	23.00	10.30	23.63	56.85	43.15		
40	4.31	22.50	9.60	21.64	56.04	43.96		
45	4.19	22.00	9.00	19.94	55.19	44.81		
50	4.08	21.50	8.50	18.84	54.40	45.60		
55	3.97	21.00	8.00	17.63	53.48	46.52		
60	3.87	20.50	7.60	16.59	52.44	47.56	21.71	78.29
90	3.37	18.00	5.80	14.02	46.30	53.70	13.77	86.23
120	2.93	16.00	4.90	13.49	39.51	60.49		
150	2.58	14.30	4.20	12.50	32.58	67.42	10.27	89.73
180	2.24	13.20	3.70	11.97	25.85	74.15		
210	1.93	12.30	3.40	11.17	19.70	80.30	3.69	96.31
240	1.67	11.30	3.10	10.76	14.57	85.43	2.68	97.32
270	1.41	10.20	2.90	10.23	10.19	89.81	2.19	97.81
300	1.18		2.80	9.86	6.47	93.53	1.24	98.76
330	0.94		2.70	8.68	3.78	96.22		
360	0.72		2.60	6.45	1.98	98.02		
390	0.52		2.50	6.12	0.93	99.07		
420	0.42		2.40	5.83	0.36	99.64		
450	0.32		2.10	2.83	0.00	100.00		

Table A37: Others Data of Surrounding Temperature of 15^{o}C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	31.60	48.00	118.96	100.00	0.00	34.55	65.45
5	5.62	30.00	27.90	58.68	100.00	0.00		
10	5.33	29.00	19.80	42.19	100.00	0.00		
15	5.10	27.00	16.50	32.98	73.27	26.73		
20	4.91	26.00	13.70	27.98	66.37	33.63		
25	4.75	25.00	12.40	25.26	60.23	39.77		
30	4.59	24.50	11.30	22.76	57.70	42.30	27.77	72.23
35	4.44	24.00	10.40	20.34	56.86	43.14		
40	4.31	23.00	9.40	19.76	55.87	44.13		
45	4.19	22.50	8.60	18.61	55.00	45.00		
50	4.08	22.00	8.00	17.63	54.12	45.88		
55	3.98	21.50	7.20	16.84	53.19	46.81		
60	3.88	21.00	6.70	15.30	52.33	47.67	22.47	77.53
90	3.45	18.50	4.90	13.05	46.85	53.15	14.81	85.19
120	3.07	16.50	4.30	12.44	41.49	58.51		
150	2.74	15.00	3.60	11.74	35.90	64.10	11.22	88.78
180	2.46	14.00	3.20	11.19	30.43	69.57		
210	2.20	13.00	2.90	10.87	25.32	74.68	7.70	92.30
240	1.96	12.00	2.70	10.62	20.57	79.43	6.78	93.22
270	1.75	11.00	2.50	10.19	16.38	83.62	5.47	94.53
300	1.56	9.50	2.40	9.51	12.57	87.43	4.53	95.47
330	1.31		2.30	8.63	9.38	90.62		
360	1.12		2.20	6.16	6.79	93.21		
390	0.94		2.10	4.35	4.71	95.29		
420	0.77		2.00	3.77	3.13	96.87		
450	0.60		1.90	2.70	1.98	98.02		

Table A38: Others Data of Surrounding Temperature of 10^{o}C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	31.50	48.00	110.26	100.00	0.00	35.11	64.89
5	5.67	29.00	25.70	55.13	100.00	0.00		
10	5.39	28.00	18.70	39.91	100.00	0.00		
15	5.18	27.00	14.60	30.49	72.37	27.63		
20	5.03	26.00	12.50	25.18	65.61	34.39		
25	4.87	25.00	11.40	23.11	62.66	37.34		
30	4.73	24.00	10.30	20.89	62.01	37.99	28.54	71.46
35	4.58	23.00	9.50	19.17	61.40	38.60		
40	4.46	22.50	8.60	17.87	60.85	39.15		
45	4.35	22.00	8.10	16.67	60.24	39.76		
50	4.25	21.50	7.50	16.03	59.74	40.26		
55	4.15	21.00	6.90	15.26	59.18	40.82		
60	4.06	20.50	6.40	14.65	58.23	41.77	23.04	76.96
90	3.61	18.50	4.70	12.60	52.99	47.01	15.18	84.82
120	3.26	17.00	4.00	11.84	47.99	52.01		
150	2.97	15.50	3.40	11.27	42.89	57.11	12.00	88.00
180	2.69	14.50	3.10	11.08	37.77	62.23		
210	2.44	13.50	2.70	10.76	32.83	67.17	9.57	90.43
240	2.26	12.50	2.50	10.55	28.14	71.86	7.78	92.22
270	2.08	11.50	2.30	10.04	23.85	76.15	6.47	93.53
300	1.87	10.50	2.20	9.43	20.00	80.00	5.34	94.66
330	1.70	9.5	2.10	8.47	16.35	83.65		
360	1.53		2.00	6.03	13.09	86.91		
390	1.40		1.80	2.33	10.31	89.69		

Table A39: Others Data of Weight of 7 kg for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	7.00	37.50	48.00	148.15	100.00	0.00	36.41	63.59
5	6.60	35.00	29.00	84.48	100.00	0.00		
10	6.27	33.50	21.50	60.87	100.00	0.00		
15	5.99	32.00	17.00	49.01	77.07	22.93		
20	5.78	30.60	16.30	46.20	66.77	33.23		
25	5.58	29.50	15.50	42.32	60.15	39.85		
30	5.38	28.30	14.50	38.88	58.46	41.54	28.10	71.90
35	5.21	27.40	14.10	36.02	55.74	44.26		
40	5.05	26.50	13.30	33.44	52.06	47.94		
45	4.89	25.60	12.40	31.30	51.32	48.68		
50	4.75	24.80	11.80	29.46	50.55	49.45		
55	4.61	24.00	11.20	27.90	49.76	50.24		
60	4.48	23.50	10.70	26.47	48.96	51.04	24.26	75.74
90	3.76	19.50	8.80	21.17	43.62	56.38	15.66	84.34
120	3.15	16.80	7.50	17.41	37.57	62.43	10.23	89.77
150	2.61	14.00	6.50	14.67	31.02	68.98	7.25	92.75
180	2.17	11.50	5.70	12.62	24.19	75.81	5.27	94.73
210	1.75		5.00	11.53	17.48	82.52	3.58	96.42
240	1.36		4.60	10.57	11.47	88.53	2.36	97.64
270	1.01		4.20	9.94	6.59	93.41	1.57	98.43
300	0.69		3.80	9.38	3.17	96.83		
330	0.39		3.40	8.77	1.06	98.94		
360	0.20		2.60	2.34	0.00	100.00		

Table A40: Others Data of Weight of 6 kg for Surrounding Temperature of 30°C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	31.00	48.00	141.18	100.00	0.00	35.76	64.24
5	5.62	29.00	27.40	78.79	100.00	0.00		
10	5.33	27.00	20.00	55.99	100.00	0.00		
15	5.10	26.00	16.20	46.89	72.87	22.13		
20	4.91	25.00	14.40	43.54	61.77	33.23		
25	4.72	24.00	13.80	39.23	57.86	47.14		
30	4.56	23.00	13.00	36.17	53.72	48.28	27.09	72.91
35	4.41	22.00	12.00	33.22	52.79	49.21		
40	4.28	21.50	11.10	30.59	49.84	50.16		
45	4.14	21.00	10.40	28.38	48.87	51.13		
50	4.02	20.00	9.80	26.71	47.80	52.20		
55	3.90	19.50	9.30	25.18	46.79	53.21		
60	3.79	19.00	8.80	23.78	45.72	54.28	20.07	79.93
90	3.21	16.00	6.80	18.49	39.80	63.20	13.81	86.19
120	2.72	14.00	5.90	15.52	33.72	71.28	7.85	92.15
150	2.37	12.00	5.20	13.20	25.64	79.36	4.27	95.73
180	1.99	10.00	4.70	11.75	17.65	86.35	3.67	96.33
210	1.65	8.50	4.30	10.51	12.02	91.98	1.17	98.83
240	1.33		4.00	9.82	7.25	95.75		
270	1.06		3.80	8.11	1.87	98.13		
300	0.81		3.60	7.98	0.62	99.38		
330	0.54		3.2	7.74	0.00	100.00		
360	0.18		2.7	2.22	0.00	100.00		

Table A41: Others Data of Weight of 5 kg for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	5.00	26.50	48.00	134.64	100.00	0.00	34.64	65.36
5	4.58	25.30	24.50	74.45	100.00	0.00		
10	4.31	24.00	17.90	54.06	100.00	0.00		
15	4.10	23.00	15.40	41.84	68.00	32.00		
20	3.91	21.50	14.80	35.23	54.91	45.09		
25	3.73	20.50	13.40	32.75	52.73	47.27		
30	3.57	19.50	12.50	29.75	50.16	49.84	25.69	74.31
35	3.38	19.00	11.40	26.83	51.32	48.68		
40	3.24	18.50	10.60	24.44	49.48	50.52		
45	3.11	18.00	9.90	22.47	47.55	52.45		
50	2.99	17.00	9.30	20.90	45.56	54.44		
55	2.88	16.50	8.80	19.23	44.52	55.48		
60	2.77	16.00	8.40	18.26	43.43	56.57	18.15	81.85
90	2.21	13.50	6.70	13.77	36.41	63.59	11.73	88.27
120	1.74	11.00	5.90	11.54	29.78	70.22	5.70	94.30
150	1.31		5.00	10.26	21.04	78.96	2.66	97.34
180	0.93		4.40	9.46	14.53	85.47	1.92	98.08
210	0.60		3.90	8.93	7.55	92.45		
240	0.29		3.50	8.41	2.88	97.12		
270	0.16		2.00	2.04	0.00	100.00		

Table A42: Others Data of Weight of 4 kg for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	4.00	20.40	48.00	130.92	100	0.00	34.13	65.87
5	3.54	19.00	23.00	72.70	100	0.00		
10	3.28	18.00	16.20	51.01	100	0.00		
15	3.07	17.00	12.80	40.53	65.62	34.38		
20	2.91	16.00	12.30	37.59	51.47	48.53		
25	2.76	15.30	11.40	33.51	50.67	49.33		
30	2.62	14.60	10.40	30.69	49.08	50.92	23.00	77.00
35	2.50	13.80	9.50	27.75	47.74	52.26		
40	2.39	13.30	8.80	25.40	47.5	52.50		
45	2.28	12.80	8.20	23.49	43.27	56.73		
50	2.17	12.30	7.70	21.98	43.92	56.08		
55	2.07	11.80	7.30	20.61	40.55	59.45		
60	1.98	11.40	7.00	19.74	39.23	60.77	14.84	85.16
90	1.50	9.50	5.70	15.24	29.89	70.11	10.27	89.73
120	1.07		4.80	12.90	19.85	80.15	4.07	95.93
150	0.72		4.10	11.48	10.79	89.21	1.90	98.10
180	0.39		3.60	10.06	4.13	95.87	0.00	100.00
210	0.12		1.20	1.03	0.00	100.00		

Table A43: Others Data of Weight of 3 kg for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	3.00	15.50	48.00	126.24	100.00	0.00	34.05	65.95
5	2.65	14.50	21.90	59.16	100.00	0.00		
10	2.40	13.50	15.00	40.62	66.78	33.22		
15	2.21	12.50	14.30	36.58	58.45	41.55		
20	2.03	11.50	12.30	30.92	49.1	50.90		
25	1.88	10.50	10.90	26.79	47.84	52.16		
30	1.75	10.00	9.60	23.30	46.5	53.50	18.76	81.24
35	1.62		8.60	20.66	45.3	54.70		
40	1.51		7.80	18.48	44.07	55.93	17.30	82.70
45	1.40		7.30	16.91	41.73	58.27		
50	1.31		6.70	15.70	39	61.00	13.57	86.43
55	1.25		6.40	14.54	36.97	63.03		
60	1.17		5.90	13.65	32.78	67.22	8.53	91.47
90	0.75		4.50	10.74	23.12	76.88	6.31	93.69
120	0.41		3.90	9.74	13.45	86.55	2.17	97.83
150	0.10		3.20	0.84	3.17	96.83		

Table A44: Others Data of Weight of 2 kg for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	2.00	10.80	48.00	121.98	100.00	0.00	33.85	66.15
5	1.70		18.40	50.93	100.00	0.00		
10	1.49		13.90	37.10	100.00	0.00	24.38	75.62
15	1.31		12.10	30.84	51.17	48.83		
20	1.16		10.00	25.05	47.05	52.95	19.96	80.04
25	1.02		8.60	21.11	44.29	55.71		
30	0.91		7.60	18.16	41.63	58.37	15.66	84.34
35	0.84		6.70	16.05	39.05	60.95		
40	0.75		6.00	14.30	37.15	62.85	12.65	87.35
45	0.67		5.50	13.06	34.52	65.48		
50	0.60		5.00	12.40	28.64	71.36	7.20	92.80
55	0.52		4.70	11.69	24.42	75.58		
60	0.46		4.50	11.19	20.28	79.72	6.27	93.73
90	0.18		3.40	9.57	11.09	88.91	2.25	97.75
120	0.00		1.00	0.22	1.45	98.55		

Table A45: Sweeting and Icing Data

Composition (Propane)	Sweeting (Minute)	Ice Formation (Minute)	Temperature (Celsius)	Flowrate (Liter/Minute)	Weight (kg)
100	45	55	30	48	6
80	50	60			
60	55	70			
40	60	90			
0	60	90			

Temperature (Celsius)	Sweeting (Minute)	Ice Formation (Minute)	Composition (Propane/Butane)	Flowrate (Liter/Minute)	Weight (kg)
35	60	90	4060	48	6
30	60	90			
25	55	70			
20	40	60			
15	30	50			
10	25	45			

Flowrate (Liter/Minute)	Sweeting (Minute)	Ice Formation (Minute)	Composition (Propane/Butane)	Flowrate (Liter/Minute)	Weight (kg)
73	30	40	4060	48	6
60	40	50			
48	60	90			
30	90	120			
20	120	150			

Weight (kg)	Sweeting (Minute)	Ice Formation (Minute)	Composition (Propane/Butane)	Temperature (Celsius)	Flowrate (Liter/Minute)
7	60	90	4060	30	48
6	60	90			
5	50	60			
4	40	55			
3	30	40			
2	20	30			

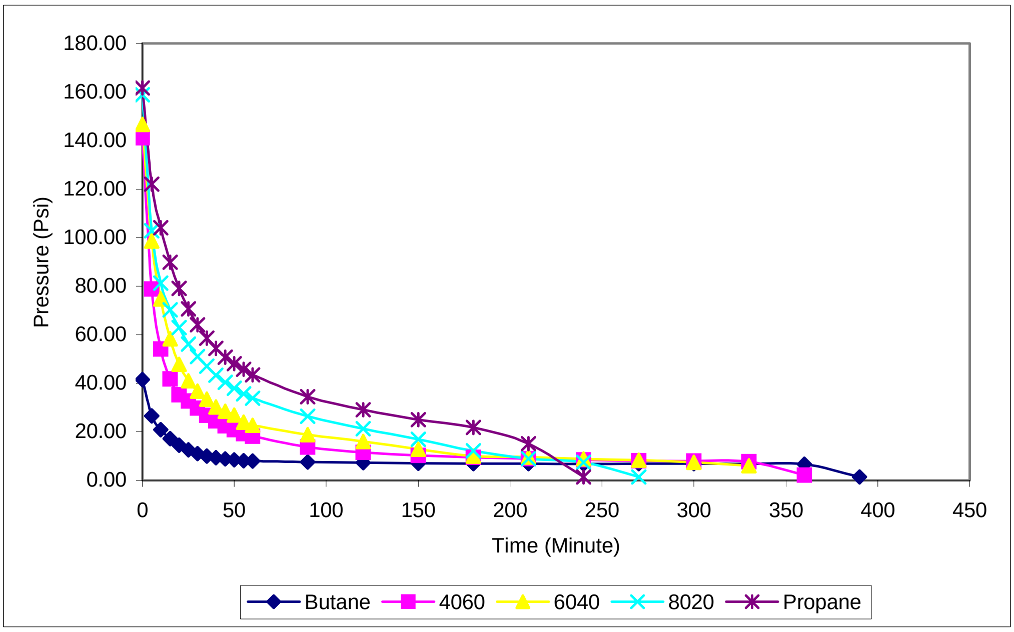


Figure B1: Cylinder Pressure of Various Compositions at Flow Rate of 48 Liter/Minute, Surrounding Temperature 30^{o}C and Weight 6 kg

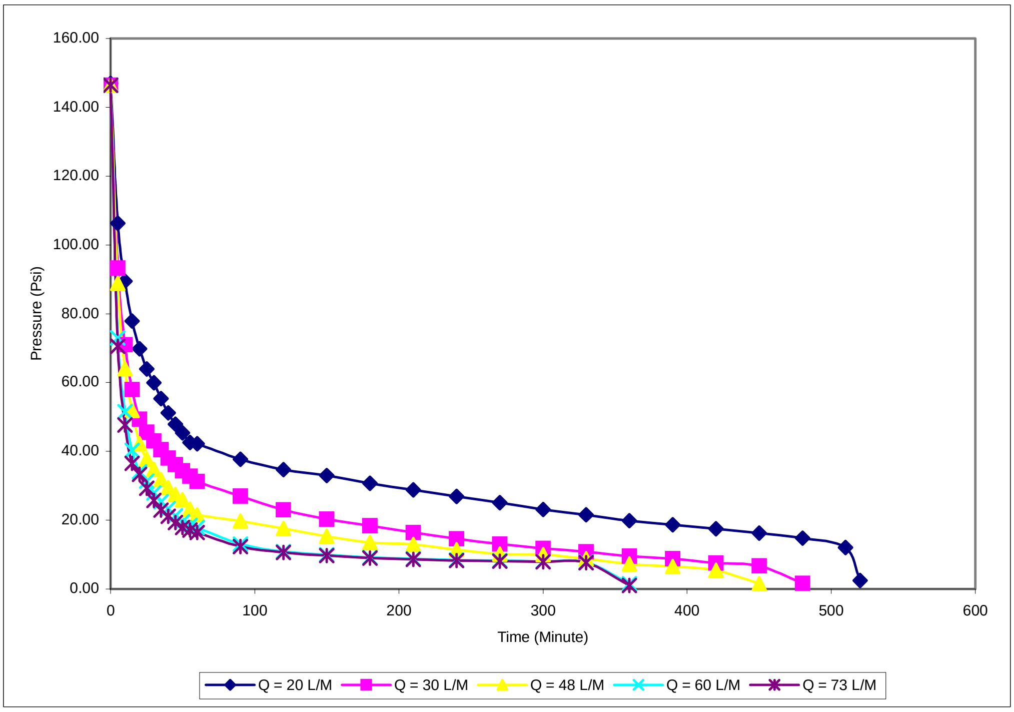


Figure B2: Cylinder Pressure of Various Flow Rate at Composition of 4060 Surrounding Temperature 30^{o}C and Weight 6 kg

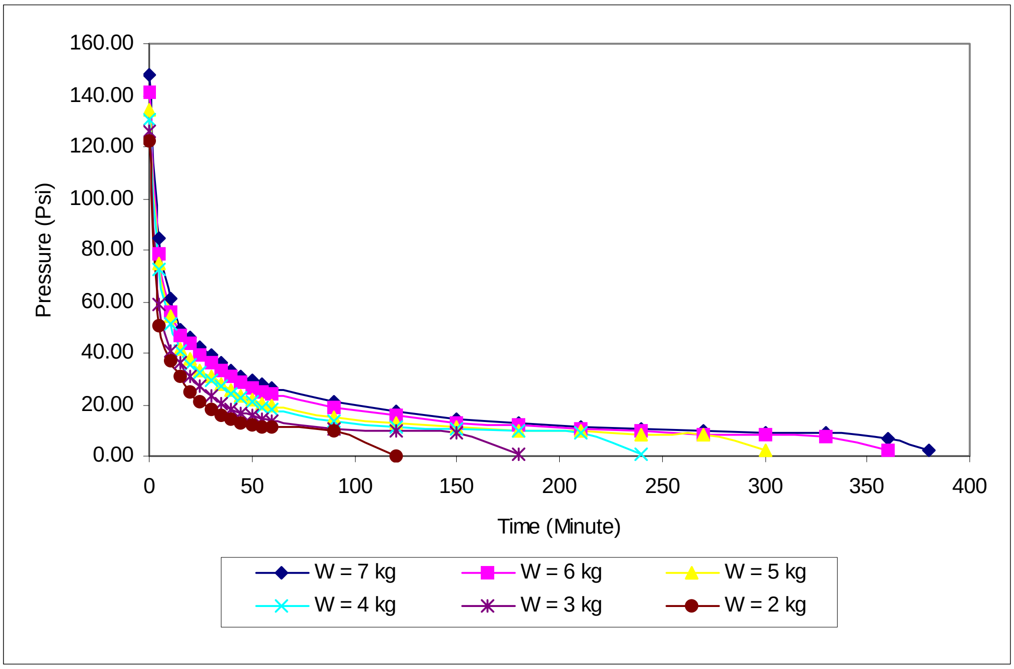


Figure B3: Cylinder Pressure of Various Weights at Composition of 4060, Surrounding Temperature of 30°C and Flow rate of 48 Liter/ Minute

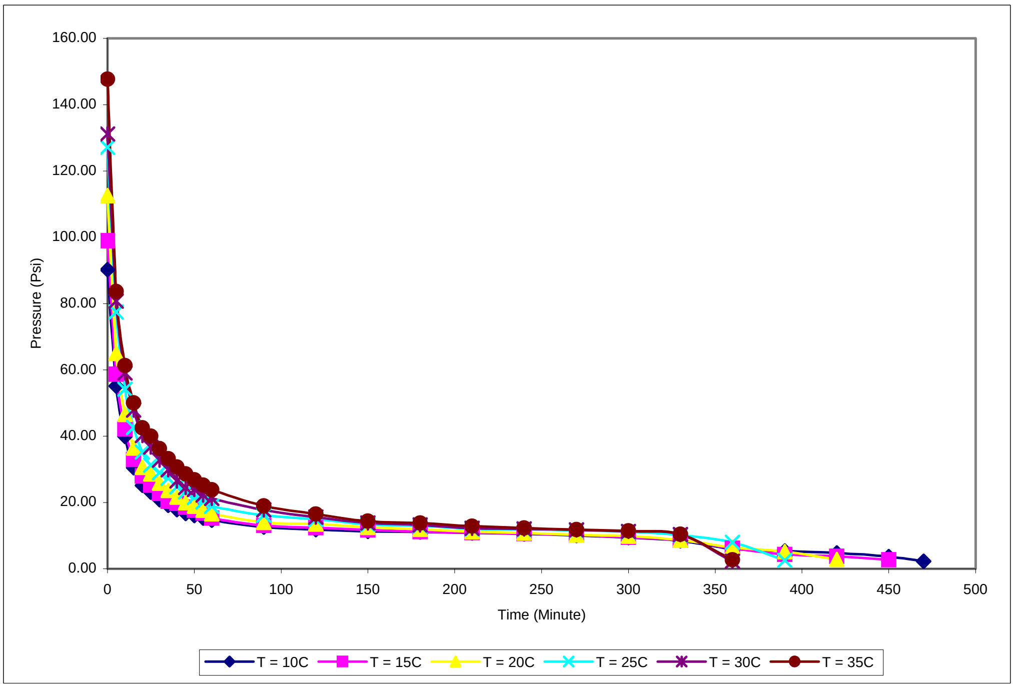


Figure B4: Cylinder Pressure of Various Surrounding Temperatures at Flow rate of 48 Liter/ Minute, Composition of 4060, and Weight of 6 kg

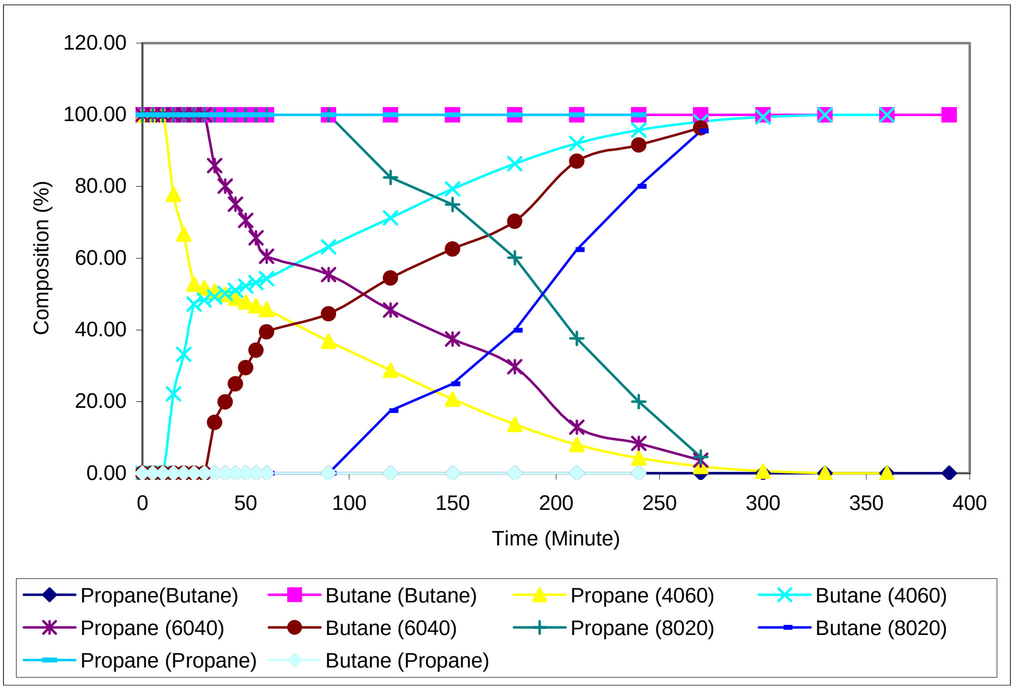


Figure C1: Vapor Compositions of Various Compositions at Flow Rate of 48 Liter/Minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

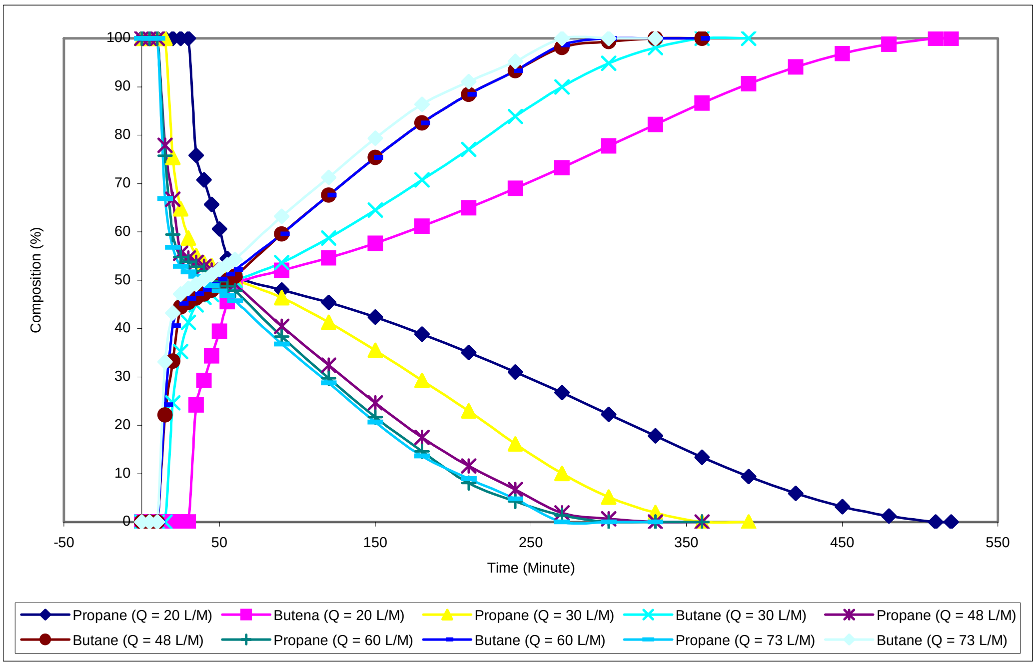


Figure C2: Vapor Compositions of Various Flow Rate at Composition of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

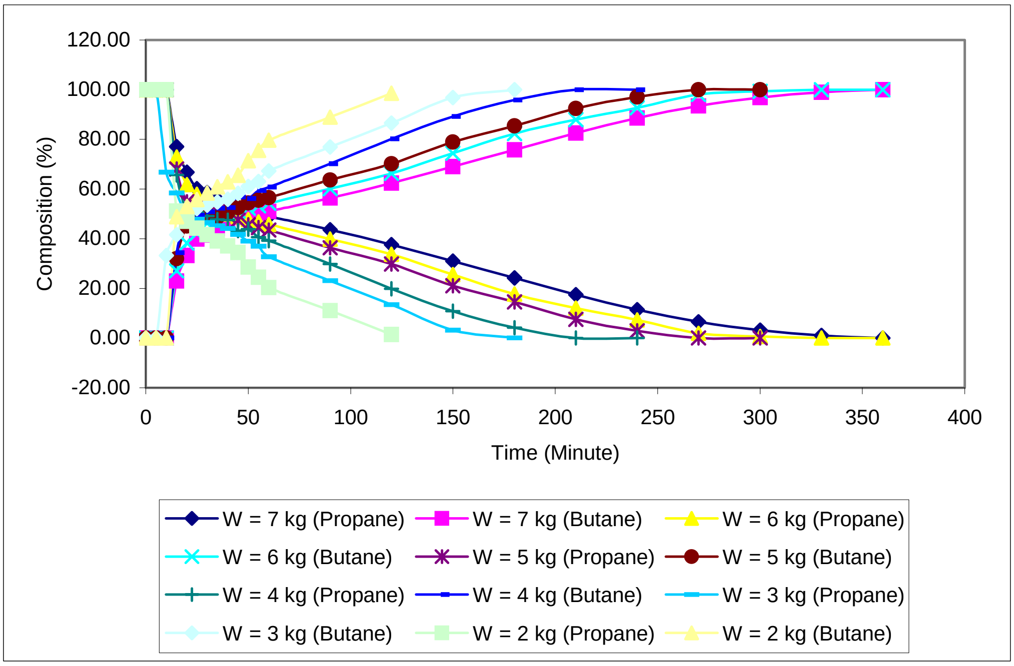


Figure C3: Vapor Compositions of Various Weights at Composition of 4060, Surrounding Temperature of 30°C and Flow Rate of 48 Liter/Minute

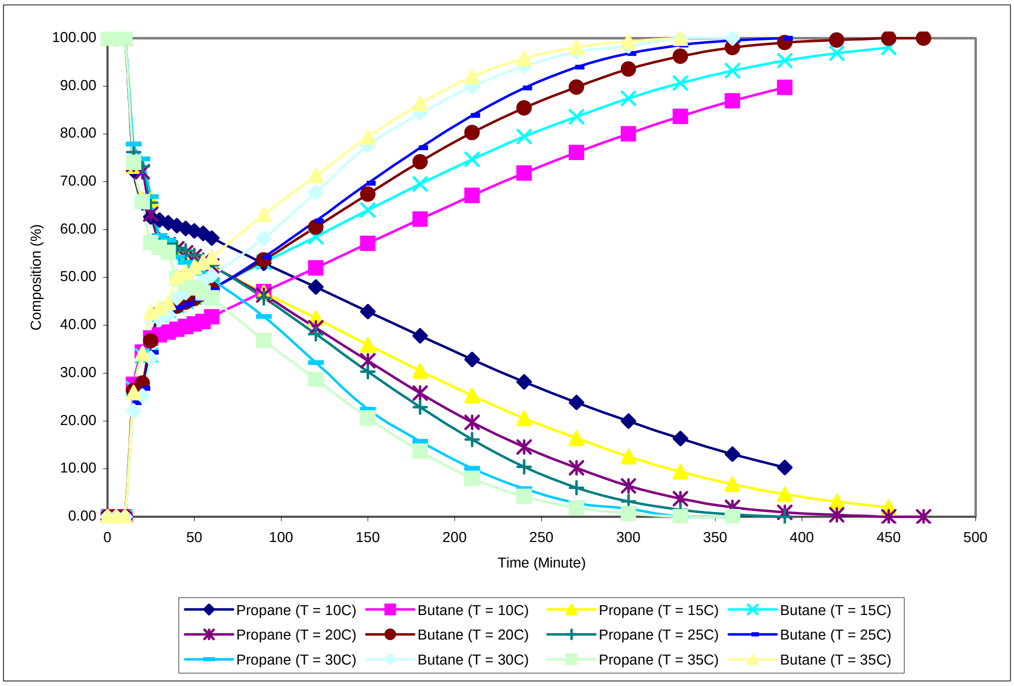


Figure C4: Vapor Compositions of Various Surrounding Temperatures at Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

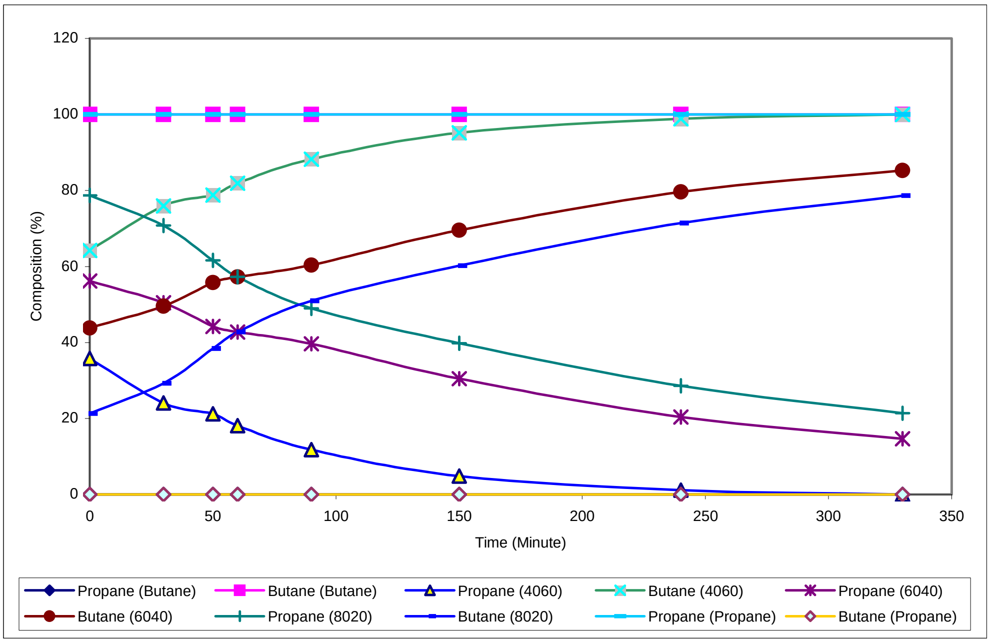


Figure C5: Liquid Compositions of Various Compositions at Flow Rate of 48 Liter/Minute, Surrounding Temperature of 30°C and Weight of 6 kg

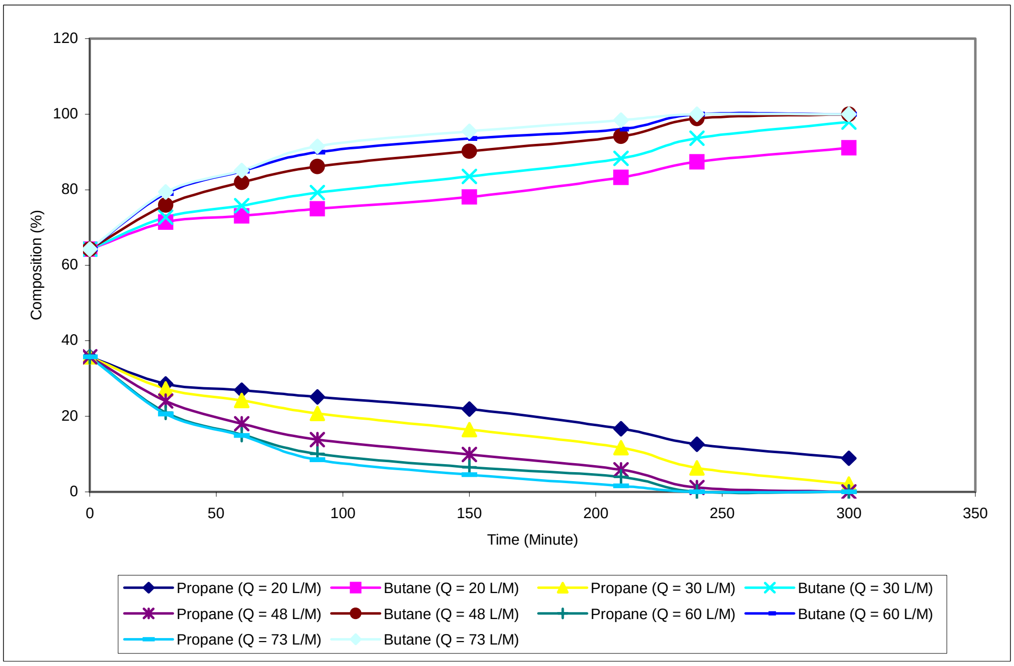


Figure C6: Liquid Compositions of Various Compositions at Flow Rate of 48 Liter/Minute, Surrounding Temperature of 30°C and Weight of 6 kg

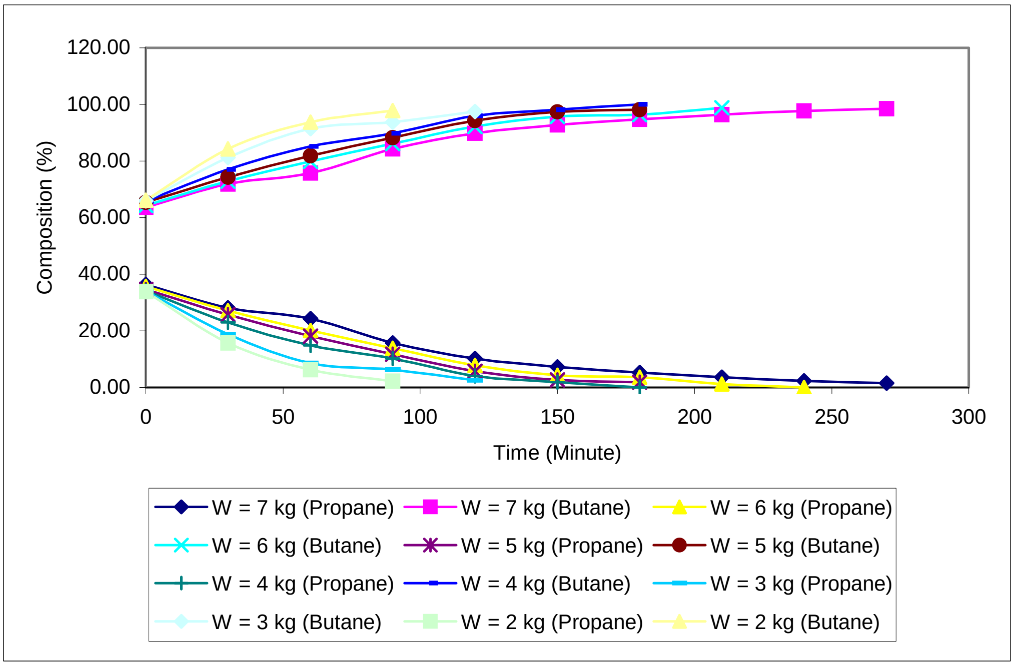


Figure C7: Liquid Compositions of Various Weights at Composition of 4060, Surrounding Temperature of 30°C and Flow Rate of 48 Liter/Minute

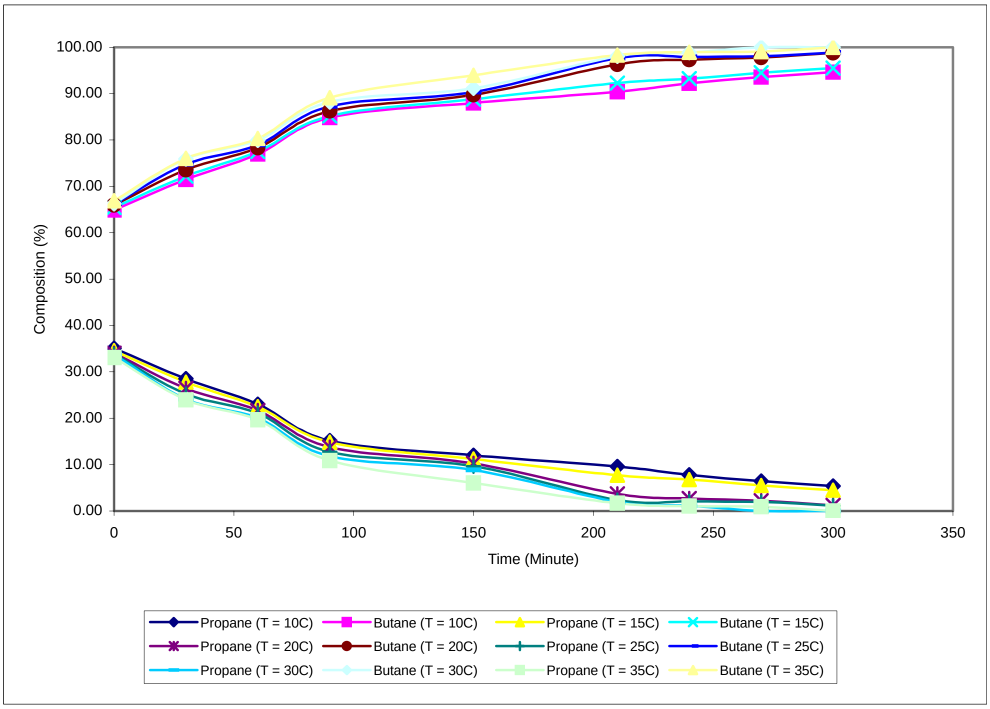


Figure C8: Liquid Compositions of Various Surrounding Temperatures at Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

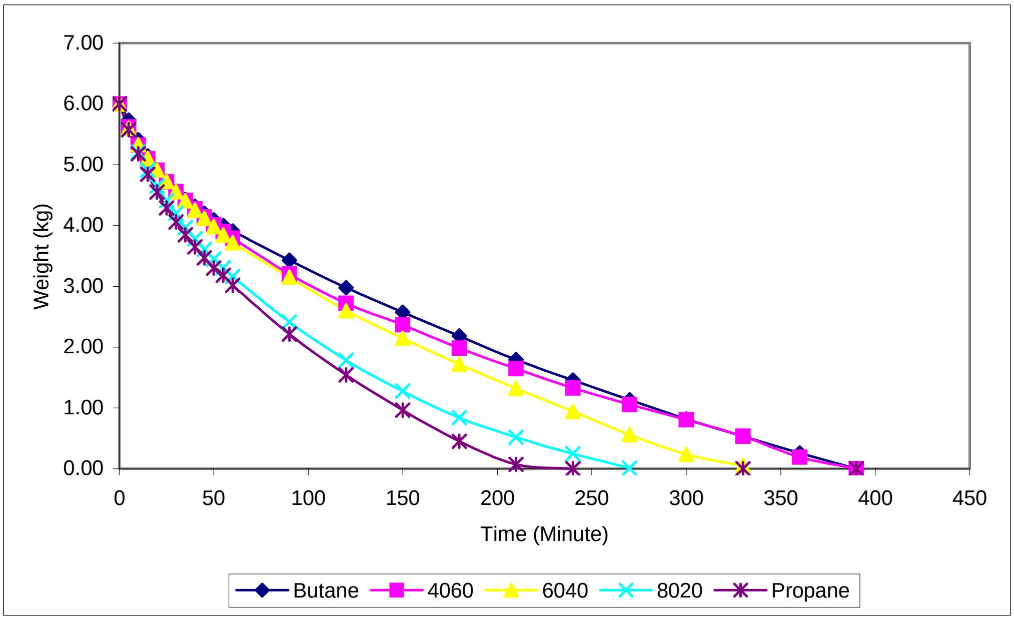


Figure D1: Weight Profile of Various Compositions at Flow Rate of 48 Liter/Minute, Surrounding Temperature of 30°C and Weight of 6 kg

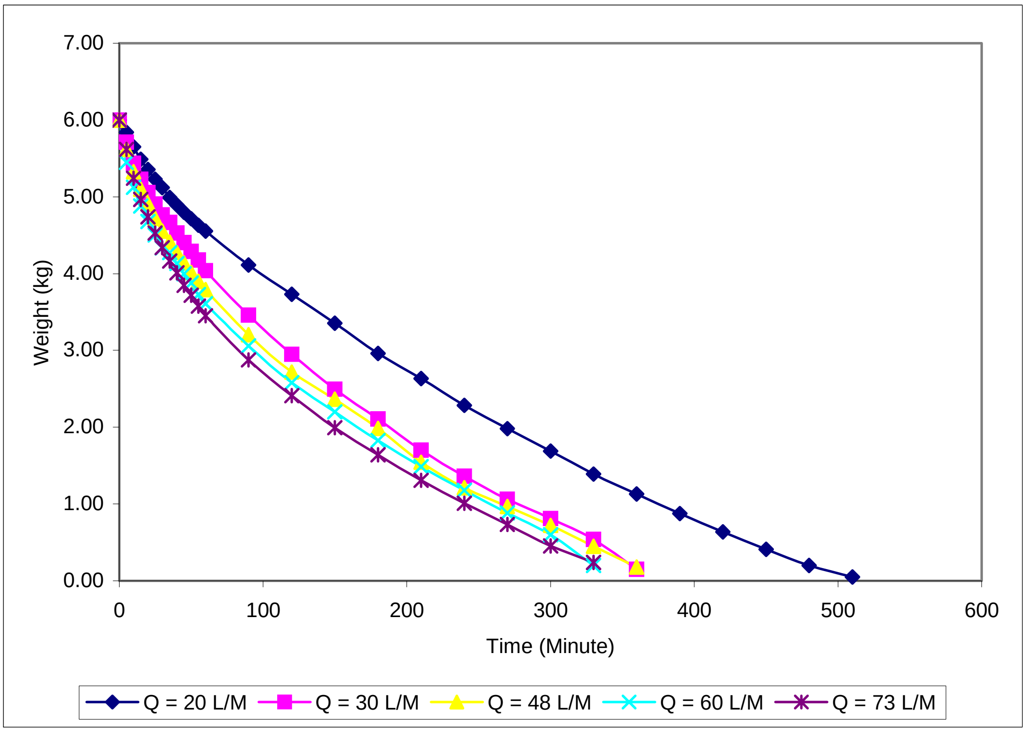


Figure D2: Weight Profile of Various Flow Rate at Compositions of 4060, Surrounding Temperature of 30°C and Weight of 6 kg

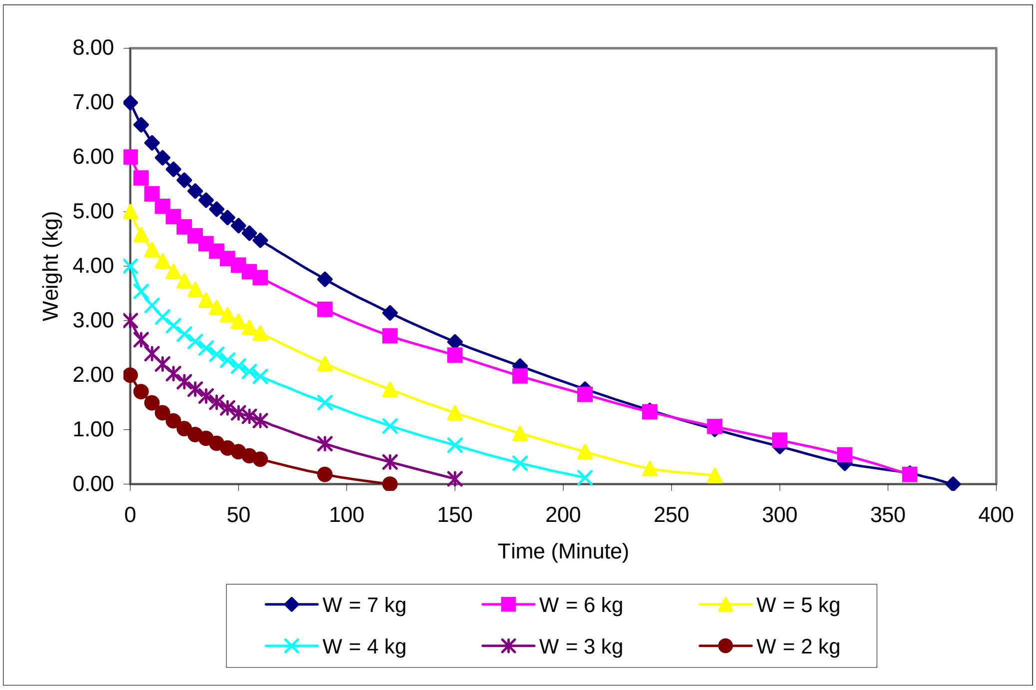


Figure D3: Weight Profile of Various Weights at Flow Rate of 48 Liter/Minute, Compositions of 4060 and Surrounding Temperature of 30°C

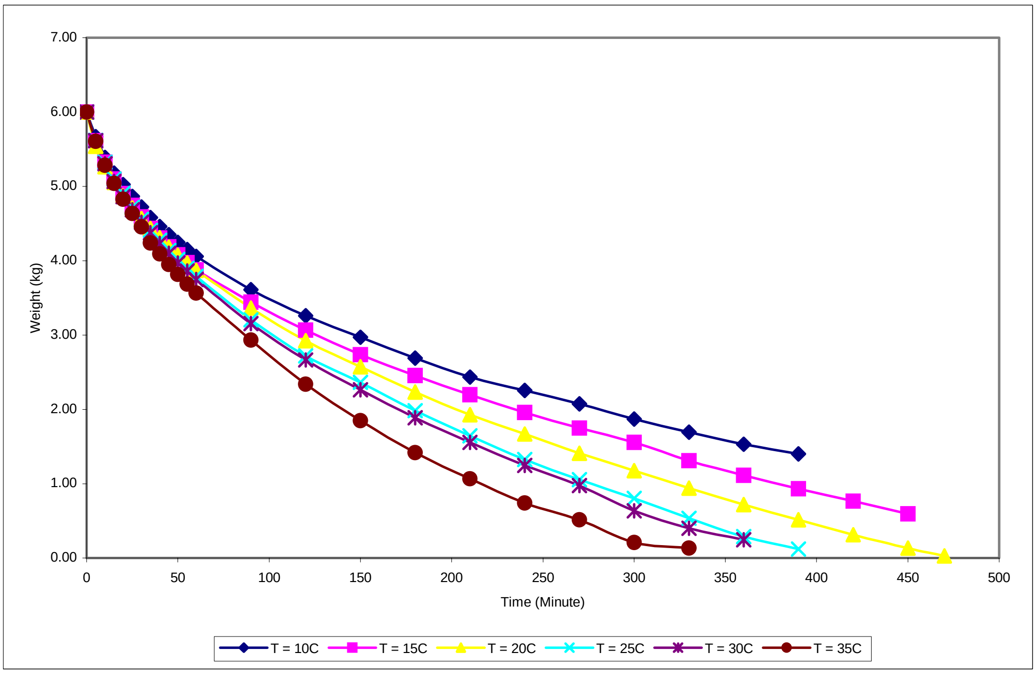


Figure D4: Weight Profile of Various Surrounding Temperatures at Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

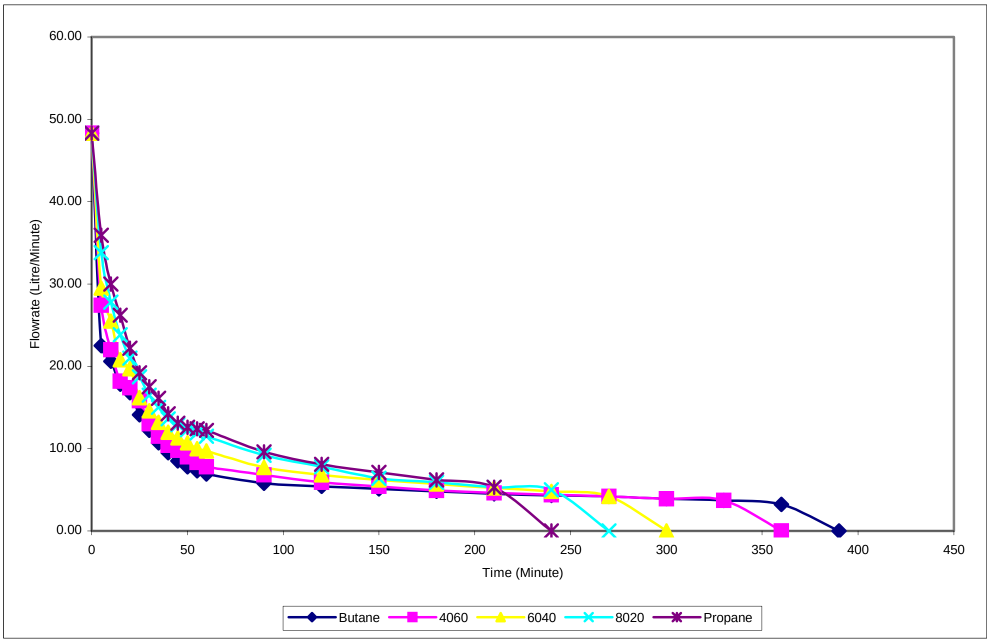


Figure E1: Discharging Flow Rate Profile of Various Compositions at Flow Rate of 48 Liter/Minute, Surrounding Temperature of 30°C and Weight of 6 kg

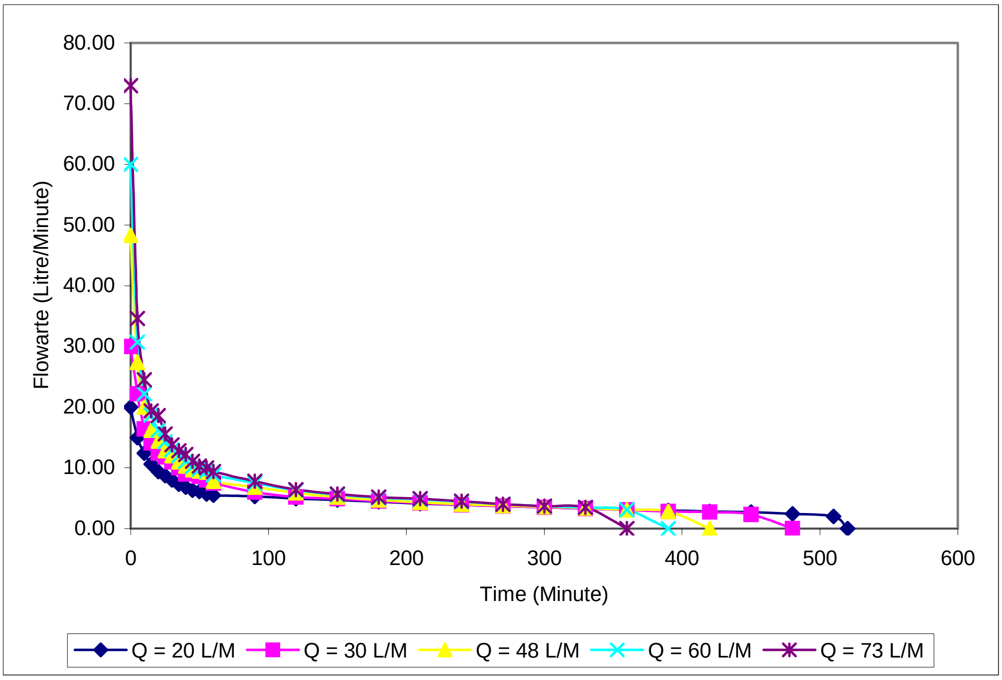


Figure E2: Discharging Flow Rate Profile of Various Flow Rates at Weight of 6 kg, Surrounding Temperature of 30°C and Composition of 4060

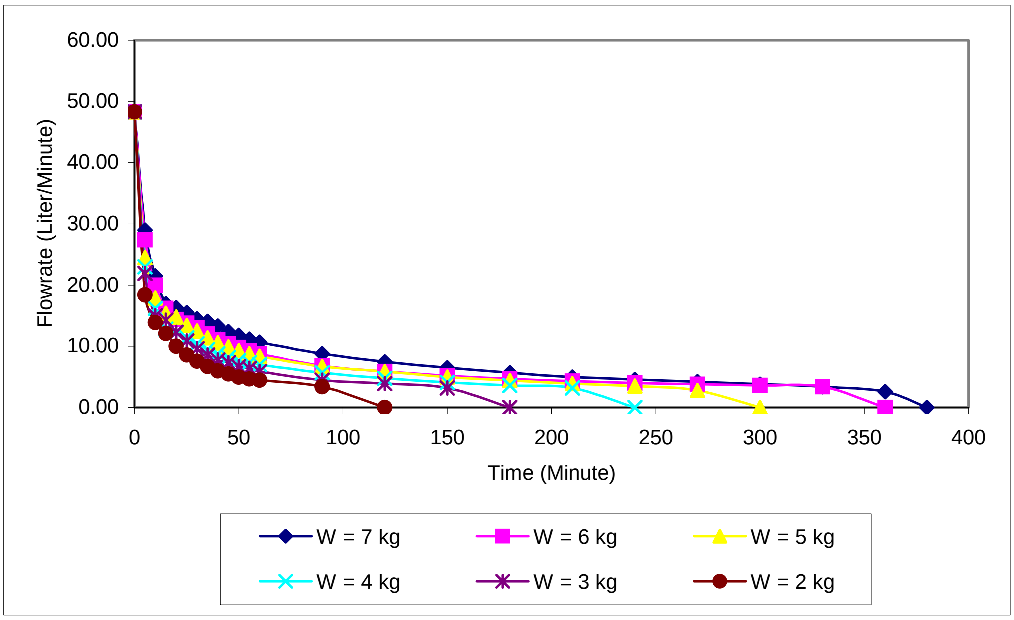


Figure E3: Discharging Flow Rate Profile of Various Weights at Composition of 4060, Surrounding Temperature of 30°C and Flow Rate of 48 Liter/Minute

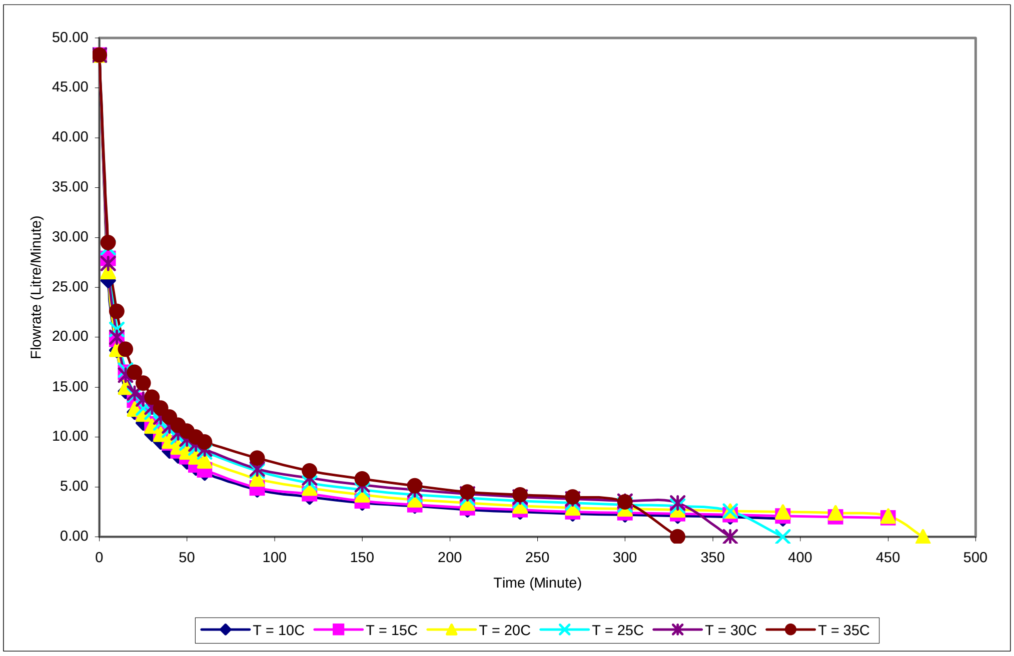


Figure E4: Discharging Flow Rate Profile of Various Surrounding Temperatures at Weight of 6 kg, Composition of 4060 and Flow Rate of 48 Liter/Minute

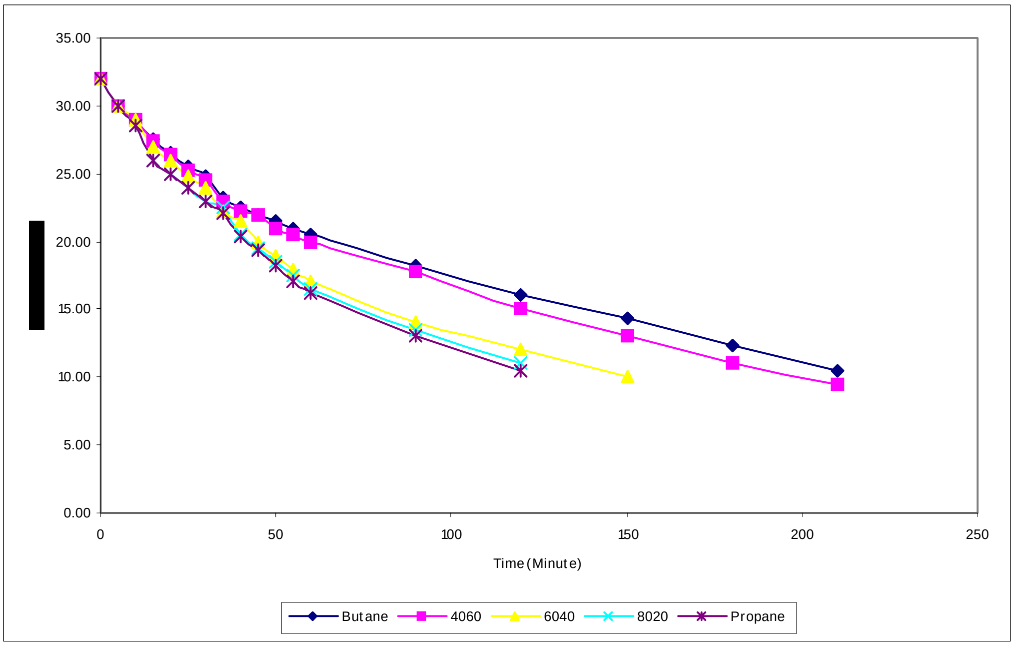


Figure F1: Liquid Level Profile of Various Compositions at Flow Rate of 48 Liter/Minute, Surrounding Temperature of 30^{o}C and Weight of 6 kg

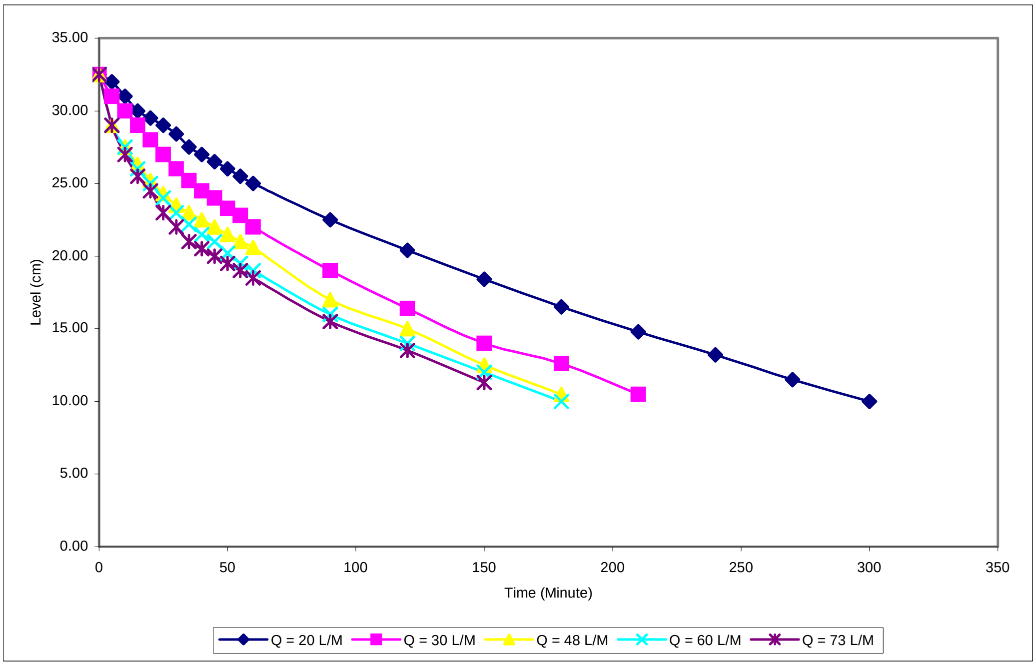


Figure F2: Liquid Level Profile of Various Flow Rates at Compositions of 4060, Surrounding Temperature of 30^{o}C and Weight of 6 kg

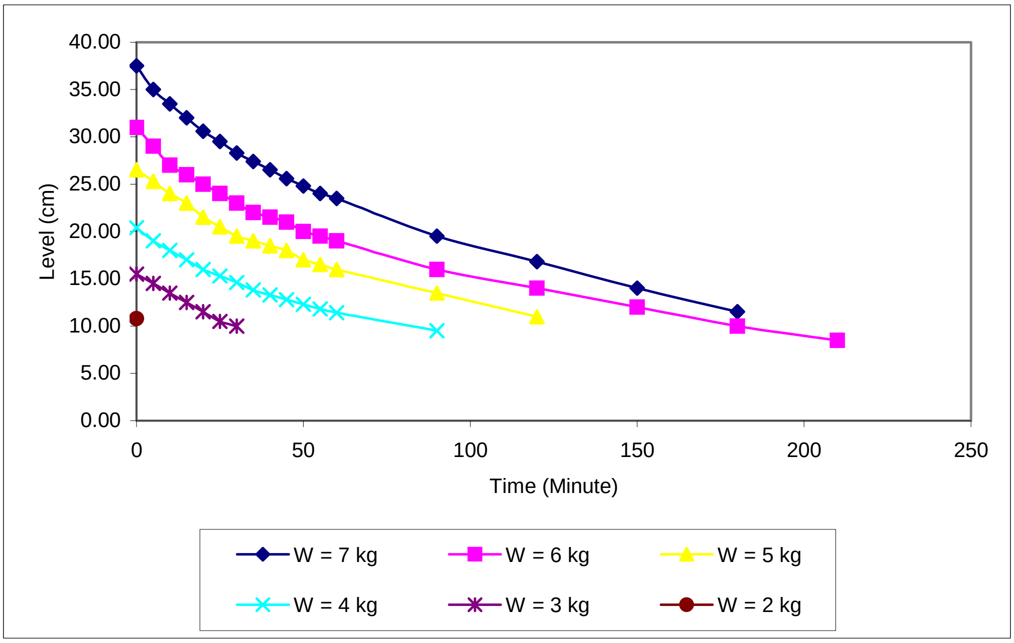


Figure F3: Liquid Level Profile of Various Weights at Compositions of 4060, Flow Rates of 48 Liter/Minute and Surrounding Temperature of 30^{o}C

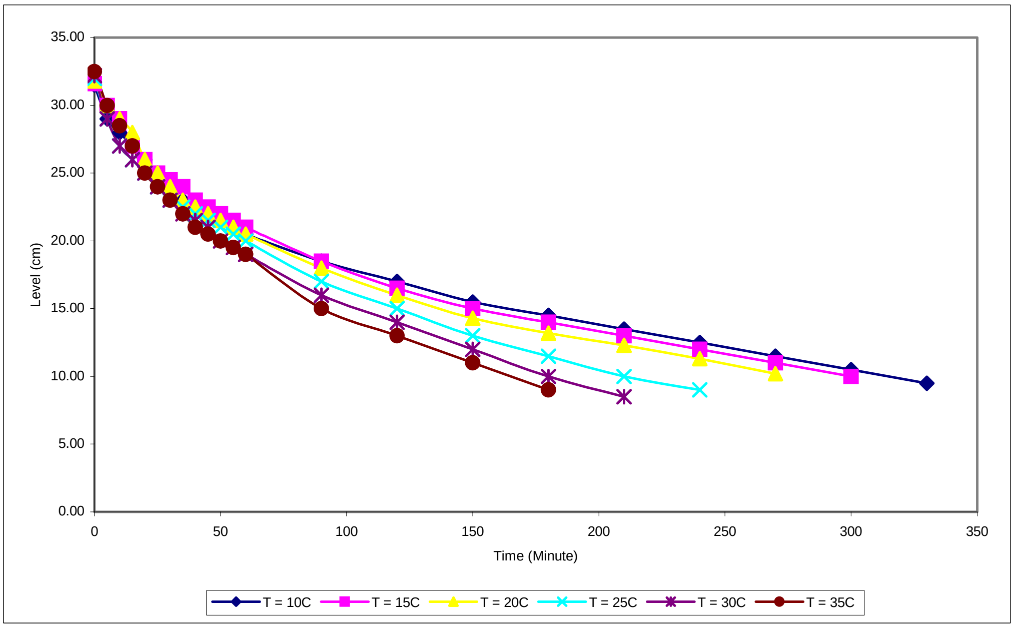


Figure F4: Liquid Level Profile of Various Surrounding Temperatures at Weight of 6 kg, Compositions of 4060 and Flow Rates of 48 Liter/Minute

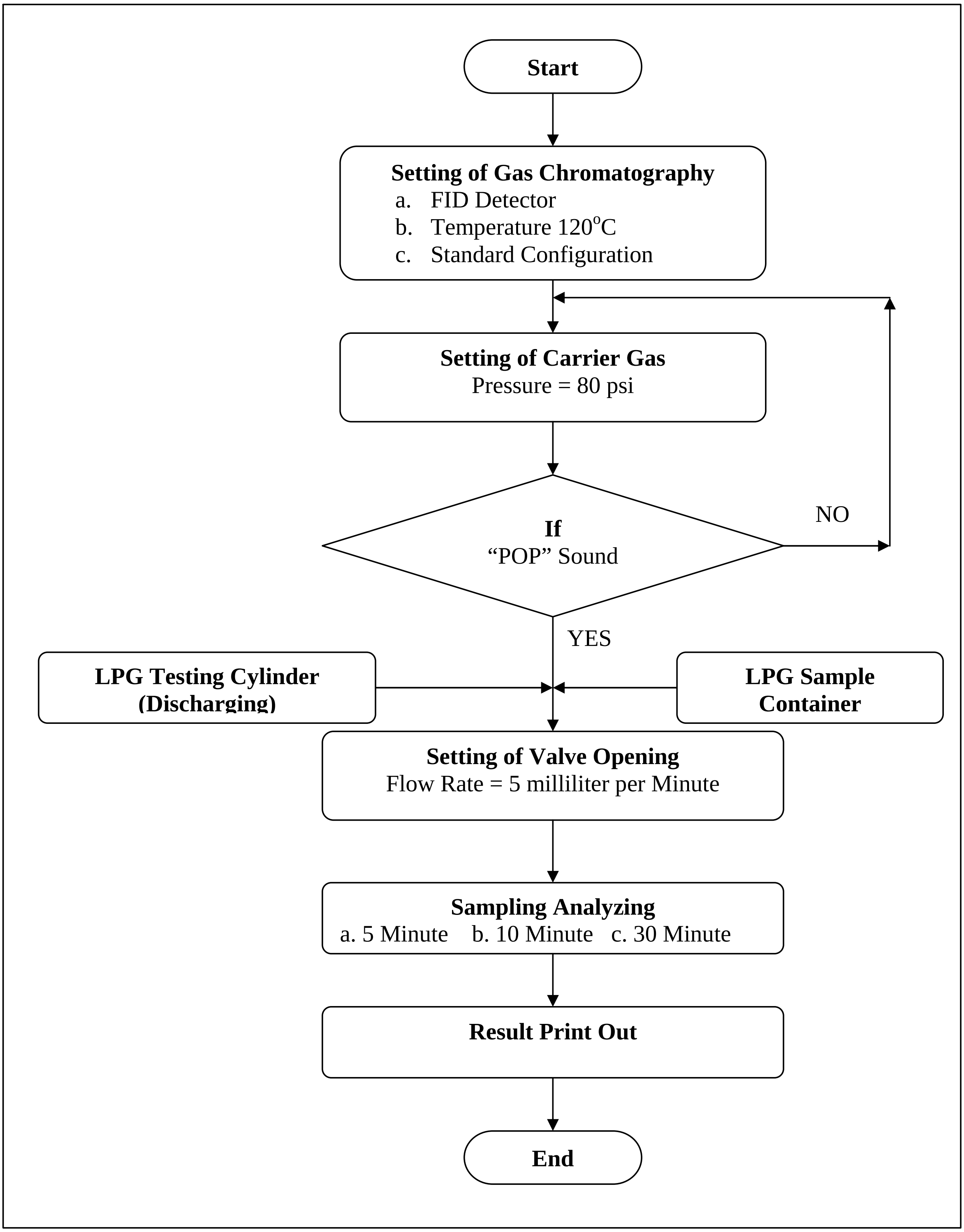


Figure G1: Flow Chart of Gas Chromatography Manual Procedure

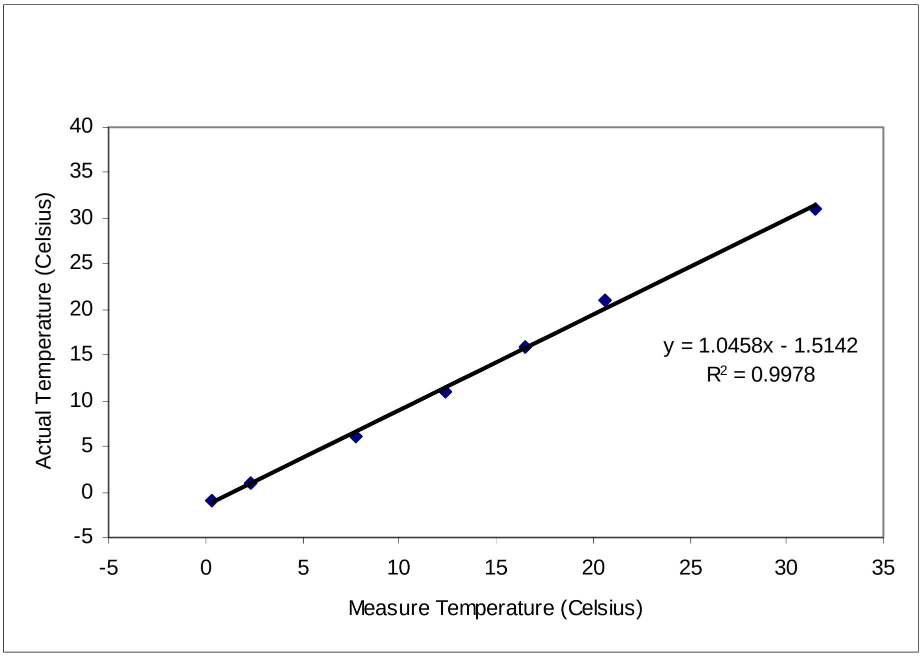


Figure H1: Calibration of Temperature Probe 1

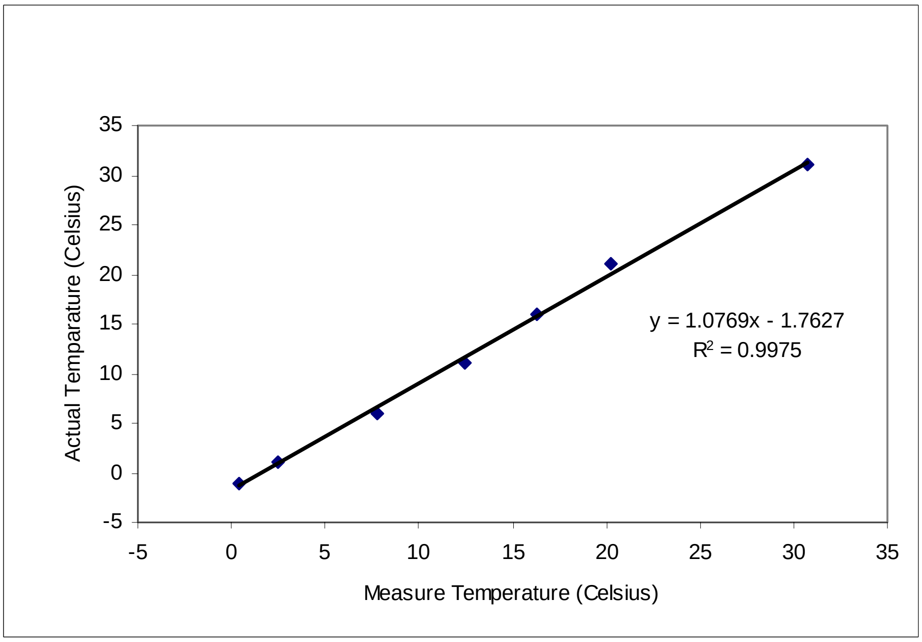


Figure H2: Calibration of Temperature Probe 2

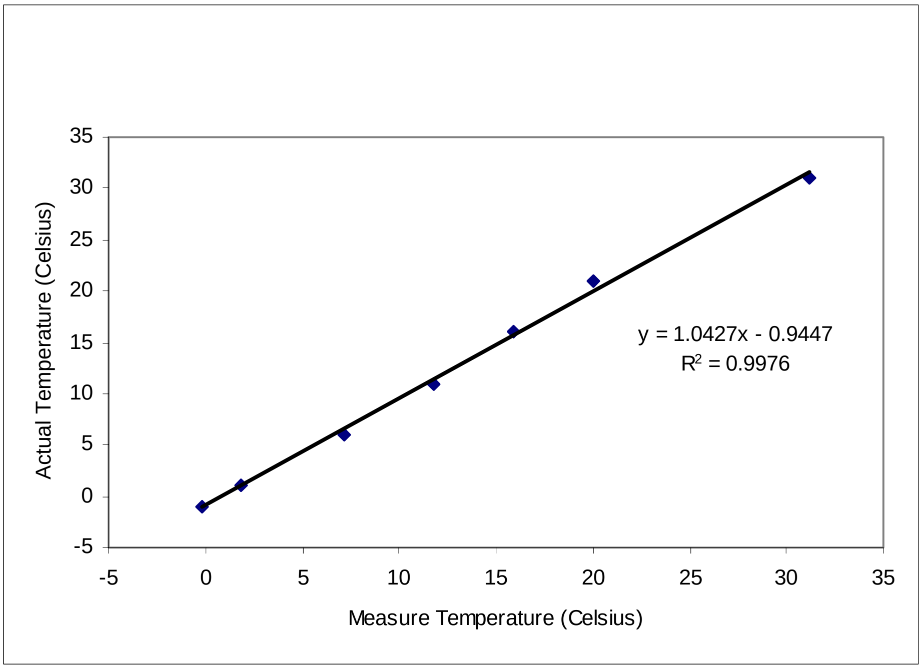


Figure H3: Calibration of Temperature Probe 3

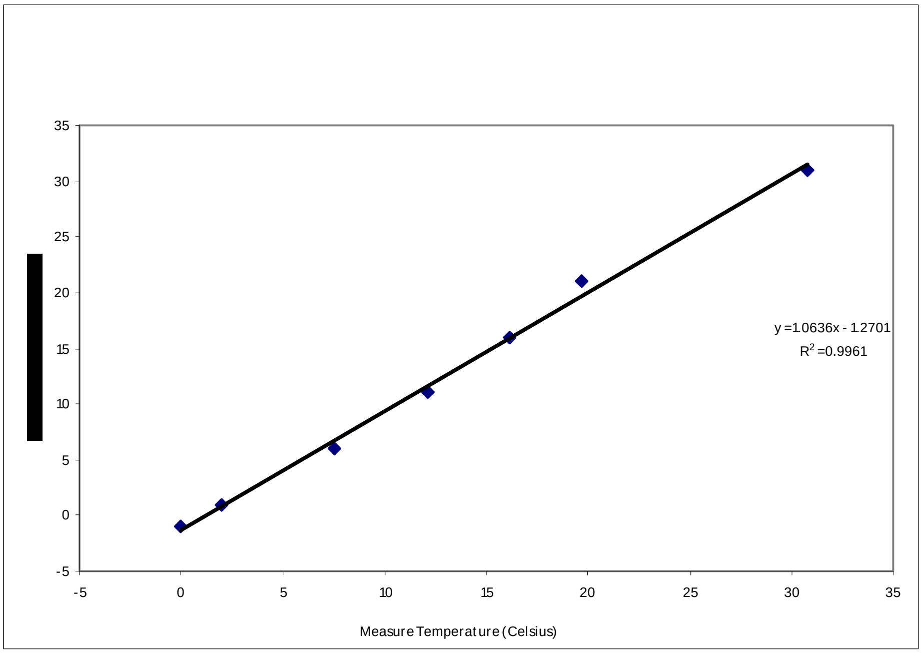


Figure H4: Calibration of Temperature Probe 4

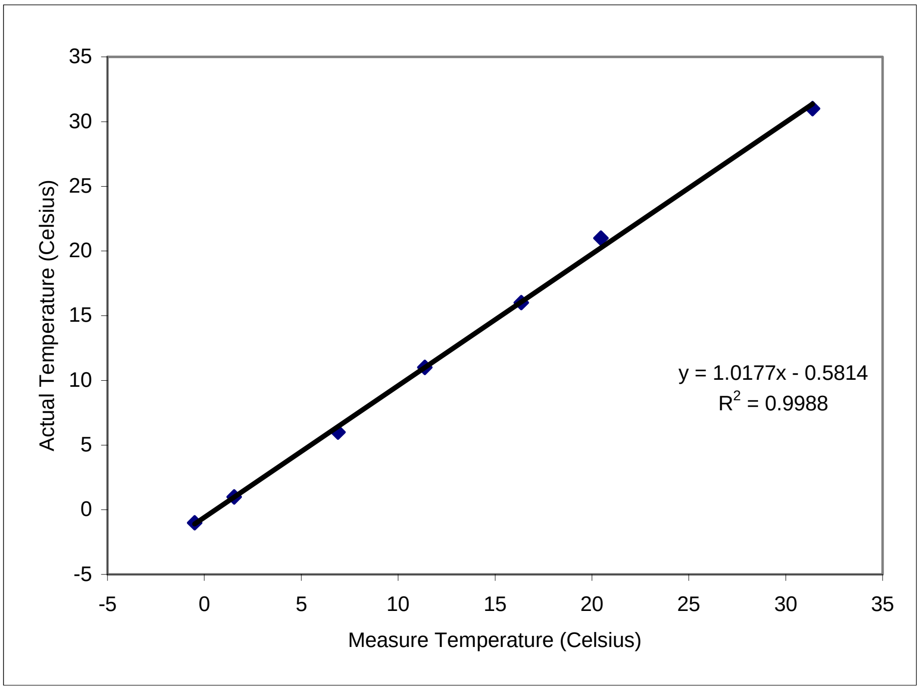


Figure H5: Calibration of Temperature Probe 5

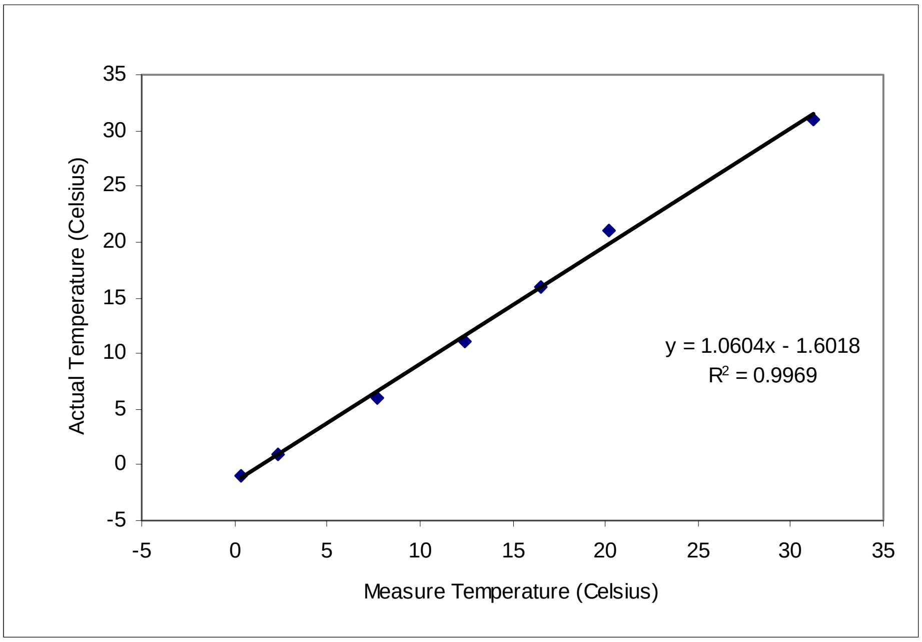


Figure H6: Calibration of Temperature Probe 6

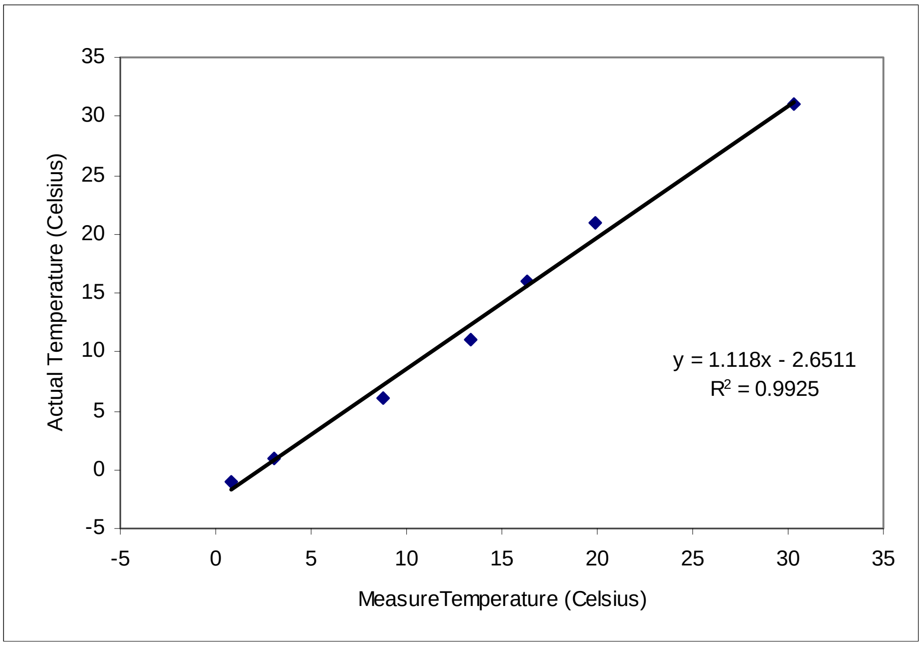


Figure H7: Calibration of Temperature Probe 7

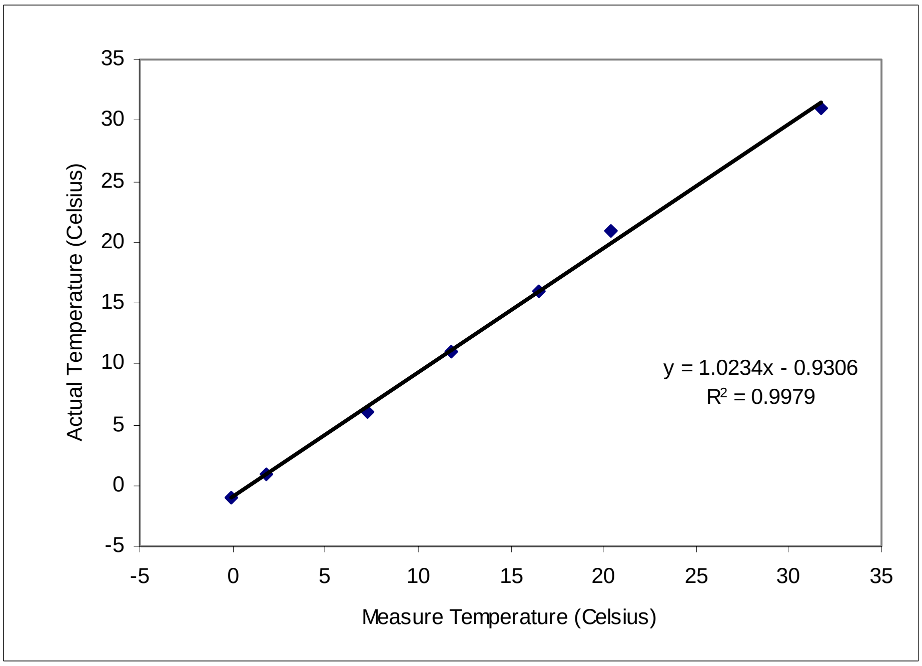


Figure H8: Calibration of Temperature Probe 8

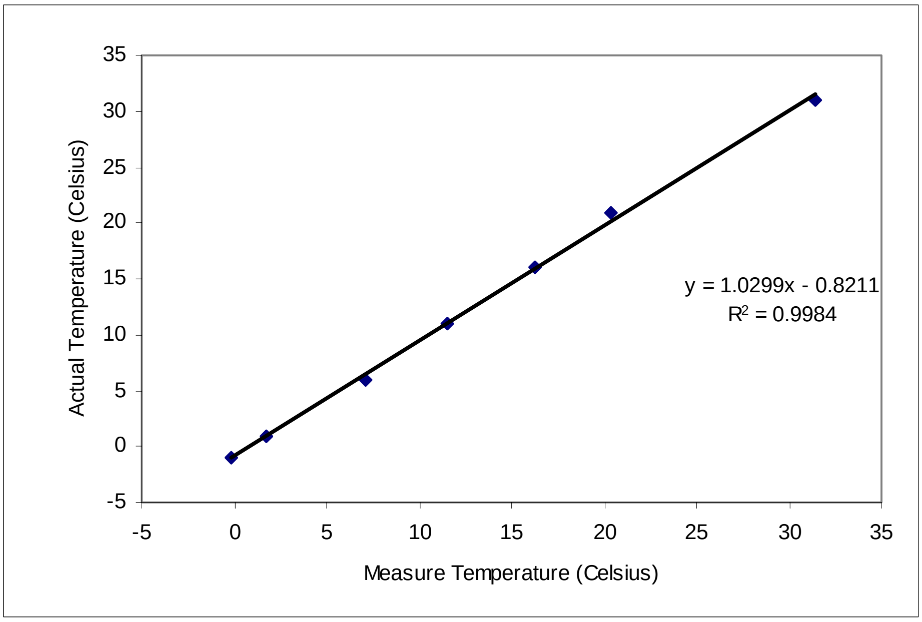


Figure H9: Calibration of Temperature Probe 9

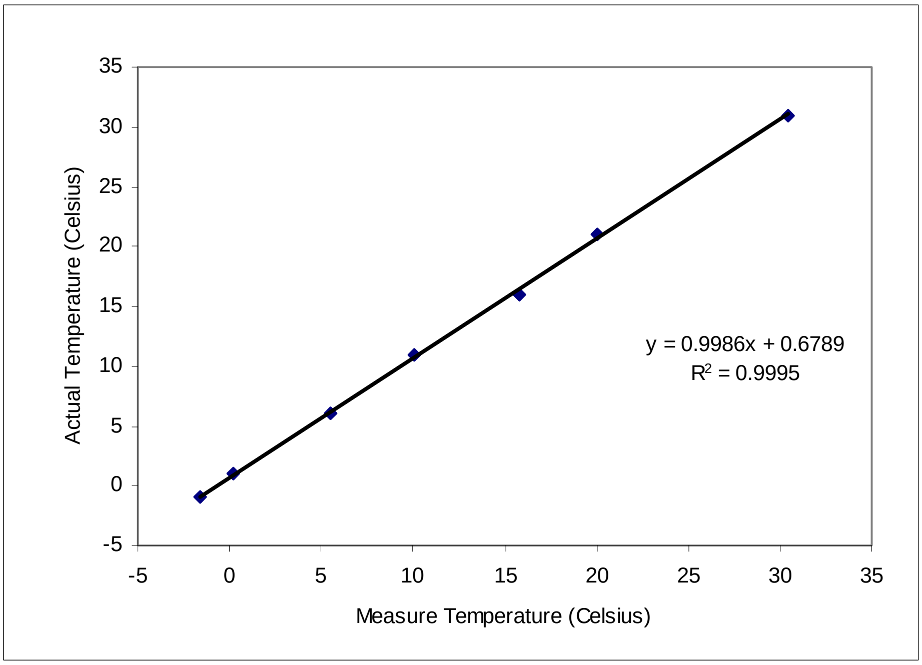


Figure H10: Calibration of Temperature Probe 10

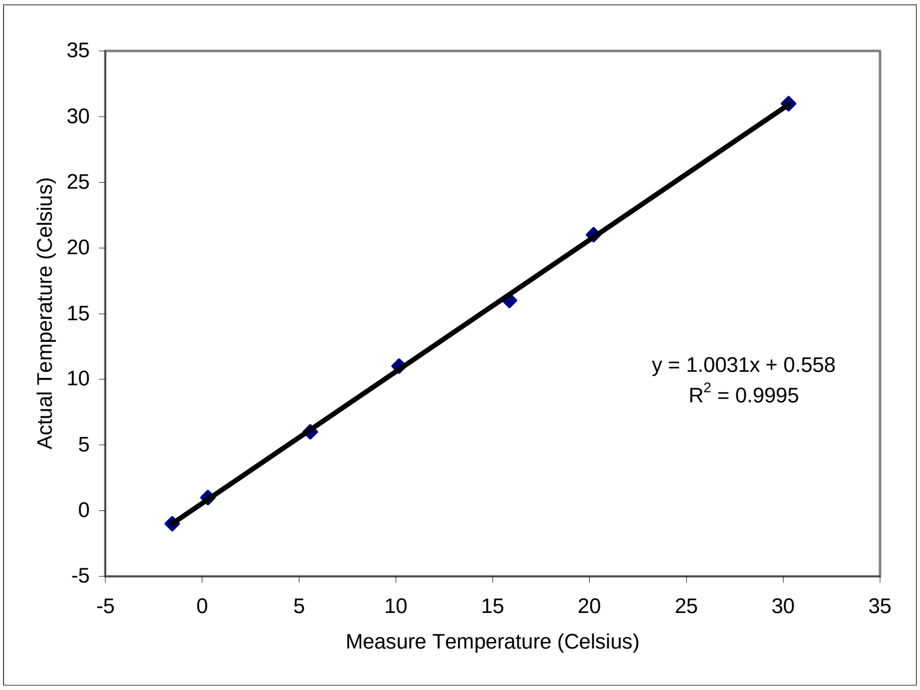


Figure H11: Calibration of Temperature Probe 11

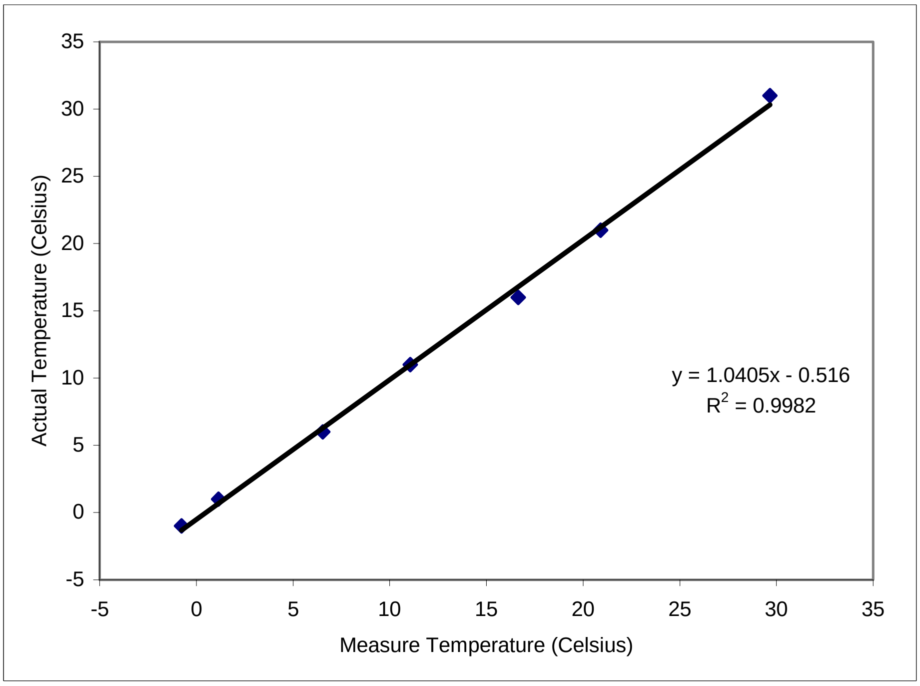


Figure H12: Calibration of Temperature Probe 12

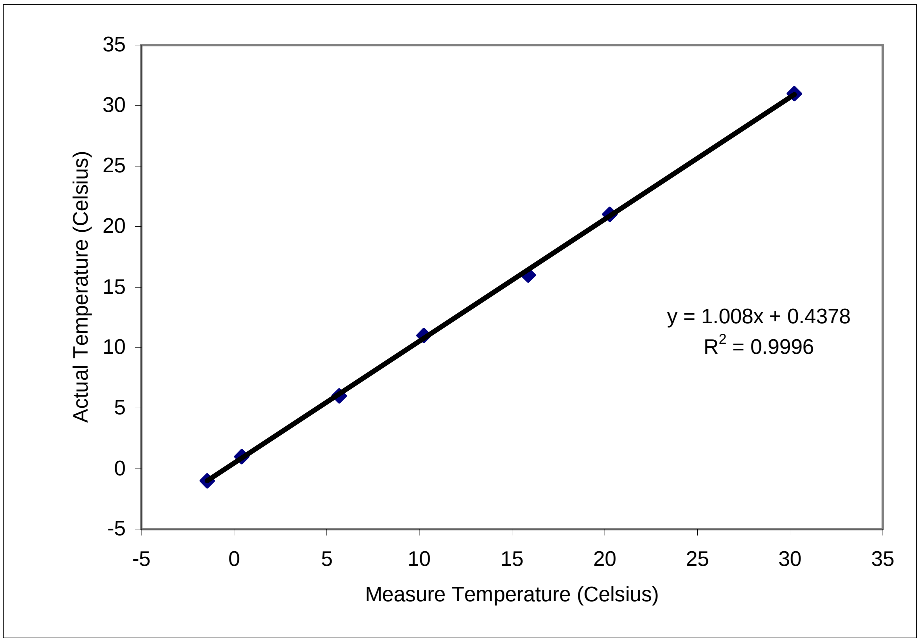


Figure H13: Calibration of Temperature Probe 13

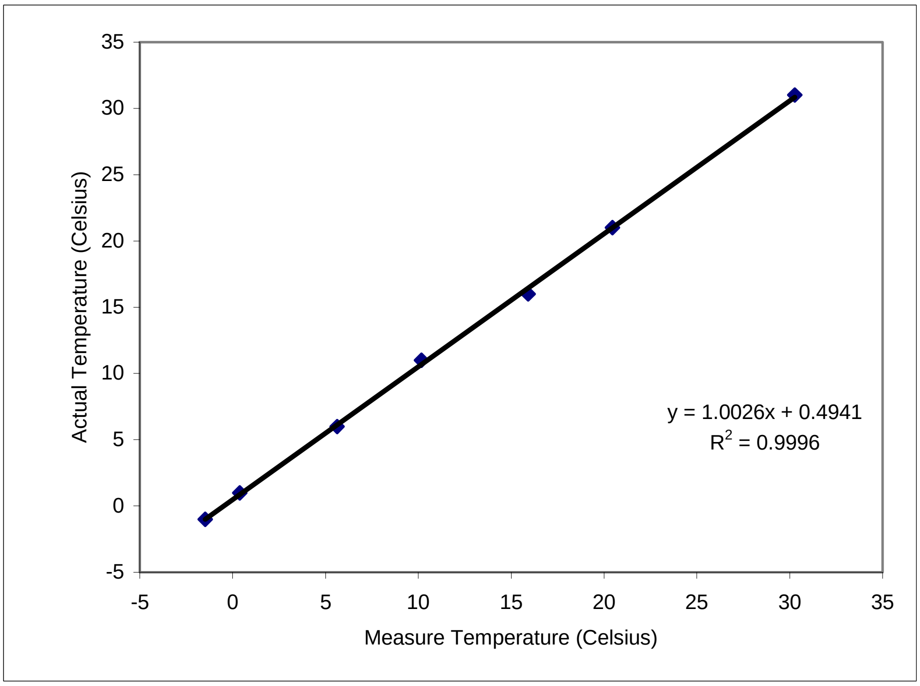


Figure H14: Calibration of Temperature Probe 14

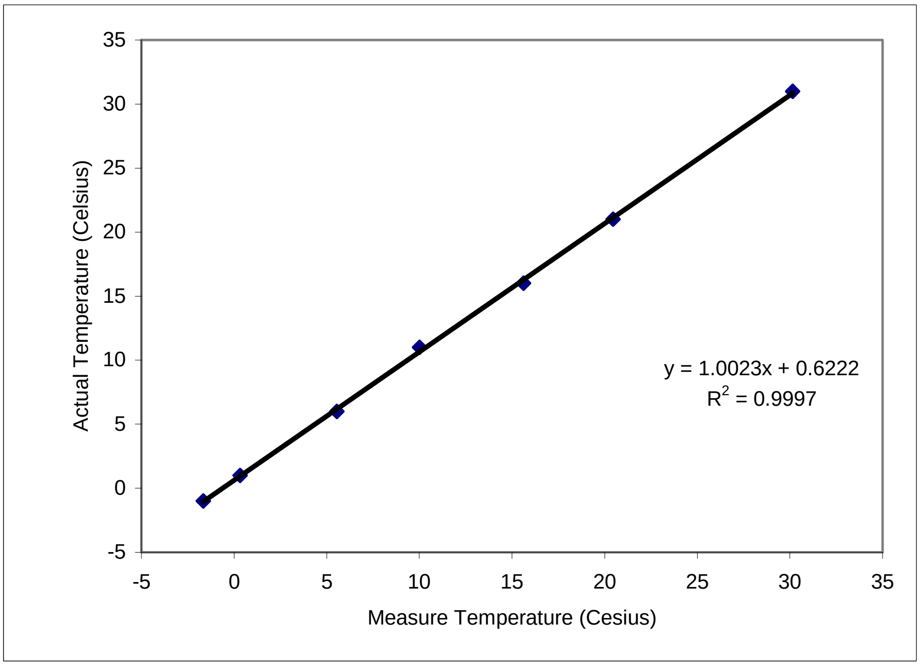


Figure H15: Calibration of Temperature Probe 15

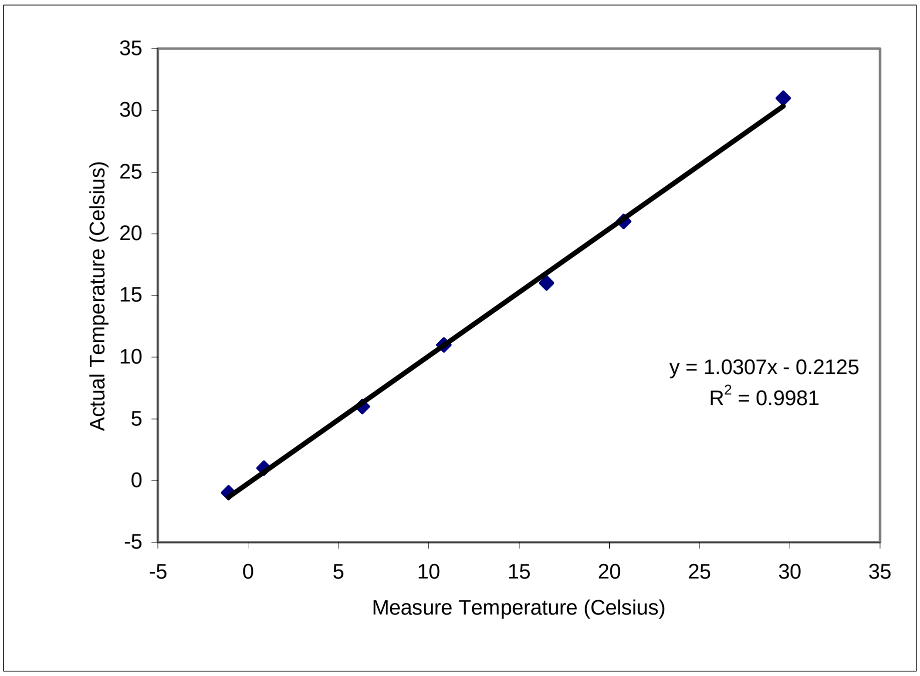


Figure H16: Calibration of Temperature Probe 16

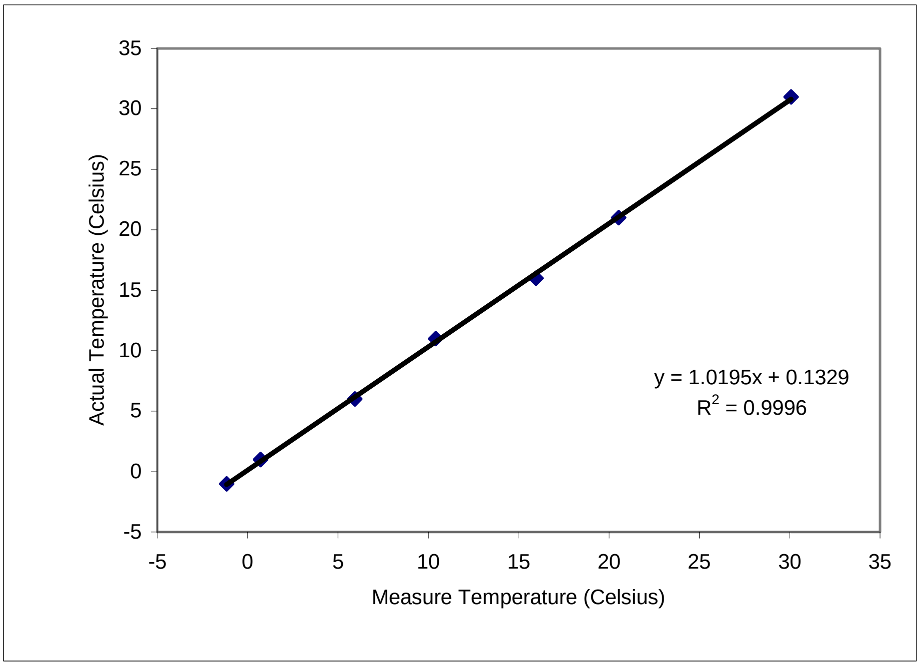


Figure H17: Calibration of Temperature Probe 17

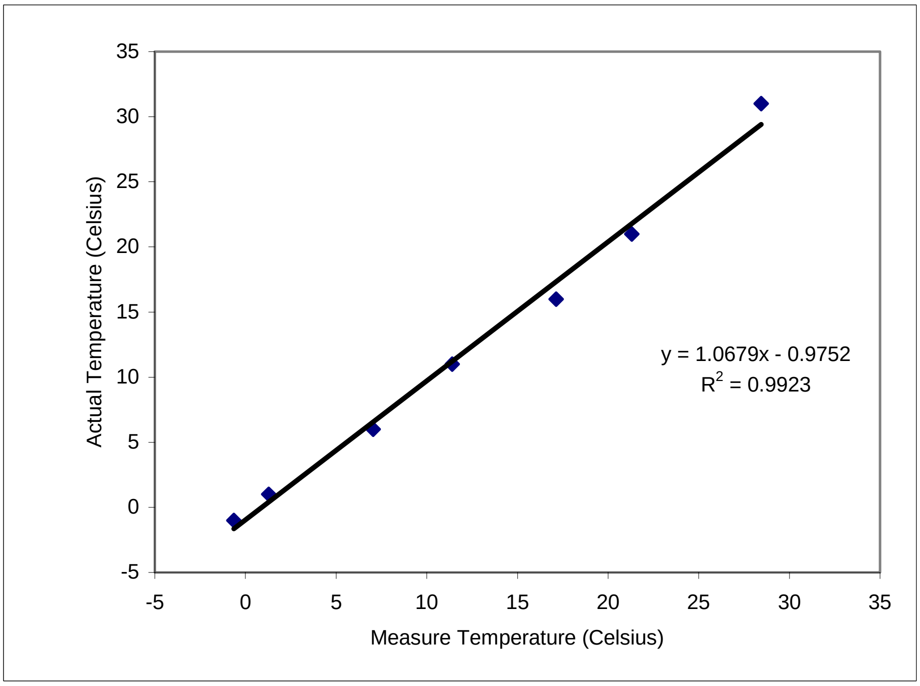


Figure H18: Calibration of Temperature Probe 18

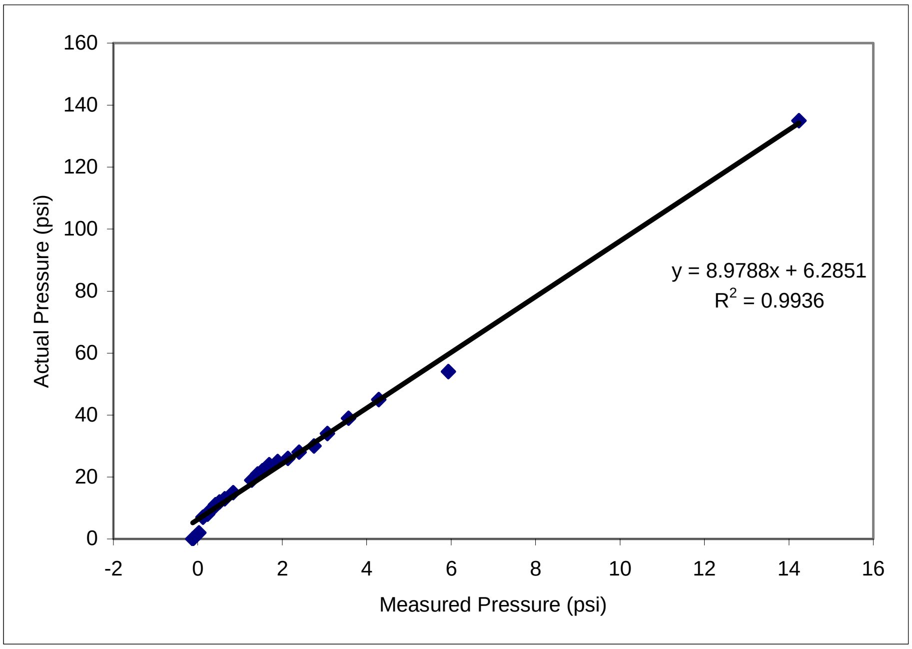


Figure H19: Calibration of Pressure Transducer

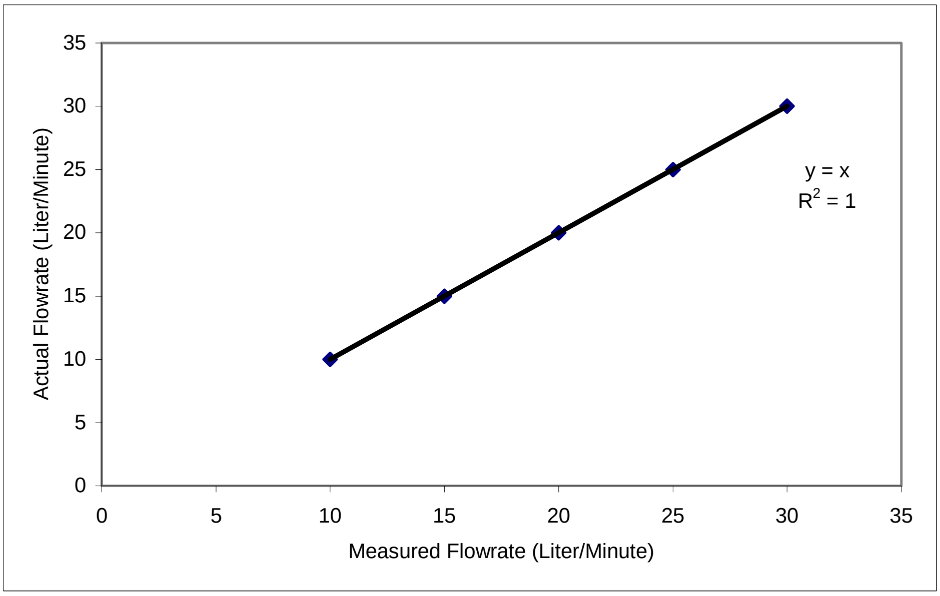


Figure H20: Calibration of Digital Flow Meter

Figure H21: Calibration of On-line Gas Chromatography

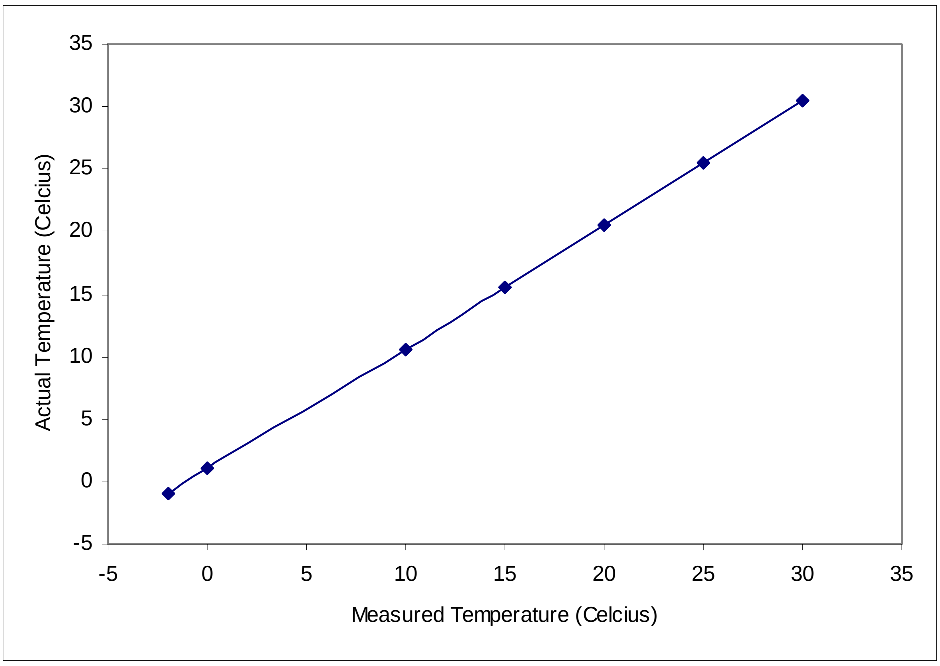


Figure H22: Calibration of Cool Incubator

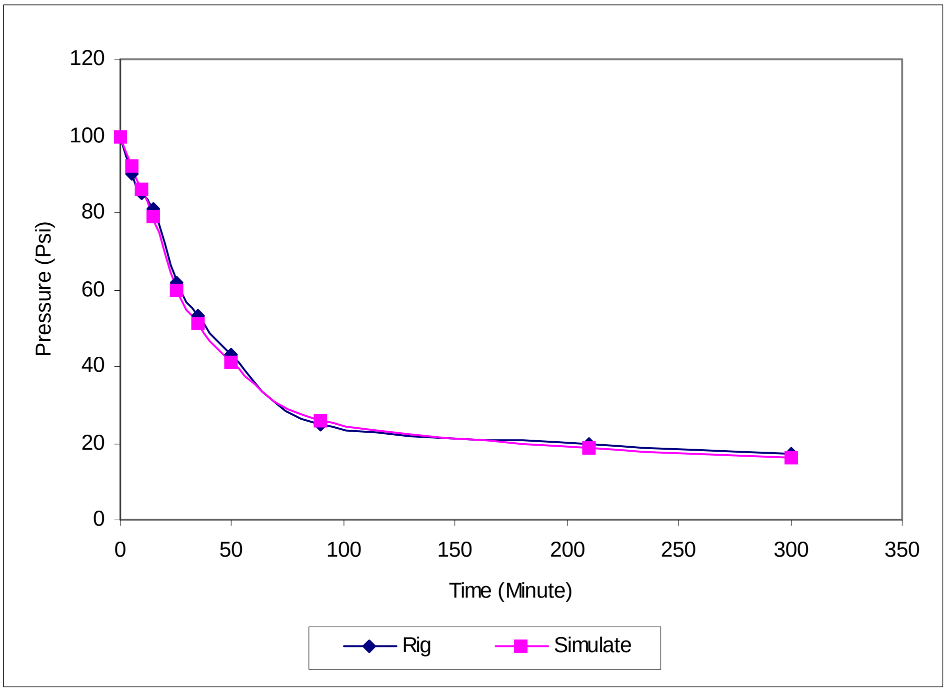


Figure H23: Calibration of Testing Rig Based on Pressure

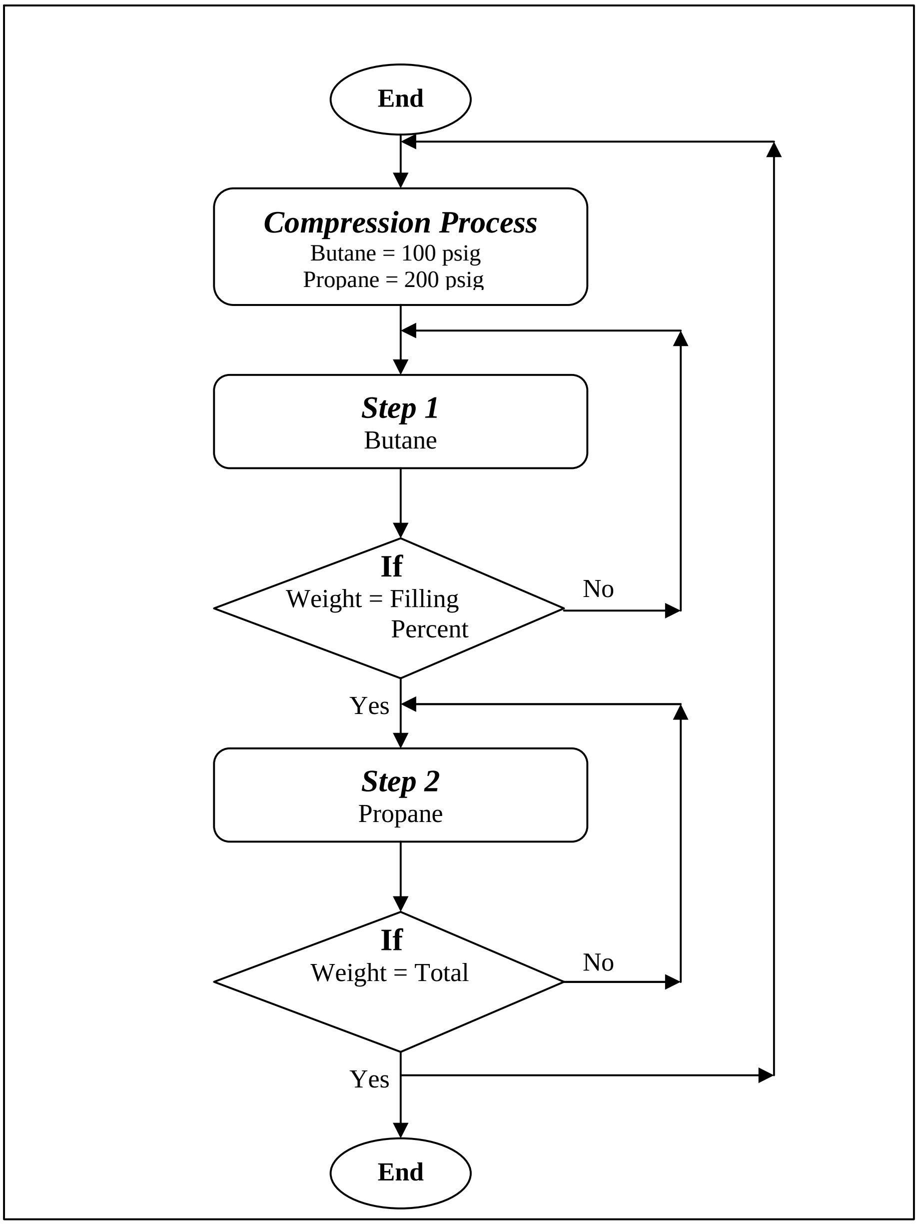


Figure I1: Flowchart of Propane and Butane Mixing Process

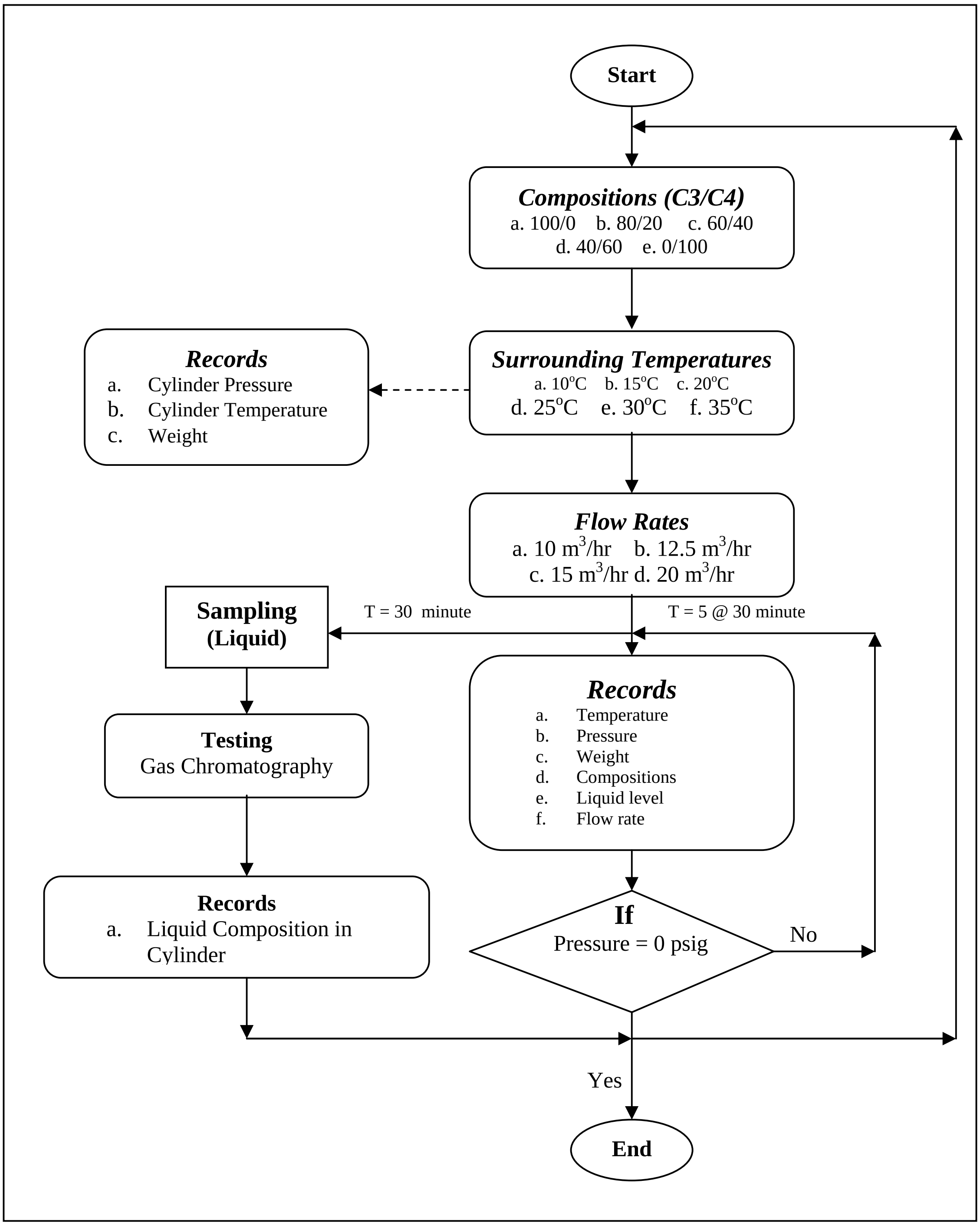


Figure I2: Flowchart of Experiment

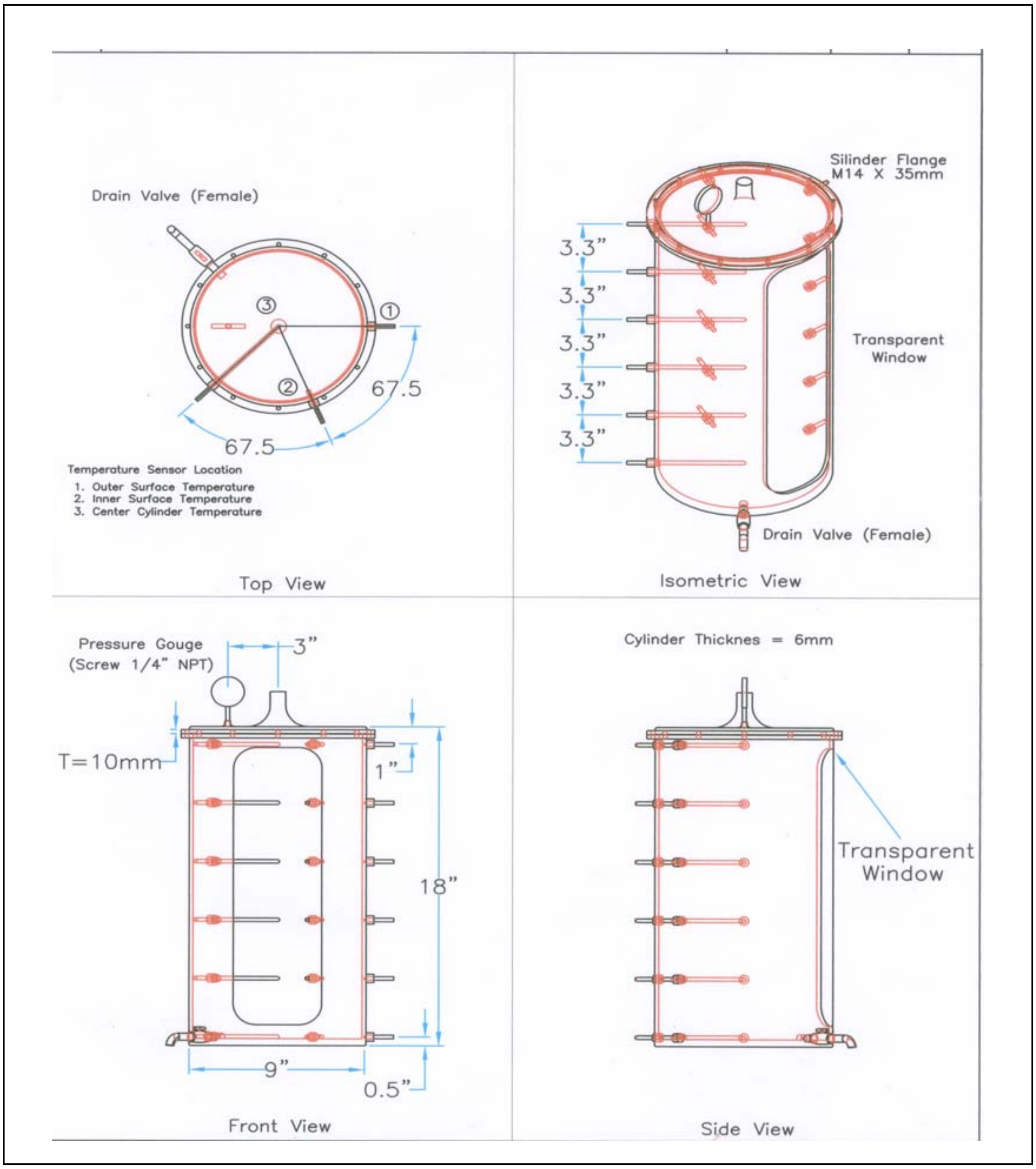


Figure J1: Dimension of Testing Cylinder

Table B1: Others Data of Commercial Propane for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	161.66	100.00	0.00	100.00	0.00
5	5.58	30.00	35.90	122.11	100.00	0.00		
10	5.18	28.50	30.00	104.15	100.00	0.00		
15	4.85	26.00	26.20	89.89	100.00	0.00		
20	4.55	25.00	22.20	79.14	100.00	0.00		
25	4.29	24.00	19.20	70.68	100.00	0.00		
30	4.06	23.00	17.50	64.04	100.00	0.00		
35	3.85	22.10	16.10	58.65	100.00	0.00		
40	3.65	20.30	14.20	54.39	100.00	0.00		
45	3.47	19.30	13.10	50.73	100.00	0.00		
50	3.30	18.20	12.60	48.12	100.00	0.00	100.00	0.00
55	3.18	17.00	12.40	45.71	100.00	0.00		
60	3.02	16.20	12.20	43.49	100.00	0.00		
90	2.22	13.00	9.60	34.49	100.00	0.00		
120	1.55	10.50	8.10	29.05	100.00	0.00		
150	0.97		7.10	25.01	100.00	0.00	100.00	0.00
180	0.45		6.20	21.77	100.00	0.00		
210	0.17		3.70	15.07	100.00	0.00		
213	0.01		0.00	1.47	100.00	0.00	100.00	0.00

Table B2: Others Data of 8020 Composition for Surrounding Temperature of 30°C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	158.90	100.00	0.00	78.73	21.27
5	5.58	30.00	33.80	102.81	100.00	0.00		
10	5.21	28.50	27.80	81.28	100.00	0.00		
15	4.91	26.00	23.80	70.27	100.00	0.00		
20	4.65	25.00	21.00	62.90	100.00	0.00		
25	4.41	24.00	18.70	56.18	100.00	0.00		
30	4.20	23.00	16.50	51.07	100.00	0.00	70.74	29.26
35	3.97	22.50	15.00	47.02	100.00	0.00		
40	3.78	20.50	13.60	43.37	100.00	0.00		
45	3.61	19.50	12.90	40.41	100.00	0.00		
50	3.45	18.50	12.30	37.92	100.00	0.00	61.56	38.44
55	3.31	17.50	11.90	35.64	100.00	0.00		
60	3.16	16.50	11.50	33.85	100.00	0.00	57.23	42.77
90	2.42	13.50	9.20	26.47	100.00	0.00	49.02	50.98
120	1.79	11.00	7.50	21.24	82.55	17.45		
150	1.28		5.30	16.97	75.03	24.97	39.79	60.21
180	0.84		4.40	12.21	60.11	39.89		
210	0.52		3.30	8.91	37.63	62.37		
240	0.25		2.30	7.45	19.95	80.05	28.56	71.44
270	0.05		0.00	1.40	4.49	95.51		

Table B3: Others Data of 6040 Composition for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	146.7	100.00	0.00	56.17	43.83
5	5.60	30.00	29.50	98.58	100.00	0.00		
10	5.33	29.00	25.50	74.77	100.00	0.00		
15	5.11	27.00	20.80	58.34	100.00	0.00		
20	4.92	26.00	19.70	47.85	100.00	0.00		
25	4.73	24.80	16.20	40.99	100.00	0.00		
30	4.56	24.00	14.60	36.83	85.87	14.13	50.45	49.55
35	4.41	22.30	13.20	33.41	80.09	19.91		
40	4.26	21.50	12.00	30.26	75.10	24.90		
45	4.12	20.00	11.30	28.48	70.56	29.44		
50	3.98	19.00	10.70	26.99	65.69	34.31	44.22	55.78
55	3.85	18.00	10.00	24.00	60.55	39.45		
60	3.72	17.00	9.70	22.75	55.48	44.52	42.76	57.24
90	3.15	14.00	7.70	18.79	45.56	54.44	39.65	60.35
120	2.60	12.00	6.80	15.98	37.46	62.54		
150	2.15	10.00	6.20	12.88	29.69	70.31	30.49	69.51
180	1.72		5.70	10.06	12.69	87.31		
210	1.32		5.20	9.59	8.38	91.62		
240	0.95		4.80	8.81	3.62	96.38	20.42	79.58
270	0.56		4.20	8.38	0.00	100.00		
300	0.24		3.50	7.39	0.00	100.00		
330	0.07		1.20	5.96	0.00	100.00	14.69	85.31

Table B4: Others Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	121.18	100.00	0.00	35.76	64.24
5	5.62	30.00	27.40	78.79	100.00	0.00		
10	5.33	29.00	22.00	54.06	100.00	0.00		
15	5.10	27.40	18.20	41.84	77.87	22.13		
20	4.91	26.40	17.40	35.23	66.77	33.23		
25	4.72	25.30	15.80	32.75	52.86	47.14		
30	4.56	24.60	13.00	29.75	51.72	48.28	24.09	75.91
35	4.41	22.90	11.50	26.83	50.79	49.21		
40	4.28	22.20	10.40	24.44	49.84	50.16		
45	4.14	21.90	9.80	22.47	48.87	51.13		
50	4.02	21.00	9.00	20.90	47.80	52.20	21.23	78.77
55	3.90	20.50	8.30	19.23	46.79	53.21		
60	3.79	20.00	7.80	18.26	45.72	54.28	18.07	81.93
90	3.21	17.80	6.80	13.77	36.80	63.20	11.81	88.19
120	2.72	15.00	5.90	11.54	28.72	71.28		
150	2.37	13.00	5.40	10.26	20.64	79.36	4.85	95.15
180	1.99	11.00	4.90	9.46	13.65	86.35		
210	1.65	9.50	4.60	8.93	8.02	91.98		
240	1.33		4.40	8.41	4.25	95.75	1.17	98.83
270	1.06		4.20	8.11	1.87	98.13		
300	0.81		3.90	7.98	0.62	99.38		
330	0.54		3.7	7.74	0	100.00	0.00	100.00
360	0.18		0	2.22	0	100.00		

Table B5: Others Data of Commercial Butane for Surrounding Temperature of 30°C, Flow Rate of 48 Liter per Minute and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.00	48.30	41.56	0.00	100.00	0.00	100.00
5	5.74	30.00	22.50	26.53	0.00	100.00		
10	5.41	29.00	20.60	20.96	0.00	100.00		
15	5.15	27.50	17.80	17.22	0.00	100.00		
20	4.92	26.60	16.80	14.51	0.00	100.00		
25	4.73	25.50	14.10	12.54	0.00	100.00		
30	4.57	24.80	12.20	11.05	0.00	100.00		
35	4.43	23.20	10.70	10.02	0.00	100.00		
40	4.32	22.50	9.50	9.40	0.00	100.00		
45	4.20	22.00	8.50	8.82	0.00	100.00		
50	4.10	21.50	7.80	8.42	0.00	100.00	0.00	100.00
55	4.00	21.00	7.30	8.14	0.00	100.00		
60	3.91	20.50	6.90	7.99	0.00	100.00		
90	3.43	18.20	5.80	7.51	0.00	100.00		
120	2.98	16.00	5.40	7.37	0.00	100.00		
150	2.57	14.30	5.10	7.06	0.00	100.00	0.00	100.00
180	2.19	12.40	4.80	6.99	0.00	100.00		
210	1.80	10.40	4.50	6.86	0.00	100.00		
240	1.46		4.30	6.85	0.00	100.00	0.00	100.00
270	1.13		4.20	6.96	0.00	100.00		
300	0.82		3.90	6.94	0.00	100.00		
330	0.64		3.70	6.77	0.00	100.00		
360	0.46		3.20	6.68	0.00	100.00		
390	0.26		0.00	1.37	0.00	100.00		

Table B6: Others Data of Flow Rate of 73 Liter/Minute for Surrounding Temperature of 30^{o}C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	73.00	146.41	100.00	0.00	35.76	64.24
5	5.62	29.00	34.60	70.53	100.00	0.00		
10	5.24	27.00	24.50	47.61	100.00	0.00		
15	4.97	25.50	19.40	36.53	66.91	33.09		
20	4.74	24.50	18.60	33.34	56.79	43.21		
25	4.53	23.00	15.60	29.29	52.86	47.14		
30	4.34	22.00	13.80	25.74	51.72	48.28	20.62	79.38
35	4.17	21.00	12.80	22.94	50.79	49.21		
40	4.01	20.50	12.20	21.14	49.84	50.16		
45	3.85	20.00	11.10	19.25	48.87	51.13		
50	3.72	19.50	10.30	17.85	47.80	52.20		
55	3.58	19.00	10.00	17.14	46.79	53.21		
60	3.45	18.50	9.40	16.35	45.72	54.28	14.90	85.10
90	2.88	15.50	7.80	12.29	36.80	63.20	8.50	91.50
120	2.41	13.50	6.40	10.58	28.72	71.28		
150	2.00	11.30	5.70	9.73	20.64	79.36	4.56	95.44
180	1.64		5.20	8.96	13.65	86.35		
210	1.31		4.90	8.57	8.94	91.06	1.56	98.44
240	1.01		4.50	8.22	4.79	95.21	0.00	100.00
270	0.74		4.00	8.05	0.00	100.00		
300	0.46		3.70	7.87	0.00	100.00		
330	0.24		2.80	1.01	0.00	100.00		

Table B7: Others Data of Flow Rate of 60 Liter/Minute for Surrounding Temperature of 30°C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	60.00	146.41	100.00	0.00	35.76	64.24
5	5.45	29.00	30.70	72.95	100.00	0.00		
10	5.13	27.50	22.20	51.56	100.00	0.00		
15	4.88	26.00	18.70	40.26	75.76	24.24		
20	4.68	25.00	16.20	34.07	59.39	40.61		
25	4.51	24.00	14.30	31.37	54.76	45.24		
30	4.34	23.00	13.00	27.93	53.83	46.17	21.03	78.97
35	4.28	22.20	12.00	25.36	52.82	47.18		
40	4.13	21.50	11.10	23.33	51.88	48.12		
45	4.00	21.00	10.20	21.27	50.84	49.16		
50	3.88	20.20	9.80	19.51	49.77	50.23		
55	3.73	19.50	9.50	18.46	48.77	51.23		
60	3.61	19.00	8.80	17.81	47.84	52.16	15.12	84.88
90	3.06	16.00	7.50	13.07	38.34	61.66	10.03	89.97
120	2.58	14.00	6.30	10.90	29.72	70.28		
150	2.20	12.00	5.60	9.94	21.69	78.31	6.47	93.53
180	1.83	10.00	5.10	9.18	14.63	85.37		
210	1.49		4.80	8.78	8.02	91.98	3.96	96.04
240	1.18		4.40	8.45	4.25	95.75	0.00	100.00
270	0.89		4.00	8.23	1.37	98.63		
300	0.60		3.70	7.94	0.00	100.00		
330	0.34		3.50	7.78	0.00	100.00		
360	0.20		2.50	1.54	0.00	100.00		

Table B8: Others Data of Flow Rate of 48 Liter/Minute for Surrounding Temperature of 30^{o}C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	48.00	146.41	100.00	0.00	35.76	64.24
5	5.62	29.00	27.40	88.79	100.00	0.00		
10	5.33	27.50	20.00	64.06	100.00	0.00		
15	5.10	26.30	16.20	51.84	77.87	22.13		
20	4.91	25.20	14.40	42.23	66.77	33.23		
25	4.72	24.30	12.80	37.75	55.55	44.45		
30	4.56	23.50	12.00	34.75	54.59	45.41	24.09	75.91
35	4.41	23.00	11.00	31.83	53.72	46.28		
40	4.28	22.50	10.30	29.44	52.89	47.11		
45	4.14	22.00	9.70	27.47	52.11	47.89		
50	4.02	21.50	9.50	25.90	51.17	48.83		
55	3.90	21.00	9.30	23.23	50.10	49.90		
60	3.79	20.60	8.80	21.56	49.18	50.82	18.07	81.93
90	3.21	17.00	6.80	19.77	40.42	59.58	13.81	86.19
120	2.72	15.00	5.90	17.54	32.44	67.56		
150	2.37	12.50	5.20	15.26	24.63	75.37	9.85	90.15
180	1.99	10.50	4.70	13.46	17.50	82.50		
210	1.55	8.50	4.30	12.93	11.55	88.45	5.85	94.15
240	1.21		4.00	11.41	6.69	93.31	1.17	98.83
270	0.97		3.80	10.11	1.87	98.13		
300	0.72		3.60	9.98	0.62	99.38	0.00	100.00
330	0.45		3.4	8.74	0.00	100.00		
360	0.18		2.8	1.52	0.00	100.00		

Table B9: Others Data of Flow Rate of 30 Liter/Minute for Surrounding Temperature of 30^{o}C, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	30.00	146.41	100.00	0.00	35.76	64.24
5	5.71	31.00	22.20	93.24	100.00	0.00		
10	5.44	30.00	16.40	71.00	100.00	0.00		
15	5.23	29.00	14.10	57.99	100.00	0.00		
20	5.06	28.00	12.40	49.36	65.40	34.60		
25	4.91	27.00	11.80	45.57	54.73	45.27		
30	4.77	26.00	11.00	43.03	53.71	46.29	27.26	72.74
35	4.67	25.20	10.00	40.43	53.12	46.88		
40	4.53	24.50	9.00	38.06	52.57	47.43		
45	4.41	24.00	9.20	36.12	51.96	48.04		
50	4.29	23.30	8.60	34.29	51.38	48.62		
55	4.18	22.80	8.00	32.75	50.75	49.25		
60	4.04	22.00	7.50	31.23	50.12	49.88	24.22	75.78
90	3.46	19.00	6.00	26.96	46.34	53.66	20.74	79.26
120	2.95	16.40	5.20	22.98	41.26	58.74		
150	2.50	14.00	4.90	20.26	35.51	64.49	16.47	83.53
180	2.11	12.60	4.50	18.34	29.27	70.73		
210	1.70	10.50	4.20	16.41	22.96	77.04	11.70	88.30
240	1.36		3.90	14.59	16.14	83.86	6.38	93.62
270	1.06		3.70	13.02	10.05	89.95		
300	0.81		3.50	11.78	5.17	94.83	2.08	97.92
330	0.54		3.30	10.74	1.96	98.04		
360	0.15		2.30	1.63	0.00	100.00		

Table B10: Others Data of Flow Rate of 20 Liter/Minute for Surrounding Temperature of 30^oC, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	20.00	146.98	100.00	0.00	35.76	64.24
5	5.84	32.00	15.00	106.34	100.00	0.00		
10	5.65	31.00	12.40	89.45	100.00	0.00		
15	5.49	30.00	10.60	77.83	100.00	0.00		
20	5.36	29.50	9.40	69.80	100.00	0.00		
25	5.23	29.00	8.70	63.93	100.00	0.00		
30	5.12	28.40	8.00	59.91	100.00	0.00	28.58	71.42
35	4.99	27.50	7.30	55.32	75.79	24.21		
40	4.90	27.00	6.80	51.16	70.72	29.28		
45	4.80	26.50	6.30	47.92	65.65	34.35		
50	4.72	26.00	6.10	45.34	60.60	39.40		
55	4.63	25.50	5.70	42.57	54.47	45.53		
60	4.56	25.00	5.50	42.23	50.76	49.24	26.92	73.08
90	4.11	22.50	5.30	37.69	47.97	52.03	25.08	74.92
120	3.73	20.40	4.90	34.69	45.40	54.60		
150	3.36	18.40	4.70	32.95	42.37	57.63	21.90	78.10
180	2.96	16.50	4.40	30.66	38.86	61.14		
210	2.64	14.80	4.10	28.75	35.04	64.96	16.71	83.29
240	2.29	13.20	3.90	26.90	31.02	68.98	12.58	87.42
270	1.98	11.50	3.70	25.09	26.77	73.23		
300	1.69	10.00	3.50	23.09	22.27	77.73	8.93	91.07
330	1.39		3.30	21.54	17.82	82.18		
360	1.13		3.10	19.85	13.4	86.60		
390	0.88		3.00	18.64	9.37	90.63		
420	0.64		2.80	17.48	5.90	94.10		
450	0.41		2.70	16.19	3.12	96.88		
480	0.20		2.40	14.79	1.20	98.80		
510	0.10		2.00	1.45	0.00	100.00		

Table B17: Others Data of Weight of 7 kg for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	7.00	37.50	48.00	148.15	100.00	0.00	36.41	63.59
5	6.60	35.00	29.00	84.48	100.00	0.00		
10	6.27	33.50	21.50	60.87	100.00	0.00		
15	5.99	32.00	17.00	49.01	77.07	22.93		
20	5.78	30.60	16.30	46.20	66.77	33.23		
25	5.58	29.50	15.50	42.32	60.15	39.85		
30	5.38	28.30	14.50	38.88	58.46	41.54	28.10	71.90
35	5.21	27.40	14.10	36.02	55.74	44.26		
40	5.05	26.50	13.30	33.44	52.06	47.94		
45	4.89	25.60	12.40	31.30	51.32	48.68		
50	4.75	24.80	11.80	29.46	50.55	49.45		
55	4.61	24.00	11.20	27.90	49.76	50.24		
60	4.48	23.50	10.70	26.47	48.96	51.04	24.26	75.74
90	3.76	19.50	8.80	21.17	43.62	56.38	15.66	84.34
120	3.15	16.80	7.50	17.41	37.57	62.43	10.23	89.77
150	2.61	14.00	6.50	14.67	31.02	68.98	7.25	92.75
180	2.17	11.50	5.70	12.62	24.19	75.81	5.27	94.73
210	1.75		5.00	11.53	17.48	82.52	3.58	96.42
240	1.36		4.60	10.57	11.47	88.53	2.36	97.64
270	1.01		4.20	9.94	6.59	93.41	1.57	98.43
300	0.69		3.80	9.38	3.17	96.83		
330	0.39		3.40	8.77	1.06	98.94		
360	0.2		2.6	2.34	0	100.00		

Table B18: Others Data of Weight of 6 kg for Surrounding Temperature of 30°C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	31.00	48.00	141.18	100.00	0.00	35.76	64.24
5	5.62	29.00	27.40	78.79	100.00	0.00		
10	5.33	27.00	20.00	55.99	100.00	0.00		
15	5.10	26.00	16.20	46.89	72.87	22.13		
20	4.91	25.00	14.40	43.54	61.77	33.23		
25	4.72	24.00	13.80	39.23	57.86	47.14		
30	4.56	23.00	13.00	36.17	53.72	48.28	27.09	72.91
35	4.41	22.00	12.00	33.22	52.79	49.21		
40	4.28	21.50	11.10	30.59	49.84	50.16		
45	4.14	21.00	10.40	28.38	48.87	51.13		
50	4.02	20.00	9.80	26.71	47.80	52.20		
55	3.90	19.50	9.30	25.18	46.79	53.21		
60	3.79	19.00	8.80	23.78	45.72	54.28	20.07	79.93
90	3.21	16.00	6.80	18.49	39.80	63.20	13.81	86.19
120	2.72	14.00	5.90	15.52	33.72	71.28	7.85	92.15
150	2.37	12.00	5.20	13.20	25.64	79.36	4.27	95.73
180	1.99	10.00	4.70	11.75	17.65	86.35	3.67	96.33
210	1.65	8.50	4.30	10.51	12.02	91.98	1.17	98.83
240	1.33		4.00	9.82	7.25	95.75		
270	1.06		3.80	8.11	1.87	98.13		
300	0.81		3.60	7.98	0.62	99.38		
330	0.54		3.2	7.74	0	100.00		
360	0.18		2.7	2.22	0	100.00		

Table B19: Others Data of Weight of 5 kg for Surrounding Temperature of 30°C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	5.00	26.50	48.00	134.64	100.00	0.00	34.64	65.36
5	4.58	25.30	24.50	74.45	100.00	0.00		
10	4.31	24.00	17.90	54.06	100.00	0.00		
15	4.10	23.00	15.40	41.84	68.00	32.00		
20	3.91	21.50	14.80	35.23	54.91	45.09		
25	3.73	20.50	13.40	32.75	52.73	47.27		
30	3.57	19.50	12.50	29.75	50.16	49.84	25.69	74.31
35	3.38	19.00	11.40	26.83	51.32	48.68		
40	3.24	18.50	10.60	24.44	49.48	50.52		
45	3.11	18.00	9.90	22.47	47.55	52.45		
50	2.99	17.00	9.30	20.90	45.56	54.44		
55	2.88	16.50	8.80	19.23	44.52	55.48		
60	2.77	16.00	8.40	18.26	43.43	56.57	18.15	81.85
90	2.21	13.50	6.70	13.77	36.41	63.59	11.73	88.27
120	1.74	11.00	5.90	11.54	29.78	70.22	5.70	94.30
150	1.31		5.00	10.26	21.04	78.96	2.66	97.34
180	0.93		4.40	9.46	14.53	85.47	1.92	98.08
210	0.60		3.90	8.93	7.55	92.45		
240	0.29		3.50	8.41	2.88	97.12		
270	0.16		2.00	2.04	0.00	100.00		

Table B20: Others Data of Weight of 4 kg for Surrounding Temperature of 30°C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	4.00	20.40	48.00	130.92	100	0.00	34.13	65.87
5	3.54	19.00	23.00	72.70	100	0.00		
10	3.28	18.00	16.20	51.01	100	0.00		
15	3.07	17.00	12.80	40.53	65.62	34.38		
20	2.91	16.00	12.30	37.59	51.47	48.53		
25	2.76	15.30	11.40	33.51	50.67	49.33		
30	2.62	14.60	10.40	30.69	49.08	50.92	23.00	77.00
35	2.50	13.80	9.50	27.75	47.74	52.26		
40	2.39	13.30	8.80	25.40	47.5	52.50		
45	2.28	12.80	8.20	23.49	43.27	56.73		
50	2.17	12.30	7.70	21.98	43.92	56.08		
55	2.07	11.80	7.30	20.61	40.55	59.45		
60	1.98	11.40	7.00	19.74	39.23	60.77	14.84	85.16
90	1.50	9.50	5.70	15.24	29.89	70.11	10.27	89.73
120	1.07		4.80	12.90	19.85	80.15	4.07	95.93
150	0.72		4.10	11.48	10.79	89.21	1.90	98.10
180	0.39		3.60	10.06	4.13	95.87	0.00	100.00
210	0.12		1.20	1.03	0.00	100.00		

Table B21: Others Data of Weight of 3 kg for Surrounding Temperature of 30^{o}C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	3.00	15.50	48.00	126.24	100.00	0.00	34.05	65.95
5	2.65	14.50	21.90	59.16	100.00	0.00		
10	2.40	13.50	15.00	40.62	66.78	33.22		
15	2.21	12.50	14.30	36.58	58.45	41.55		
20	2.03	11.50	12.30	30.92	49.1	50.90		
25	1.88	10.50	10.90	26.79	47.84	52.16		
30	1.75	10.00	9.60	23.30	46.5	53.50	18.76	81.24
35	1.62		8.60	20.66	45.3	54.70		
40	1.51		7.80	18.48	44.07	55.93	17.30	82.70
45	1.40		7.30	16.91	41.73	58.27		
50	1.31		6.70	15.70	39	61.00	13.57	86.43
55	1.25		6.40	14.54	36.97	63.03		
60	1.17		5.90	13.65	32.78	67.22	8.53	91.47
90	0.75		4.50	10.74	23.12	76.88	6.31	93.69
120	0.41		3.90	9.74	13.45	86.55	2.17	97.83
150	0.10		3.20	0.84	3.17	96.83		

Table B22: Others Data of Weight of 2 kg for Surrounding Temperature of 30°C, Flow Rate of 48 Liter/Minute and Composition of 4060

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample Propane (%)	Gas Sample Butane (%)	Liquid Sample Propane (%)	Liquid Sample Butane (%)
0	2.00	10.80	48.00	121.98	100.00	0.00	33.85	66.15
5	1.70		18.40	50.93	100.00	0.00		
10	1.49		13.90	37.10	100.00	0.00	24.38	75.62
15	1.31		12.10	30.84	51.17	48.83		
20	1.16		10.00	25.05	47.05	52.95	19.96	80.04
25	1.02		8.60	21.11	44.29	55.71		
30	0.91		7.60	18.16	41.63	58.37	15.66	84.34
35	0.84		6.70	16.05	39.05	60.95		
40	0.75		6.00	14.30	37.15	62.85	12.65	87.35
45	0.67		5.50	13.06	34.52	65.48		
50	0.60		5.00	12.40	28.64	71.36	7.20	92.80
55	0.52		4.70	11.69	24.42	75.58		
60	0.46		4.50	11.19	20.28	79.72	6.27	93.73
90	0.18		3.40	9.57	11.09	88.91	2.25	97.75
120	0.00		1.00	0.22	1.45	98.55		

Table B11: Others Data of Surrounding Temperature of 35°C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.50	48.00	147.66	100.00	0.00	33.09	66.91
5	5.61	30.00	29.50	83.67	100.00	0.00		
10	5.29	28.50	22.60	61.27	100.00	0.00		
15	5.04	27.00	18.80	50.03	74.02	25.98		
20	4.83	25.00	16.50	42.51	65.83	34.17		
25	4.64	24.00	15.40	40.04	57.26	42.74		
30	4.46	23.00	14.00	36.21	56.30	43.70	23.93	76.07
35	4.24	22.00	12.90	33.21	55.23	44.77		
40	4.09	21.00	12.00	30.67	49.84	50.16		
45	3.95	20.50	11.20	28.65	48.87	51.13		
50	3.82	20.00	10.60	26.87	47.80	52.20		
55	3.69	19.50	10.00	25.28	46.79	53.21		
60	3.57	19.00	9.50	23.88	45.72	54.28	19.67	80.33
90	2.94	15.00	7.90	18.97	36.80	63.20	10.88	89.12
120	2.34	13.00	6.60	16.53	28.72	71.28		
150	1.85	11.00	5.80	14.39	20.64	79.36	6.04	93.96
180	1.42	9.00	5.10	13.80	13.65	86.35		
210	1.07		4.50	12.89	8.02	91.98	1.69	98.31
240	0.74		4.20	12.29	4.25	95.75	1.07	98.93
270	0.52		4.00	11.82	1.87	98.13	0.95	99.05
300	0.21		3.50	11.42	0.62	99.38		
310	0.04		0.00	2.72	0	100.00		

Table B12: Others Data of Surrounding Temperature of 30°C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	32.20	48.30	131.18	100.00	0.00	33.76	66.24
5	5.62	29.00	27.40	80.79	100.00	0.00		
10	5.31	27.00	20.00	59.06	100.00	0.00		
15	5.07	26.00	16.20	47.84	77.87	22.13		
20	4.86	25.00	14.40	40.23	74.77	25.23		
25	4.69	24.00	13.80	36.75	66.86	33.14		
30	4.52	23.00	13.00	32.75	58.72	41.28	24.09	75.91
35	4.38	22.00	12.00	29.83	57.79	42.21		
40	4.24	21.50	11.10	26.44	54.25	45.75		
45	4.10	21.00	10.40	24.47	53.14	46.86		
50	3.97	20.00	9.80	23.90	52.02	47.98		
55	3.86	19.50	9.30	22.23	50.88	49.12		
60	3.75	19.00	8.80	21.26	49.60	50.40	20.07	79.93
90	3.16	16.00	6.80	17.77	41.86	58.14	11.81	88.19
120	2.67	14.00	5.90	15.54	32.22	67.78		
150	2.27	12.00	5.20	13.81	22.45	77.55	8.45	91.55
180	1.89	10.00	4.70	13.26	15.73	84.27		
210	1.56	8.50	4.30	12.23	10.09	89.91	1.97	98.03
240	1.25		4.00	11.99	5.88	94.12	1.17	98.83
270	0.98		3.80	11.71	2.87	97.13		
300	0.64		3.60	11.28	1.62	98.38		
330	0.40		3.4	10.34	0	100.00		
360	0.18		0	2.22	0	100.00		

Table B13: Others Data of Surrounding Temperature of 25^{o}C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample Propane (%)	Gas Sample Butane (%)	Liquid Sample Propane (%)	Liquid Sample Butane (%)
0	6.00	32.00	48.00	127.12	100.00	0.00	33.83	66.17
5	5.62	29.00	29.00	77.50	100.00	0.00		
10	5.33	27.00	20.80	54.18	100.00	0.00		
15	5.10	26.00	16.70	42.60	76.20	23.80		
20	4.91	25.00	14.20	35.21	73.18	26.82		
25	4.72	24.00	12.90	31.30	65.65	34.35		
30	4.56	23.00	12.50	29.04	57.83	42.17	25.24	74.76
35	4.41	22.50	11.40	27.31	57.07	42.93		
40	4.28	22.00	10.70	24.74	56.19	43.81		
45	4.14	21.50	10.00	23.17	55.54	44.46		
50	4.02	21.00	9.40	21.49	54.62	45.38		
55	3.90	20.50	8.90	20.20	53.66	46.34		
60	3.79	20.00	8.50	18.83	52.57	47.43	21.06	78.94
90	3.21	17.00	6.60	16.11	45.74	54.26	12.77	87.23
120	2.72	15.00	5.40	14.89	38.17	61.83		
150	2.37	13.00	4.70	13.46	30.34	69.66	9.67	90.33
180	1.99	11.50	4.20	12.92	22.90	77.10		
210	1.65	10.00	3.90	12.03	16.15	83.85	2.36	97.64
240	1.33	9.00	3.60	11.79	10.38	89.62	2.05	97.95
270	1.06		3.40	11.50	6.07	93.93	1.96	98.04
300	0.81		3.20	11.19	3.17	96.83	1.15	98.85
330	0.54		3.10	10.18	1.4	98.60		
360	0.38		2.60	7.94	0.47	99.53		
390	0.25		0.00	2.49	0.00	100.00		

Table B14: Others Data of Surrounding Temperature of 20°C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	31.80	48.00	122.59	100.00	0.00	34.05	65.95
5	5.54	30.00	26.60	65.01	100.00	0.00		
10	5.27	29.00	18.80	46.54	100.00	0.00		
15	5.06	28.00	15.00	36.43	73.68	26.32		
20	4.88	26.00	12.80	30.61	72.10	27.90		
25	4.71	25.00	12.30	28.62	63.23	36.77		
30	4.57	24.00	11.10	25.80	57.64	42.36	26.47	73.53
35	4.44	23.00	10.30	23.63	56.85	43.15		
40	4.31	22.50	9.60	21.64	56.04	43.96		
45	4.19	22.00	9.00	19.94	55.19	44.81		
50	4.08	21.50	8.50	18.84	54.40	45.60		
55	3.97	21.00	8.00	17.63	53.48	46.52		
60	3.87	20.50	7.60	16.59	52.44	47.56	21.71	78.29
90	3.37	18.00	5.80	14.02	46.30	53.70	13.77	86.23
120	2.93	16.00	4.90	13.49	39.51	60.49		
150	2.58	14.30	4.20	12.50	32.58	67.42	10.27	89.73
180	2.24	13.20	3.70	11.97	25.85	74.15		
210	1.93	12.30	3.40	11.17	19.70	80.30	3.69	96.31
240	1.67	11.30	3.10	10.76	14.57	85.43	2.68	97.32
270	1.41	10.20	2.90	10.23	10.19	89.81	2.19	97.81
300	1.18		2.80	9.86	6.47	93.53	1.24	98.76
330	0.94		2.70	8.68	3.78	96.22		
360	0.72		2.60	6.45	1.98	98.02		
390	0.52		2.50	6.12	0.93	99.07		
420	0.42		2.40	5.83	0.36	99.64		
450	0.32		2.10	2.83	0.00	100.00		

Table B15: Others Data of Surrounding Temperature of 15°C for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample		Liquid Sample	
					Propane (%)	Butane (%)	Propane (%)	Butane (%)
0	6.00	31.60	48.00	118.96	100.00	0.00	34.55	65.45
5	5.62	30.00	27.90	58.68	100.00	0.00		
10	5.33	29.00	19.80	42.19	100.00	0.00		
15	5.10	27.00	16.50	32.98	73.27	26.73		
20	4.91	26.00	13.70	27.98	66.37	33.63		
25	4.75	25.00	12.40	25.26	60.23	39.77		
30	4.59	24.50	11.30	22.76	57.70	42.30	27.77	72.23
35	4.44	24.00	10.40	20.34	56.86	43.14		
40	4.31	23.00	9.40	19.76	55.87	44.13		
45	4.19	22.50	8.60	18.61	55.00	45.00		
50	4.08	22.00	8.00	17.63	54.12	45.88		
55	3.98	21.50	7.20	16.84	53.19	46.81		
60	3.88	21.00	6.70	15.30	52.33	47.67	22.47	77.53
90	3.45	18.50	4.90	13.05	46.85	53.15	14.81	85.19
120	3.07	16.50	4.30	12.44	41.49	58.51		
150	2.74	15.00	3.60	11.74	35.90	64.10	11.22	88.78
180	2.46	14.00	3.20	11.19	30.43	69.57		
210	2.20	13.00	2.90	10.87	25.32	74.68	7.70	92.30
240	1.96	12.00	2.70	10.62	20.57	79.43	6.78	93.22
270	1.75	11.00	2.50	10.19	16.38	83.62	5.47	94.53
300	1.56	9.50	2.40	9.51	12.57	87.43	4.53	95.47
330	1.31		2.30	8.63	9.38	90.62		
360	1.12		2.20	6.16	6.79	93.21		
390	0.94		2.10	4.35	4.71	95.29		
420	0.77		2.00	3.77	3.13	96.87		
450	0.60		1.90	2.70	1.98	98.02		

Table B16: Others Data of Surrounding Temperature of 10^oC for Flow Rate of 48 Liter/Minute, Composition of 4060 and Weight of 6 kg

Time (Minute)	Weight (kg)	Liquid Level (cm)	Flowrate (liter/minute)	Pressure (Psi)	Gas Sample Propane (%)	Gas Sample Butane (%)	Liquid Sample Propane (%)	Liquid Sample Butane (%)
0	6.00	31.50	48.00	110.26	100.00	0.00	35.11	64.89
5	5.67	29.00	25.70	55.13	100.00	0.00		
10	5.39	28.00	18.70	39.91	100.00	0.00		
15	5.18	27.00	14.60	30.49	72.37	27.63		
20	5.03	26.00	12.50	25.18	65.61	34.39		
25	4.87	25.00	11.40	23.11	62.66	37.34		
30	4.73	24.00	10.30	20.89	62.01	37.99	28.54	71.46
35	4.58	23.00	9.50	19.17	61.40	38.60		
40	4.46	22.50	8.60	17.87	60.85	39.15		
45	4.35	22.00	8.10	16.67	60.24	39.76		
50	4.25	21.50	7.50	16.03	59.74	40.26		
55	4.15	21.00	6.90	15.26	59.18	40.82		
60	4.06	20.50	6.40	14.65	58.23	41.77	23.04	76.96
90	3.61	18.50	4.70	12.60	52.99	47.01	15.18	84.82
120	3.26	17.00	4.00	11.84	47.99	52.01		
150	2.97	15.50	3.40	11.27	42.89	57.11	12.00	88.00
180	2.69	14.50	3.10	11.08	37.77	62.23		
210	2.44	13.50	2.70	10.76	32.83	67.17	9.57	90.43
240	2.26	12.50	2.50	10.55	28.14	71.86	7.78	92.22
270	2.08	11.50	2.30	10.04	23.85	76.15	6.47	93.53
300	1.87	10.50	2.20	9.43	20.00	80.00	5.34	94.66
330	1.70	9.5	2.10	8.47	16.35	83.65		
360	1.53		2.00	6.03	13.09	86.91		
390	1.40		1.80	2.33	10.31	89.69		

Table A1: Temperatures Data of Commercial Propane for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	27.5	24.1	23.4	21.1	25.4	25.5	27.4	25.2	24.5	23.0	26.8	27.4	28.5	27.4	26.9	27.1	26.8	28.0
10	24.2	19.0	17.0	14.9	17.4	19.5	23.6	20.5	18.1	17.0	20.0	21.5	27.3	25.1	24.5	23.1	25.0	26.6
15	20.4	15.1	11.1	9.7	12.2	14.2	22.2	18.7	14.2	11.7	16.8	17.3	26.2	25.1	23.6	22.8	23.5	24.6
20	17.0	12.9	7.6	5.5	8.2	8.9	19.8	15.6	9.9	9.6	9.8	10.2	25.9	24.3	22.4	20.7	21.1	22.5
25	15.9	11.7	4.6	2.3	4.5	5.1	15.8	13.0	7.3	5.4	5.6	6.3	24.7	23.4	21.6	18.5	18.4	18.4
30	14.6	10.7	2.6	2.5	3.4	2.0	15.6	12.6	5.5	4.4	4.8	5.1	23.7	22.8	20.8	17.1	17.3	17.3
35	13.9	10.1	1.1	0.3	1.0	0.5	14.9	11.8	4.5	2.8	2.7	2.5	23.6	22.5	20.5	15.8	16.4	16.8
40	13.4	9.6	0.2	-1.4	-1.3	-1.8	14.5	11.3	3.7	1.9	1.8	1.8	23.1	22.0	20.5	14.8	15.1	15.9
45	12.4	8.6	-1.1	-2.4	-3.2	-3.7	13.4	10.3	2.5	0.9	0.8	0.2	22.7	21.7	19.6	13.7	12.4	12.2
50	12.4	7.6	-1.8	-3.1	-4.9	-5.6	13.5	9.0	1.3	-0.2	-0.7	-0.9	22.2	20.7	19.0	13.3	10.8	10.6
55	12.6	9.2	-0.6	-5.0	-5.7	-6.6	13.6	11.0	6.3	-1.5	-1.4	-2.5	23.5	22.9	20.2	13.3	10.5	9.9
60	13.8	10.7	0.9	-4.5	-5.5	-6.8	14.5	11.4	1.9	-2.1	-4.6	-5.8	23.5	20.6	19.2	13.7	11.9	10.2
90	14.4	11.2	3.1	-4.8	-6.0	-7.4	15.1	12.9	3.6	-3.8	-5.5	-6.8	24.2	21.6	18.7	12.5	10.7	8.6
120	15.3	12.2	5.7	-4.2	-6.9	-7.8	16.8	13.6	6.4	-3.1	-6.1	-7.1	25.5	22.6	19.5	13.6	9.4	7.7
150	16.3	13.6	7.4	-3.2	-8.6	-11.9	17.7	14.2	8.3	-2.9	-7.5	-11.3	26.1	23.6	20.5	14.4	8.9	6.7
180	22.7	18.3	11.9	1.4	-9.6	-14.9	23.3	19.8	12.5	2.1	-8.8	-14.1	26.3	23.9	21.3	15.4	10.5	4.7
210	23.9	20.1	15.5	5.6	-2.1	-12.2	24.4	20.8	16.9	6.4	-1.4	-11.6	28.2	26.7	25.7	20.7	11.4	6.5

Table A2: Temperatures Data of Commercial Butane for Surrounding Temperature of 30°C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.0
5	28.6	23.4	23.3	20.9	24.2	25.6	26.1	24.7	24.2	22.5	25.9	26.3	29.5	27.2	27.9	26.8	28.8	29.7
10	27.4	23.4	22.2	19.7	24.7	26.2	25.6	23.9	20.7	19.2	22.0	24.3	28.8	26.9	25.9	24.7	27.1	29.6
15	19.7	16.6	13.3	12.5	12.9	13.0	21.9	17.4	14.9	14.3	16.8	17.1	26.1	25.2	24.4	22.7	23.8	25.0
20	18.3	14.2	10.8	9.3	9.9	9.1	20.9	15.0	13.7	13.2	13.5	13.8	25.6	24.3	23.5	21.4	22.8	24.2
25	17.9	12.5	8.0	7.6	7.7	6.8	20.1	13.5	11.4	10.7	10.6	11.0	24.9	23.8	22.7	19.2	20.7	21.7
30	17.2	11.5	6.5	5.6	6.2	5.7	19.6	12.8	9.4	9.3	8.7	8.6	24.6	23.6	22.3	18.7	19.6	21.0
35	17.4	12.0	5.7	4.3	4.2	3.4	19.8	12.7	8.8	8.2	6.4	5.4	24.4	23.3	21.9	18.4	19.0	19.1
40	17.5	12.5	4.9	3.3	3.9	2.8	19.7	12.6	8.4	7.1	5.2	4.5	24.1	23.0	21.5	17.7	18.1	18.1
45	17.6	13.6	4.3	2.4	2.7	1.9	19.6	12.4	8.0	6.1	4.7	3.6	23.8	22.9	21.4	17.5	17.5	17.5
50	17.7	14.0	5.9	1.7	2.4	1.5	19.6	12.5	7.9	4.5	3.8	2.9	23.6	22.7	21.0	17.2	17.4	16.6
55	18.1	14.5	6.2	1.4	2.2	0.9	19.7	12.8	8.2	4.2	3.6	2.6	23.4	23.0	21.4	17.1	16.9	16.5
60	18.6	15.2	6.8	2.2	1.8	0.2	19.1	16.3	7.9	3.7	2.7	1.1	26.1	23.7	22.5	18.7	16.5	16.3
90	19.4	16.5	9.4	3.6	0.8	-0.6	20.4	17.3	9.6	2.1	1.1	0.6	26.4	24.6	21.5	15.9	14.6	15.6
120	20.5	17.8	10.7	3.7	0.4	-0.7	21.4	18.2	11.6	2.5	0.9	0.0	26.7	24.2	23.4	17.7	15.5	15.0
150	20.8	18.3	12.8	4.1	0.2	-0.7	21.5	19.3	13.5	4.7	0.1	0.0	27.1	25.9	24.7	18.3	14.5	13.9
180	21.3	18.7	14.2	5.7	0.0	-0.9	21.8	19.8	15.7	6.7	0.6	-0.5	27.3	26.1	25.2	19.9	15.6	13.0
210	21.3	20.8	15.6	6.3	1.6	-0.5	21.8	21.6	16.3	7.4	2.4	0.6	27.4	26.4	25.6	20.6	16.2	13.6
240	22.4	21.2	16.7	9.6	2.8	0.0	23.6	21.8	17.9	10.9	3.4	0.9	27.5	26.8	25.6	22.4	18.5	14.5
270	23.2	21.5	16.1	10.7	5.8	0.8	24.3	21.8	18.9	12.3	6.8	1.7	27.9	26.9	25.7	23.2	19.5	15.2
300	23.8	22.6	18.7	12.9	6.9	1.2	25.2	23.4	19.6	14.4	7.7	2.2	28.1	27.4	26.4	23.9	20.3	16.2
330	24.5	22.8	19.6	13.2	8.0	1.2	25.7	23.9	20.3	14.8	8.7	2.8	28.3	27.8	26.7	24.2	21.7	18.3
360	25.8	23.4	19.8	13.8	8.9	2.7	25.9	24.7	21.4	15.9	9.3	3.0	28.5	27.9	27.5	25.6	21.9	19.2
390	26.7	24.0	20.2	14.8	12.3	4.8	26.4	25.9	22.5	16.7	12.8	4.5	28.5	28.1	27.6	25.5	22.6	20.7

Table A3: Temperatures Data of 8020 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	17.0	15.8	15.3	17.1	21.4	24.0	27.8	26.4	24.7	23.9	25.2	25.6	28.4	27.4	26.5	24.9	27.8	28.9
10	25.6	20.2	18.7	16.1	19.4	21.3	24.1	21.3	18.5	17.2	20.2	21.8	27.5	25.6	24.9	23.3	26.4	28.3
15	14.8	11.0	5.8	9.4	11.1	8.7	20.2	13.1	9.7	9.8	10.0	10.8	26.7	24.9	23.4	21.2	25.5	27.3
20	15.2	10.3	4.5	6.3	7.8	5.3	19.7	12.3	7.4	7.1	6.8	7.3	26.5	24.6	22.6	20.2	24.4	25.9
25	14.5	9.2	3.6	3.2	2.8	2.1	18.9	11.3	6.0	4.6	3.7	3.9	25.9	23.9	22.1	18.7	22.7	25.3
30	14.5	8.9	2.2	0.7	1.7	-0.6	18.7	11.0	4.4	2.9	2.4	1.1	25.5	23.6	21.5	17.7	22.4	24.7
35	14.0	8.2	1.2	-0.1	-0.1	-1.2	18.4	10.4	4.5	1.8	1.0	0.2	25.0	22.9	21.5	17.2	21.7	22.4
40	13.8	8.0	0.1	-0.7	-1.1	-2.1	18.0	10.2	4.4	-0.3	-0.8	-1.2	24.9	22.8	21.2	16.3	19.8	19.2
45	13.2	9.7	-0.4	-1.0	-2.8	-3.0	17.8	10.0	4.0	-1.3	-1.6	-2.1	24.6	23.1	20.7	15.1	17.7	16.6
50	13.0	10.3	-0.7	-1.4	-3.2	-4.4	17.1	9.8	3.9	-2.2	-2.1	-3.5	24.4	22.6	20.8	14.9	15.9	14.2
55	13.1	10.5	-1.1	-2.0	-4.3	-5.8	16.7	10.0	3.1	-2.6	-3.2	-4.7	24.2	22.6	20.6	14.3	13.2	12.6
60	14.7	11.7	1.7	-2.3	-4.7	-6.1	15.7	12.1	2.5	-1.8	-3.8	-5.5	24.2	21.6	20.8	13.8	12.5	11.1
90	15.1	12.3	4.6	-3.2	-5.2	-6.8	16.5	13.9	5.1	-2.5	-4.4	-5.9	24.4	22.2	19.8	13.1	11.6	9.4
120	16.5	13.2	6.6	-3.0	-6.6	-7.6	17.4	14.4	7.3	-2.9	-5.8	-6.9	25.7	22.8	20.8	14.5	10.1	8.9
150	17.2	15.1	8.9	-2.3	-7.7	-10.4	18.9	16.4	9.2	-1.7	-6.2	-9.8	26.3	24.5	21.6	15.1	9.9	7.7
180	17.7	16.4	10.1	2.4	-8.7	-12.1	19.3	17.4	11.6	3.2	-7.9	-11.8	26.7	25.2	23.3	17.5	12.8	7.5
210	18.9	17.2	11.7	3.2	-6.5	-12.7	20.8	17.9	12.2	4.1	-5.7	-10.8	26.8	25.5	24.2	19.7	14.3	9.5
240	20.4	18.7	12.9	5.1	-3.4	-8.7	21.2	19.2	13.8	6.8	-2.8	-8.1	26.8	25.7	25.2	20.7	15.2	10.5
270	21.6	19.5	14.7	7.6	2.3	-4.2	22.4	20.4	15.2	8.3	3.2	-3.2	27.1	26.0	25.8	21.9	16.6	11.7
300	21.9	23.2	19.4	14.5	10.3	3.9	26.4	24.5	20.5	15.9	11.5	5.3	27.4	26.8	26.1	22.6	18.1	13.1

Table A4: Temperatures Data of 6040 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.2	26.0	24.9	25.1	25.5	26.1	29.3	28.4	27.4	26.4	25.6	25.9	29.5	28.7	26.1	27.6	29.1	29.3
10	26.6	21.7	20.5	17.1	22.3	23.4	24.9	22.9	19.3	18.1	22.7	22.4	28.1	26.2	25.3	24.8	26.7	29.1
15	18.8	17.1	14.8	15.9	16.6	16.8	24.2	18.6	16.5	16.8	17.8	17.3	25.1	24.8	25.7	24.4	26.3	27.0
20	17.4	14.2	9.3	12.1	13.5	10.6	22.1	16.4	11.5	13.0	14.1	14.0	24.8	24.3	24.4	23.5	25.5	26.4
25	16.2	12.6	7.4	9.4	7.1	6.1	21.5	15.1	10.6	11.0	10.4	8.9	25.0	24.3	23.2	22.8	24.7	24.9
30	14.5	12.0	6.3	7.3	0.8	2.6	20.9	13.4	9.5	8.4	6.1	4.5	25.1	23.8	22.4	22.3	24.2	24.4
35	14.4	11.2	4.6	5.6	1.8	-0.4	20.6	13.2	8.5	6.7	0.3	1.5	24.8	23.8	22.4	21.9	21.3	20.8
40	13.9	10.5	3.5	4.1	0.2	-1.6	20.4	12.7	7.6	5.2	1.5	0.9	24.9	23.6	22.0	21.7	19.9	19.3
45	14.3	10.3	2.9	2.9	-0.8	-2.2	20.2	12.7	6.9	4.9	2.5	-1.4	24.7	22.9	22.0	20.2	17.8	16.7
50	14.2	10.1	2.6	1.8	-1.5	-3.9	20.2	12.7	6.3	1.9	3.4	-2.1	24.5	21.6	21.4	18.4	16.9	15.6
55	13.9	9.8	2.1	0.7	-2.4	-4.3	20.0	12.7	6.0	0.7	-1.9	-3.9	24.5	22.1	20.9	17.5	15.5	14.9
60	16.2	12.5	2.7	-1.3	-3.5	-5.3	17.2	13.7	3.8	-0.1	-2.6	-4.9	25.1	22.5	19.4	16.7	14.2	13.9
90	17.1	13.6	6.6	-1.6	-4.3	-6.2	18.1	14.5	6.8	-1.1	-3.1	-5.3	25.3	22.9	20.3	14.0	12.8	11.3
120	17.9	14.4	7.5	-1.9	-5.2	-6.7	18.5	15.7	8.4	-0.9	-4.7	-6.3	25.9	23.4	21.7	15.1	11.9	10.6
150	18.7	16.3	9.3	-1.5	-6.6	-8.9	19.1	17.1	10.1	1.8	-5.2	-7.7	26.5	23.9	22.5	16.5	11.4	9.2
180	18.9	17.2	11.5	3.8	-6.7	-9.5	20.1	18.3	12.4	4.6	-6.2	-8.7	26.9	25.1	23.9	17.6	12.2	8.6
210	19.4	18.3	12.9	4.8	-5.6	-7.2	20.9	18.9	13.6	5.3	-4.7	-6.8	26.9	25.8	24.6	18.8	13.9	10.9
240	20.8	19.5	13.5	6.9	-1.6	-5.9	21.8	20.6	14.4	7.7	-1.7	-4.6	27.1	25.9	24.9	19.1	15.7	11.8
270	22.2	20.5	14.8	8.7	2.8	-3.2	22.9	20.6	15.9	9.5	3.9	-2.6	27.3	26.1	25.3	21.6	16.5	13.1
300	22.8	20.8	16.5	9.3	4.2	-1.3	23.5	21.2	17.1	10.5	4.7	-1.2	27.6	26.7	26.5	22.8	18.7	14.9
330	23.8	22.4	20.6	14.5	9.8	-0.1	26.3	24.1	21.4	15.3	10.5	0.7	27.9	27.1	26.9	23.5	19.2	15.3

Table A5: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.2	25.7	24.5	26.9	29.4	28.7	27.7	25.8	25.2	27.8	29.6	29.5	29.2	27.4	26.4	30.6	30.9
10	27.1	22.1	21.7	18.9	23.5	24.3	25.4	23.6	20.2	20.7	24.3	24.9	24.4	26.7	25.3	24.4	26.8	29.6
15	25.2	23.6	19.8	18.1	20.4	21.1	24.9	23.2	19.3	19.5	21.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	20.9	18.8	14.9	13.0	15.1	16.3	23.9	22.7	18.1	16.1	18.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	18.7	16.3	11.4	11.9	8.9	7.3	22.8	21.4	17.9	14.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	16.4	14.8	6.1	9.6	5.3	4.6	21.8	20.3	14.1	12.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	15.3	13.8	4.3	8.7	3.1	1.8	20.3	18.2	10.2	9.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	14.3	11.1	3.6	5.9	1.0	0.4	20.8	16.1	8.4	7.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	10.8	2.3	3.0	0.3	-1.8	19.3	14.1	6.7	4.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	14.7	12.0	3.0	2.1	-0.3	-1.9	18.6	13.3	4.9	2.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	15.4	13.3	3.2	0.5	-1.0	-2.0	17.5	14.3	4.2	1.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	17.8	14.8	4.5	1.2	-1.3	-3.1	18.8	15.2	5.1	2.1	-0.3	-2.7	26.4	24.6	23.2	16.3	15.8	15.3
90	18.6	15.7	8.5	2.9	-2.4	-3.4	19.8	16.6	8.8	0.6	-1.9	-2.9	25.6	23.8	20.7	14.7	13.6	13.3
120	19.5	16.4	9.8	3.9	-2.6	-3.8	20.7	17.1	10.8	1.8	-1.1	-3.2	26.2	24.3	22.8	16.7	14.6	13.6
150	19.9	17.6	13.1	4.5	-2.1	-4.4	20.9	18.7	12.6	3.8	-1.4	-3.6	26.5	24.5	23.9	18.0	16.3	12.4
180	20.4	19.9	14.8	5.7	-1.0	-2.8	21.9	17.9	14.1	5.2	-1.6	-3.9	27.3	25.8	24.2	18.7	17.2	13.0
210	21.1	20.2	15.4	8.7	1.1	-1.8	22.2	18.2	15.5	6.2	0.1	-2.2	27.6	26.1	24.5	20.4	17.6	12.9
240	22.8	21.2	16.4	10.1	4.8	-0.9	23.5	19.4	16.8	9.4	2.2	-1.1	27.8	25.4	24.7	22.0	18.6	13.4
270	23.4	21.9	17.8	11.8	5.2	0.0	24.2	20.9	18.4	11.5	5.9	0.4	27.9	25.7	24.9	22.7	19.5	14.9
300	24.1	22.2	18.2	12.4	6.8	1.1	24.6	21.5	19.8	13.7	8.4	1.4	28.0	26.2	25.2	23.3	20.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	23.5	20.6	15.0	10.6	3.1	28.2	26.4	25.4	23.9	21.9	17.4
360	25.5	23.4	20.8	14.8	8.9	3.7	26.0	24.9	21.2	17.8	12.4	6.9	28.6	26.7	25.8	24.9	23.0	18.8

Table A1: Temperatures Data of Commercial Propane for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	27.5	24.1	23.4	21.1	25.4	25.5	27.4	25.2	24.5	23.0	26.8	27.4	28.5	27.4	26.9	27.1	26.8	28.0
10	24.2	19.0	17.0	14.9	17.4	19.5	23.6	20.5	18.1	17.0	20.0	21.5	27.3	25.1	24.5	23.1	25.0	26.6
15	20.4	15.1	11.1	9.7	12.2	14.2	22.2	18.7	14.2	11.7	16.8	17.3	26.2	25.1	23.6	22.8	23.5	24.6
20	17.0	12.9	7.6	5.5	8.2	8.9	19.8	15.6	9.9	9.6	9.8	10.2	25.9	24.3	22.4	20.7	21.1	22.5
25	15.9	11.7	4.6	2.3	4.5	5.1	15.8	13.0	7.3	5.4	5.6	6.3	24.7	23.4	21.6	18.5	18.4	18.4
30	14.6	10.7	2.6	2.5	3.4	2.0	15.6	12.6	5.5	4.4	4.8	5.1	23.7	22.8	20.8	17.1	17.3	17.3
35	13.9	10.1	1.1	0.3	1.0	0.5	14.9	11.8	4.5	2.8	2.7	2.5	23.6	22.5	20.5	15.8	16.4	16.8
40	13.4	9.6	0.2	-1.4	-1.3	-1.8	14.5	11.3	3.7	1.9	1.8	1.8	23.1	22.0	20.5	14.8	15.1	15.9
45	12.4	8.6	-1.1	-2.4	-3.2	-3.7	13.4	10.3	2.5	0.9	0.8	0.2	22.7	21.7	19.6	13.7	12.4	12.2
50	12.4	7.6	-1.8	-3.1	-4.9	-5.6	13.5	9.0	1.3	-0.2	-0.7	-0.9	22.2	20.7	19.0	13.3	10.8	10.6
55	12.6	9.2	-0.6	-5.0	-5.7	-6.6	13.6	11.0	6.3	-1.5	-1.4	-2.5	23.5	22.9	20.2	13.3	10.5	9.9
60	13.8	10.7	0.9	-4.5	-5.5	-6.8	14.5	11.4	1.9	-2.1	-4.6	-5.8	23.5	20.6	19.2	13.7	11.9	10.2
90	14.4	11.2	3.1	-4.8	-6.0	-7.4	15.1	12.9	3.6	-3.8	-5.5	-6.8	24.2	21.6	18.7	12.5	10.7	8.6
120	15.3	12.2	5.7	-4.2	-6.9	-7.8	16.8	13.6	6.4	-3.1	-6.1	-7.1	25.5	22.6	19.5	13.6	9.4	7.7
150	16.3	13.6	7.4	-3.2	-8.6	-11.9	17.7	14.2	8.3	-2.9	-7.5	-11.3	26.1	23.6	20.5	14.4	8.9	6.7
180	22.7	18.3	11.9	1.4	-9.6	-14.9	23.3	19.8	12.5	2.1	-8.8	-14.1	26.3	23.9	21.3	15.4	10.5	4.7
210	23.9	20.1	15.5	5.6	-2.1	-12.2	24.4	20.8	16.9	6.4	-1.4	-11.6	28.2	26.7	25.7	20.7	11.4	6.5

Table A2: Temperatures Data of Commercial Butane for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.0
5	28.6	23.4	23.3	20.9	24.2	25.6	26.1	24.7	24.2	22.5	25.9	26.3	29.5	27.2	27.9	26.8	28.8	29.7
10	27.4	23.4	22.2	19.7	24.7	26.2	25.6	23.9	20.7	19.2	22.0	24.3	28.8	26.9	25.9	24.7	27.1	29.6
15	19.7	16.6	13.3	12.5	12.9	13.0	21.9	17.4	14.9	14.3	16.8	17.1	26.1	25.2	24.4	22.7	23.8	25.0
20	18.3	14.2	10.8	9.3	9.9	9.1	20.9	15.0	13.7	13.2	13.5	13.8	25.6	24.3	23.5	21.4	22.8	24.2
25	17.9	12.5	8.0	7.6	7.7	6.8	20.1	13.5	11.4	10.7	10.6	11.0	24.9	23.8	22.7	19.2	20.7	21.7
30	17.2	11.5	6.5	5.6	6.2	5.7	19.6	12.8	9.4	9.3	8.7	8.6	24.6	23.6	22.3	18.7	19.6	21.0
35	17.4	12.0	5.7	4.3	4.2	3.4	19.8	12.7	8.8	8.2	6.4	5.4	24.4	23.3	21.9	18.4	19.0	19.1
40	17.5	12.5	4.9	3.3	3.9	2.8	19.7	12.6	8.4	7.1	5.2	4.5	24.1	23.0	21.5	17.7	18.1	18.1
45	17.6	13.6	4.3	2.4	2.7	1.9	19.6	12.4	8.0	6.1	4.7	3.6	23.8	22.9	21.4	17.5	17.5	17.5
50	17.7	14.0	5.9	1.7	2.4	1.5	19.6	12.5	7.9	4.5	3.8	2.9	23.6	22.7	21.0	17.2	17.4	16.6
55	18.1	14.5	6.2	1.4	2.2	0.9	19.7	12.8	8.2	4.2	3.6	2.6	23.4	23.0	21.4	17.1	16.9	16.5
60	18.6	15.2	6.8	2.2	1.8	0.2	19.1	16.3	7.9	3.7	2.7	1.1	26.1	23.7	22.5	18.7	16.5	16.3
90	19.4	16.5	9.4	3.6	0.8	-0.6	20.4	17.3	9.6	2.1	1.1	0.6	26.4	24.6	21.5	15.9	14.6	15.6
120	20.5	17.8	10.7	3.7	0.4	-0.7	21.4	18.2	11.6	2.5	0.9	0.0	26.7	24.2	23.4	17.7	15.5	15.0
150	20.8	18.3	12.8	4.1	0.2	-0.7	21.5	19.3	13.5	4.7	0.1	0.0	27.1	25.9	24.7	18.3	14.5	13.9
180	21.3	18.7	14.2	5.7	0.0	-0.9	21.8	19.8	15.7	6.7	0.6	-0.5	27.3	26.1	25.2	19.9	15.6	13.0
210	21.3	20.8	15.6	6.3	1.6	-0.5	21.8	21.6	16.3	7.4	2.4	0.6	27.4	26.4	25.6	20.6	16.2	13.6
240	22.4	21.2	16.7	9.6	2.8	0.0	23.6	21.8	17.9	10.9	3.4	0.9	27.5	26.8	25.6	22.4	18.5	14.5
270	23.2	21.5	16.1	10.7	5.8	0.8	24.3	21.8	18.9	12.3	6.8	1.7	27.9	26.9	25.7	23.2	19.5	15.2
300	23.8	22.6	18.7	12.9	6.9	1.2	25.2	23.4	19.6	14.4	7.7	2.2	28.1	27.4	26.4	23.9	20.3	16.2
330	24.5	22.8	19.6	13.2	8.0	1.2	25.7	23.9	20.3	14.8	8.7	2.8	28.3	27.8	26.7	24.2	21.7	18.3
360	25.8	23.4	19.8	13.8	8.9	2.7	25.9	24.7	21.4	15.9	9.3	3.0	28.5	27.9	27.5	25.6	21.9	19.2
390	26.7	24.0	20.2	14.8	12.3	4.8	26.4	25.9	22.5	16.7	12.8	4.5	28.5	28.1	27.6	25.5	22.6	20.7

Table A3: Temperatures Data of 8020 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	17.0	15.8	15.3	17.1	21.4	24.0	27.8	26.4	24.7	23.9	25.2	25.6	28.4	27.4	26.5	24.9	27.8	28.9
10	25.6	20.2	18.7	16.1	19.4	21.3	24.1	21.3	18.5	17.2	20.2	21.8	27.5	25.6	24.9	23.3	26.4	28.3
15	14.8	11.0	5.8	9.4	11.1	8.7	20.2	13.1	9.7	9.8	10.0	10.8	26.7	24.9	23.4	21.2	25.5	27.3
20	15.2	10.3	4.5	6.3	7.8	5.3	19.7	12.3	7.4	7.1	6.8	7.3	26.5	24.6	22.6	20.2	24.4	25.9
25	14.5	9.2	3.6	3.2	2.8	2.1	18.9	11.3	6.0	4.6	3.7	3.9	25.9	23.9	22.1	18.7	22.7	25.3
30	14.5	8.9	2.2	0.7	1.7	-0.6	18.7	11.0	4.4	2.9	2.4	1.1	25.5	23.6	21.5	17.7	22.4	24.7
35	14.0	8.2	1.2	-0.1	-0.1	-1.2	18.4	10.4	4.5	1.8	1.0	0.2	25.0	22.9	21.5	17.2	21.7	22.4
40	13.8	8.0	0.1	-0.7	-1.1	-2.1	18.0	10.2	4.4	-0.3	-0.8	-1.2	24.9	22.8	21.2	16.3	19.8	19.2
45	13.2	9.7	-0.4	-1.0	-2.8	-3.0	17.8	10.0	4.0	-1.3	-1.6	-2.1	24.6	23.1	20.7	15.1	17.7	16.6
50	13.0	10.3	-0.7	-1.4	-3.2	-4.4	17.1	9.8	3.9	-2.2	-2.1	-3.5	24.4	22.6	20.8	14.9	15.9	14.2
55	13.1	10.5	-1.1	-2.0	-4.3	-5.8	16.7	10.0	3.1	-2.6	-3.2	-4.7	24.2	22.6	20.6	14.3	13.2	12.6
60	14.7	11.7	1.7	-2.3	-4.7	-6.1	15.7	12.1	2.5	-1.8	-3.8	-5.5	24.2	21.6	20.8	13.8	12.5	11.1
90	15.1	12.3	4.6	-3.2	-5.2	-6.8	16.5	13.9	5.1	-2.5	-4.4	-5.9	24.4	22.2	19.8	13.1	11.6	9.4
120	16.5	13.2	6.6	-3.0	-6.6	-7.6	17.4	14.4	7.3	-2.9	-5.8	-6.9	25.7	22.8	20.8	14.5	10.1	8.9
150	17.2	15.1	8.9	-2.3	-7.7	-10.4	18.9	16.4	9.2	-1.7	-6.2	-9.8	26.3	24.5	21.6	15.1	9.9	7.7
180	17.7	16.4	10.1	2.4	-8.7	-12.1	19.3	17.4	11.6	3.2	-7.9	-11.8	26.7	25.2	23.3	17.5	12.8	7.5
210	18.9	17.2	11.7	3.2	-6.5	-12.7	20.8	17.9	12.2	4.1	-5.7	-10.8	26.8	25.5	24.2	19.7	14.3	9.5
240	20.4	18.7	12.9	5.1	-3.4	-8.7	21.2	19.2	13.8	6.8	-2.8	-8.1	26.8	25.7	25.2	20.7	15.2	10.5
270	21.6	19.5	14.7	7.6	2.3	-4.2	22.4	20.4	15.2	8.3	3.2	-3.2	27.1	26.0	25.8	21.9	16.6	11.7
300	21.9	23.2	19.4	14.5	10.3	3.9	26.4	24.5	20.5	15.9	11.5	5.3	27.4	26.8	26.1	22.6	18.1	13.1

Table A4: Temperatures Data of 6040 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.2	26.0	24.9	25.1	25.5	26.1	29.3	28.4	27.4	26.4	25.6	25.9	29.5	28.7	26.1	27.6	29.1	29.3
10	26.6	21.7	20.5	17.1	22.3	23.4	24.9	22.9	19.3	18.1	22.7	22.4	28.1	26.2	25.3	24.8	26.7	29.1
15	18.8	17.1	14.8	15.9	16.6	16.8	24.2	18.6	16.5	16.8	17.8	17.3	25.1	24.8	25.7	24.4	26.3	27.0
20	17.4	14.2	9.3	12.1	13.5	10.6	22.1	16.4	11.5	13.0	14.1	14.0	24.8	24.3	24.4	23.5	25.5	26.4
25	16.2	12.6	7.4	9.4	7.1	6.1	21.5	15.1	10.6	11.0	10.4	8.9	25.0	24.3	23.2	22.8	24.7	24.9
30	14.5	12.0	6.3	7.3	0.8	2.6	20.9	13.4	9.5	8.4	6.1	4.5	25.1	23.8	22.4	22.3	24.2	24.4
35	14.4	11.2	4.6	5.6	1.8	-0.4	20.6	13.2	8.5	6.7	0.3	1.5	24.8	23.8	22.4	21.9	21.3	20.8
40	13.9	10.5	3.5	4.1	0.2	-1.6	20.4	12.7	7.6	5.2	1.5	0.9	24.9	23.6	22.0	21.7	19.9	19.3
45	14.3	10.3	2.9	2.9	-0.8	-2.2	20.2	12.7	6.9	4.9	2.5	-1.4	24.7	22.9	22.0	20.2	17.8	16.7
50	14.2	10.1	2.6	1.8	-1.5	-3.9	20.2	12.7	6.3	1.9	3.4	-2.1	24.5	21.6	21.4	18.4	16.9	15.6
55	13.9	9.8	2.1	0.7	-2.4	-4.3	20.0	12.7	6.0	0.7	-1.9	-3.9	24.5	22.1	20.9	17.5	15.5	14.9
60	16.2	12.5	2.7	-1.3	-3.5	-5.3	17.2	13.7	3.8	-0.1	-2.6	-4.9	25.1	22.5	19.4	16.7	14.2	13.9
90	17.1	13.6	6.6	-1.6	-4.3	-6.2	18.1	14.5	6.8	-1.1	-3.1	-5.3	25.3	22.9	20.3	14.0	12.8	11.3
120	17.9	14.4	7.5	-1.9	-5.2	-6.7	18.5	15.7	8.4	-0.9	-4.7	-6.3	25.9	23.4	21.7	15.1	11.9	10.6
150	18.7	16.3	9.3	-1.5	-6.6	-8.9	19.1	17.1	10.1	1.8	-5.2	-7.7	26.5	23.9	22.5	16.5	11.4	9.2
180	18.9	17.2	11.5	3.8	-6.7	-9.5	20.1	18.3	12.4	4.6	-6.2	-8.7	26.9	25.1	23.9	17.6	12.2	8.6
210	19.4	18.3	12.9	4.8	-5.6	-7.2	20.9	18.9	13.6	5.3	-4.7	-6.8	26.9	25.8	24.6	18.8	13.9	10.9
240	20.8	19.5	13.5	6.9	-1.6	-5.9	21.8	20.6	14.4	7.7	-1.7	-4.6	27.1	25.9	24.9	19.1	15.7	11.8
270	22.2	20.5	14.8	8.7	2.8	-3.2	22.9	20.6	15.9	9.5	3.9	-2.6	27.3	26.1	25.3	21.6	16.5	13.1
300	22.8	20.8	16.5	9.3	4.2	-1.3	23.5	21.2	17.1	10.5	4.7	-1.2	27.6	26.7	26.5	22.8	18.7	14.9
330	23.8	22.4	20.6	14.5	9.8	-0.1	26.3	24.1	21.4	15.3	10.5	0.7	27.9	27.1	26.9	23.5	19.2	15.3

Table A5: Temperatures Data of 4060 Composition for Surrounding Temperature of 30°C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.2	25.7	24.5	26.9	29.4	28.7	27.7	25.8	25.2	27.8	29.6	29.5	29.2	27.4	26.4	30.6	30.9
10	27.1	22.1	21.7	18.9	23.5	24.3	25.4	23.6	20.2	20.7	24.3	24.9	24.4	26.7	25.3	24.4	26.8	29.6
15	25.2	23.6	19.8	18.1	20.4	21.1	24.9	23.2	19.3	19.5	21.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	20.9	18.8	14.9	13.0	15.1	16.3	23.9	22.7	18.1	16.1	18.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	18.7	16.3	11.4	11.9	8.9	7.3	22.8	21.4	17.9	14.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	16.4	14.8	6.1	9.6	5.3	4.6	21.8	20.3	14.1	12.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	15.3	13.8	4.3	8.7	3.1	1.8	20.3	18.2	10.2	9.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	14.3	11.1	3.6	5.9	1.0	0.4	20.8	16.1	8.4	7.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	10.8	2.3	3.0	0.3	-1.8	19.3	14.1	6.7	4.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	14.7	12.0	3.0	2.1	-0.3	-1.9	18.6	13.3	4.9	2.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	15.4	13.3	3.2	0.5	-1.0	-2.0	17.5	14.3	4.2	1.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	17.8	14.8	4.5	1.2	-1.3	-3.1	18.8	15.2	5.1	2.1	-0.3	-2.7	26.4	24.6	23.2	16.3	15.8	15.3
90	18.6	15.7	8.5	2.9	-2.4	-3.4	19.8	16.6	8.8	0.6	-1.9	-2.9	25.6	23.8	20.7	14.7	13.6	13.3
120	19.5	16.4	9.8	3.9	-2.6	-3.8	20.7	17.1	10.8	1.8	-1.1	-3.2	26.2	24.3	22.8	16.7	14.6	13.6
150	19.9	17.6	13.1	4.5	-2.1	-4.4	20.9	18.7	12.6	3.8	-1.4	-3.6	26.5	24.5	23.9	18.0	16.3	12.4
180	20.4	19.9	14.8	5.7	-1.0	-2.8	21.9	17.9	14.1	5.2	-1.6	-3.9	27.3	25.8	24.2	18.7	17.2	13.0
210	21.1	20.2	15.4	8.7	1.1	-1.8	22.2	18.2	15.5	6.2	0.1	-2.2	27.6	26.1	24.5	20.4	17.6	12.9
240	22.8	21.2	16.4	10.1	4.8	-0.9	23.5	19.4	16.8	9.4	2.2	-1.1	27.8	25.4	24.7	22.0	18.6	13.4
270	23.4	21.9	17.8	11.8	5.2	0.0	24.2	20.9	18.4	11.5	5.9	0.4	27.9	25.7	24.9	22.7	19.5	14.9
300	24.1	22.2	18.2	12.4	6.8	1.1	24.6	21.5	19.8	13.7	8.4	1.4	28.0	26.2	25.2	23.3	20.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	23.5	20.6	15.0	10.6	3.1	28.2	26.4	25.4	23.9	21.9	17.4
360	25.5	23.4	20.8	14.8	8.9	3.7	26.0	24.9	21.2	17.8	12.4	6.9	28.6	26.7	25.8	24.9	23.0	18.8

Table A6: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 70 Liter per Minute and Weight 6 kg

Time (min)	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	30.1	28.9	28.0	21.5	29.2	29.4	29.5	28.3	29.0	26.8	29.7	30.5	29.8	29.5	29.5	27.7	30.4	30.0
10	19.1	15.4	12.7	8.9	26.5	27.3	22.1	17.0	15.7	14.0	26.5	29.2	27.3	26.1	25.6	24.8	27.7	29.3
15	17.9	12.7	7.1	6.3	15.5	26.8	21.3	15.3	9.4	8.5	18.1	28.4	25.9	24.2	22.9	21.8	26.4	29.3
20	16.9	11.8	6.8	5.9	10.5	15.2	20.5	13.9	9.1	7.7	15.1	21.1	24.5	22.8	22.2	21.4	24.1	26.7
25	15.6	11.3	5.8	4.7	9.5	10.3	20.3	13.5	7.8	7.5	13.0	18.1	24.2	22.9	22.0	20.6	22.5	24.4
30	15.4	7.8	5.1	2.6	7.3	9.6	20.0	12.2	7.0	5.8	8.4	13.1	23.7	22.5	21.7	18.7	20.8	22.1
35	15.4	10.5	4.0	1.7	6.4	6.1	19.4	12.7	5.2	3.4	8.2	11.0	23.5	21.3	20.1	18.1	18.6	20.1
40	14.1	10.3	3.3	-0.1	3.6	3.2	19.3	12.3	4.5	1.6	5.4	8.4	23.2	20.3	19.7	17.3	17.6	18.4
45	13.8	9.6	2.1	-2.4	-0.8	-1.1	18.9	11.8	4.0	-0.6	2.5	3.9	22.8	20.0	19.4	15.8	16.6	15.8
50	13.5	9.5	1.6	-3.7	-1.5	-1.5	18.7	11.4	3.5	-1.8	-0.1	2.2	22.7	19.8	19.1	15.0	16.2	13.0
55	13.4	9.4	1.3	-5.6	-3.5	-3.6	18.4	11.1	3.1	-2.7	-1.9	0.0	22.5	19.6	18.6	12.4	13.3	11.6
60	13.4	7.8	0.5	-5.0	-5.3	-5.9	18.0	11.6	2.4	-3.8	-3.9	-2.9	22.3	20.3	18.0	10.3	9.9	8.3
90	14.6	10.0	1.1	-4.8	-5.8	-6.3	17.4	12.5	2.9	-4.3	-4.1	-3.7	22.0	20.6	18.4	9.6	8.3	7.3
120	16.5	11.6	4.3	-4.4	-6.1	-6.5	18.1	13.5	5.8	-3.9	-5.6	-4.5	22.6	21.3	19.5	8.7	8.1	6.0
150	17.9	12.6	6.2	-3.5	-5.1	-6.7	19.3	14.7	7.5	-2.0	-4.3	-5.4	23.6	21.6	19.9	8.5	6.5	4.5
180	20.4	15.3	8.6	-1.6	-4.2	-6.8	21.5	16.3	9.5	0.4	-3.6	-5.5	24.4	21.7	20.4	10.1	6.8	3.9
210	21.4	16.1	9.6	2.2	-2.4	-6.0	22.8	19.8	11.2	3.9	-2.0	-4.3	25.6	22.7	20.6	11.5	8.4	5.1
240	22.0	18.0	12.7	2.8	-0.4	-4.0	24.3	20.1	14.9	5.4	0.3	-2.5	26.3	23.3	21.1	13.0	10.4	6.5
270	22.6	18.8	14.3	4.7	1.8	-1.9	24.6	21.0	16.6	6.4	3.1	0.5	26.9	24.2	21.5	15.1	12.0	8.9
300	22.8	19.3	15.2	5.7	2.7	-1.5	25.4	22.8	20.8	7.1	4.8	1.6	27.3	25.3	22.9	17.6	14.3	11.4
330	23.1	20.3	16.7	7.5	4.5	-0.7	25.9	23.5	21.4	9.8	5.3	2.5	27.8	26.5	23.4	19.1	16.3	13.9
360	25.0	22.6	19.2	12.4	6.8	2.7	26.6	24.5	22.7	13.7	7.3	4.2	28.3	27.0	25.2	23.2	18.8	15.4
380	25.6	23.3	20.4	14.0	11.2	4.6	27.1	25.2	23.7	15.1	12.6	6.1	28.6	27.7	26.4	24.9	21.3	17.4

Table A7: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 60 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	28.4	27.5	24.0	25.5	27.3	29.9	29.4	28.2	26.2	28.2	29.6	30.4	30.3	28.9	27.7	28.7	30.3	30.5
10	19.9	16.5	13.3	9.6	27.1	29.7	22.3	18.6	16.8	14.9	27.9	28.9	28.1	26.9	25.3	24.9	28.1	29.4
15	16.9	12.3	7.4	7.0	20.1	26.2	19.9	15.3	12.4	13.9	22.4	28.4	25.8	24.0	23.5	22.2	26.9	29.0
20	15.2	10.1	6.5	5.4	15.2	21.4	19.5	11.9	9.6	10.9	17.0	22.7	24.8	23.3	22.4	20.8	25.3	26.3
25	13.7	9.5	5.8	4.3	10.3	16.1	19.4	11.6	9.0	9.3	14.6	17.8	24.4	23.1	22.1	20.5	23.4	24.0
30	14.9	8.7	5.6	3.8	8.6	10.3	19.1	12.9	7.9	7.7	9.4	14.3	24.3	23.1	21.9	20.1	21.7	23.2
35	15.9	9.8	5.0	3.2	5.5	6.2	18.8	13.2	7.5	6.5	7.4	10.0	24.2	22.9	21.6	19.9	21.4	21.5
40	16.0	10.7	4.9	3.0	4.6	5.2	19.0	13.6	7.3	4.8	5.4	7.1	24.0	22.7	21.5	18.8	20.2	19.7
45	16.4	11.8	4.8	1.2	2.8	2.4	19.2	13.9	6.9	4.0	3.8	5.4	23.8	22.4	21.1	18.5	17.4	17.9
50	16.6	12.0	4.7	-0.1	1.4	1.0	19.5	14.2	6.7	2.6	2.1	3.2	23.6	22.3	21.0	17.4	15.0	15.3
55	16.7	12.1	4.4	-1.6	0.3	-0.2	19.7	14.5	6.5	0.4	1.0	2.2	23.3	22.5	20.4	14.8	12.9	12.3
60	16.9	12.4	4.6	-2.3	-2.4	-2.8	19.9	13.6	5.7	-2.1	-1.4	-1.6	23.1	21.8	20.0	12.5	11.5	9.9
90	17.1	12.8	4.9	-3.4	-3.6	-4.7	20.2	14.1	5.6	-2.2	-3.0	-2.9	24.1	22.0	20.6	11.4	10.4	9.4
120	17.7	13.0	5.3	-4.3	-4.1	-5.8	20.4	15.5	6.3	-2.7	-3.6	-3.7	24.3	22.5	21.2	9.9	9.7	8.4
150	19.7	13.9	6.8	-2.4	-4.2	-6.3	21.1	16.6	7.5	-1.6	-2.9	-3.0	24.6	22.7	21.6	9.3	8.7	6.9
180	20.9	15.9	9.1	-0.5	-3.3	-6.4	22.3	17.3	10.1	1.9	-3.2	-3.8	24.9	23.3	21.9	12.5	9.8	5.5
210	21.6	16.5	10.2	2.5	-2.0	-5.7	23.4	18.7	12.1	3.7	-0.9	-2.9	26.1	23.6	22.5	13.2	8.4	5.1
240	22.5	18.7	13.1	3.8	0.5	-3.4	24.0	20.0	15.7	5.2	1.1	-1.2	26.5	24.4	22.7	15.0	12.2	8.6
270	23.3	19.2	14.6	5.2	2.6	-1.4	25.2	21.0	17.9	7.6	3.8	1.5	27.1	24.6	23.4	16.3	13.8	9.9
300	24.1	20.9	15.9	6.6	3.5	-0.9	25.5	22.6	19.1	8.9	5.3	2.4	27.5	25.6	24.2	18.3	15.2	12.6
330	24.9	22.0	17.4	7.3	4.7	0.4	26.5	23.2	20.8	9.5	6.6	3.7	28.1	26.8	25.1	21.6	17.4	15.1
360	25.6	23.1	19.8	13.1	7.9	3.3	27.2	24.6	21.3	15.2	9.1	5.1	28.8	28.4	26.7	23.0	20.6	18.4
390	26.7	24.5	21.6	16.3	10.1	5.3	27.6	25.3	22.7	18.5	13.1	8.4	29.1	28.7	28.3	24.4	21.8	20.1

Table A8: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.5	17.2	17.7	22.5	28.9	25.4	25.7	24.7	26.1	24.2	29.8	30.6	29.5	29.2	27.4	26.4	30.6	30.9
10	15.1	9.1	7.0	8.9	26.5	24.3	24.1	17.6	12.0	14.3	27.3	30.3	29.4	28.7	26.3	25.4	29.8	30.8
15	14.2	4.6	2.8	4.1	10.4	17.1	23.9	17.2	10.3	13.5	17.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	13.9	3.8	1.9	3.0	5.1	10.3	23.9	16.7	11.1	12.1	10.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	13.7	4.3	1.4	1.9	2.9	5.3	23.8	16.4	11.9	11.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	13.4	4.8	0.1	0.6	1.3	2.6	23.8	16.3	12.1	11.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	13.3	5.8	-0.3	-0.7	1.1	1.8	23.3	16.2	12.2	10.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	13.3	6.1	-0.6	-0.9	0.0	0.4	22.8	16.1	12.4	8.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	6.8	-0.3	-1.0	0.3	-1.8	22.3	16.1	12.7	7.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	12.7	7.0	0.0	-1.1	-1.3	-1.9	21.6	15.3	12.9	5.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	12.4	7.3	0.2	-1.5	-1.7	-2.0	21.5	15.3	13.2	4.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	13.4	7.8	1.5	-2.0	-2.3	-3.1	21.8	15.2	13.9	5.7	-0.3	-0.7	26.4	24.6	23.2	16.3	15.8	15.3
90	14.6	10.0	2.5	-3.0	-3.3	-4.4	19.8	14.6	14.1	6.6	-1.9	-3.2	25.0	23.8	23.7	14.7	13.6	13.3
120	15.5	11.4	4.8	-2.0	-2.6	-4.2	19.7	15.1	14.8	8.8	-1.7	-3.0	25.2	24.3	23.8	15.7	14.6	13.6
150	16.9	13.1	7.2	0.0	-1.4	-3.2	19.9	16.7	15.6	11.8	-0.7	-2.0	26.1	24.5	23.9	18.0	16.3	13.4
180	17.9	14.6	9.1	1.5	-1.0	-2.4	21.9	17.9	16.1	13.2	1.3	-1.3	26.3	24.8	24.2	18.7	17.2	13.5
210	19.4	15.9	10.8	4.7	-0.5	-1.8	23.2	18.2	17.1	14.2	2.1	-0.2	26.6	25.1	24.5	20.4	17.6	13.9
240	20.1	17.2	12.4	7.0	-0.1	-1.4	23.5	19.4	18.8	15.4	4.2	0.1	26.8	25.4	24.7	22.0	18.6	14.4
270	20.8	18.3	13.8	8.1	1.8	-1.3	24.2	19.9	19.4	16.5	6.9	0.4	26.9	25.7	24.9	22.7	19.5	14.9
300	21.4	19.0	14.8	8.8	2.0	-1.5	24.6	20.5	19.8	17.7	8.4	1.4	27.3	26.2	25.2	23.3	20.6	15.8
330	22.1	19.9	16.2	11.4	4.8	-0.7	25.2	21.5	20.6	18.0	10.6	3.1	27.5	26.4	25.4	23.9	21.9	17.4
360	23.5	21.8	19.2	15.0	6.8	2.7	26.0	23.9	22.2	20.8	14.4	6.9	27.6	26.7	25.8	24.9	23.0	18.8

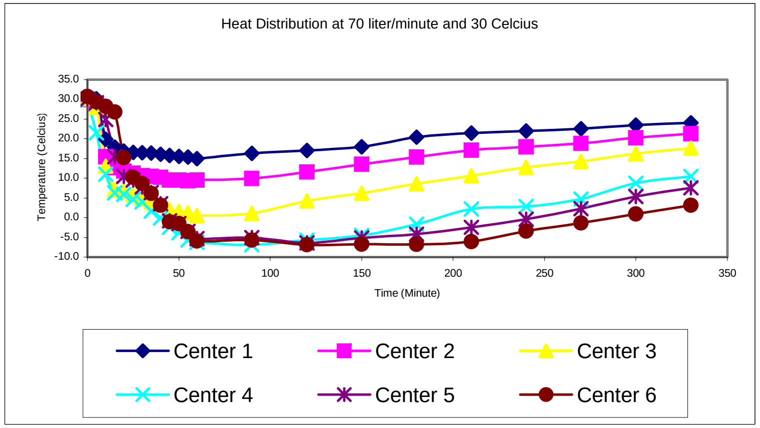
Table A9: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 30 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.3	26.3	25.9	28.0	28.7	28.9	28.1	27.8	26.5	28.3	29.7	29.3	28.5	28.6	27.3	29.7	30.9
10	25.1	19.6	17.1	14.2	26.0	27.6	26.4	24.9	23.4	18.5	27.8	29.0	28.8	28.1	25.5	26.7	28.5	29.7
15	23.9	16.4	10.4	9.5	23.4	24.6	24.2	22.8	14.8	14.0	25.7	27.3	27.5	25.3	24.8	23.7	26.8	28.6
20	21.3	15.3	9.6	8.6	19.4	20.8	22.0	20.8	13.5	12.7	20.9	25.5	26.7	24.0	23.7	22.7	25.1	27.1
25	19.5	14.4	8.8	7.9	16.8	17.6	21.9	18.4	12.1	10.8	18.1	23.1	26.4	23.4	23.3	22.2	23.2	26.7
30	17.8	13.7	8.1	7.5	12.8	15.2	22.8	17.0	11.3	9.7	15.9	18.9	25.7	23.3	23.2	22.3	23.7	25.6
35	17.7	12.4	8.3	6.9	11.6	12.5	19.6	14.6	9.6	8.8	12.5	16.1	25.4	23.0	22.8	21.2	21.0	21.9
40	17.9	13.1	8.2	6.5	9.0	10.9	18.4	14.5	9.4	7.1	11.9	13.4	25.5	22.6	22.5	20.5	20.4	21.4
45	18.1	13.6	7.8	6.3	7.7	8.4	18.6	14.8	9.0	8.2	9.7	10.3	25.1	22.4	22.3	20.4	20.2	20.0
50	18.2	13.9	7.3	6.0	5.6	6.2	19.1	15.0	8.5	7.8	7.6	8.1	25.3	22.3	22.1	19.6	18.8	19.0
55	18.4	14.3	7.1	5.5	4.7	5.2	19.8	15.8	8.4	6.9	6.0	7.3	25.4	23.0	22.8	19.1	18.5	17.1
60	18.6	14.1	7.1	5.1	4.9	4.8	20.3	15.3	8.2	6.3	5.5	6.5	25.1	23.8	22.5	18.9	17.2	15.8
90	19.6	15.0	7.9	4.9	3.7	2.7	21.2	17.2	9.8	4.6	4.1	5.0	24.7	23.4	22.3	17.2	16.3	13.9
120	20.9	15.7	9.9	4.1	2.6	1.9	21.5	17.5	10.7	4.9	3.7	3.8	24.5	23.3	22.5	15.1	14.6	12.7
150	21.4	16.0	10.5	3.3	1.5	1.3	22.1	17.7	11.7	5.7	3.5	3.7	24.7	24.2	23.2	14.5	13.5	11.5
180	22.6	17.1	11.1	2.9	0.8	0.1	22.9	18.5	14.4	6.1	3.7	3.9	25.5	23.2	22.8	15.1	12.3	9.1
210	23.6	19.2	14.6	5.1	2.1	0.9	23.9	19.6	15.2	7.8	4.3	4.1	26.6	24.5	23.7	15.3	14.4	10.7
240	23.9	19.9	15.3	6.9	3.8	1.9	24.5	20.4	16.7	8.8	5.4	4.7	27.3	25.8	24.2	17.2	15.6	11.8
270	24.1	20.2	16.5	8.7	4.8	1.7	24.9	20.9	17.3	9.8	6.2	5.6	27.5	26.1	25.1	20.2	17.6	14.2
300	24.9	21.4	18.6	9.7	6.3	2.7	25.5	22.0	19.7	11.3	8.1	6.3	27.5	24.4	22.6	18.2	13.8	11.6
330	25.2	21.9	19.1	10.4	7.8	3.3	26.8	23.0	20.5	13.5	10.7	6.5	28.2	25.3	25.6	22.2	18.8	16.6
360	26.4	22.6	21.5	12.7	9.6	6.3	27.9	26.8	22.2	16.7	13.2	7.6	28.6	27.9	26.9	24.3	21.6	19.7
375	27.4	23.6	22.5	15.9	11.5	8.1	28.2	27.2	23.8	18.7	14.8	11.3	29.2	28.6	27.7	25.1	22.6	20.3

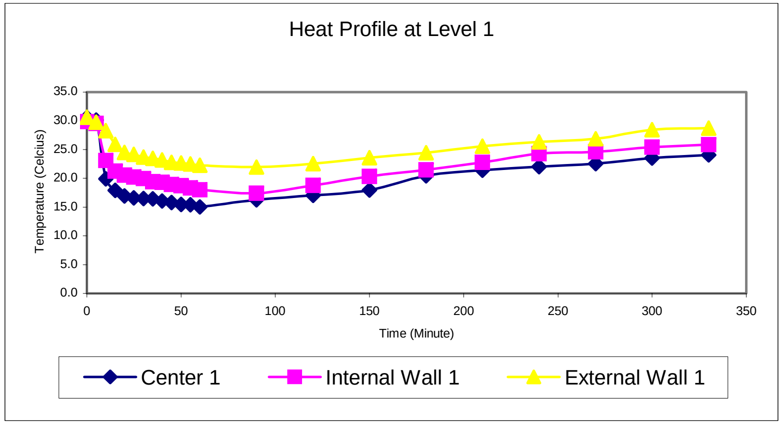
Table A10: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 20 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	27.3	24.1	22.3	20.7	27.2	28.8	28.3	26.8	25.8	24.4	28.4	29.2	29.6	29.1	28.4	27.6	28.9	29.7
10	25.7	20.1	17.8	14.8	26.3	27.9	26.0	25.2	25.1	22.2	27.3	28.2	28.9	28.3	27.9	27.2	28.7	29.7
15	23.4	17.7	14.7	12.7	23.3	25.7	25.6	22.5	21.6	20.5	23.3	27.1	28.1	27.0	26.0	25.0	27.3	27.4
20	21.2	16.2	12.0	10.4	19.2	23.4	24.5	20.5	17.1	14.7	20.1	24.7	27.7	26.3	25.0	23.9	26.1	26.8
25	19.6	14.8	10.5	8.3	16.8	18.4	24.0	18.3	14.8	13.5	18.9	20.9	27.0	25.8	23.7	23.3	25.7	26.3
30	18.7	14.0	8.6	7.8	13.2	16.9	23.4	17.4	11.8	10.7	16.4	19.2	26.2	25.6	23.5	22.8	24.3	25.0
35	18.2	12.8	8.2	6.7	8.8	13.5	20.2	17.2	11.1	9.6	11.7	17.0	23.7	25.4	22.3	22.1	22.7	23.6
40	17.8	10.2	7.9	6.5	8.5	10.1	20.4	17.1	10.3	9.4	10.3	14.5	24.2	24.9	22.1	21.7	22.1	23.1
45	17.3	11.7	7.5	6.3	7.8	9.9	20.9	16.8	10.2	8.8	9.6	12.1	24.4	24.5	21.4	21.3	21.5	21.5
50	17.0	12.5	7.4	6.1	7.1	7.9	21.1	16.6	10.3	8.9	9.3	9.9	24.5	24.3	21.3	20.8	20.8	21.2
55	18.1	13.4	7.2	5.9	6.2	6.1	21.3	16.5	9.5	8.0	8.8	8.6	24.7	24.2	21.0	20.6	19.7	20.7
60	18.9	14.7	6.8	5.7	5.8	5.5	21.5	16.4	10.1	7.4	7.7	8.0	25.2	24.1	21.6	20.1	19.1	18.9
90	20.1	15.4	8.0	5.5	5.2	4.8	22.2	17.6	10.4	7.9	7.1	7.0	25.3	23.9	21.8	18.7	17.8	14.7
120	21.5	16.8	11.7	5.3	4.7	3.5	22.4	18.5	11.1	6.7	6.6	6.5	25.5	24.4	22.0	17.5	16.5	15.6
150	21.9	16.4	10.8	4.9	2.1	1.7	22.6	18.9	12.0	6.4	5.6	5.1	25.9	24.2	22.4	15.8	14.2	13.7
180	22.5	17.7	13.1	3.6	1.1	0.6	22.9	19.3	15.3	6.9	5.6	5.9	26.2	24.5	22.7	17.0	15.5	12.5
210	23.1	19.8	15.1	6.5	3.8	3.3	23.8	20.8	16.4	8.2	6.6	6.4	26.3	24.7	23.1	16.5	15.2	12.1
240	24.1	20.4	16.2	7.5	4.7	3.9	24.5	21.2	17.2	9.0	7.5	6.8	26.6	25.2	24.5	17.9	16.5	13.2
270	24.4	20.6	16.7	9.3	5.2	3.0	25.2	22.5	19.1	11.4	7.9	6.9	27.2	25.7	24.8	18.7	17.6	14.4
300	25.2	21.5	19.4	10.3	6.5	3.6	26.3	23.4	20.3	13.7	8.3	7.2	27.7	26.3	25.2	23.1	19.5	15.1
330	25.6	22.3	19.8	11.7	8.1	4.6	26.0	24.7	21.9	15.3	11.7	7.8	27.9	26.7	25.5	25.4	22.2	16.7
360	26.0	23.6	20.3	14.6	10.2	6.9	26.3	25.8	23.2	17.6	13.1	8.5	27.8	26.9	26.0	29.1	26.3	17.6
390	26.3	24.0	21.2	15.8	12.4	7.2	26.9	26.5	23.9	18.5	14.1	10.2	28.1	27.4	26.2	22.1	16.5	18.1
420	26.8	25.5	21.9	16.9	14.5	9.2	27.4	26.9	24.5	18.9	16.7	12.0	29.3	27.7	26.5	23.1	18.8	19.1
450	27.4	26.4	23.2	17.5	16.8	11.7	28.2	27.6	25.3	20.0	18.9	14.1	29.6	28.7	26.7	23.7	21.3	19.7
480	27.7	26.6	24.2	18.6	18.7	14.2	28.8	27.7	26.8	21.4	19.6	16.3	29.9	29.4	27.6	24.3	22.9	20.4
490	28.0	26.9	24.8	20.9	19.1	15.7	28.9	28.8	28.0	22.5	20.8	18.3	30.0	29.6	28.7	25.2	24.5	21.6

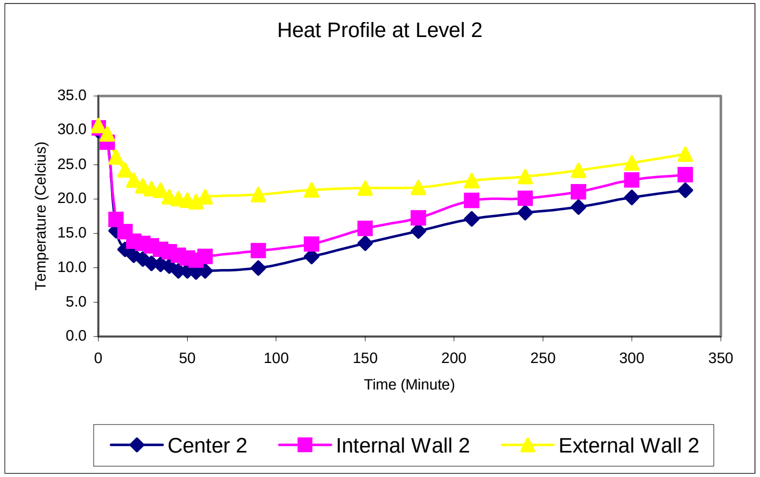
Q = 70 L/M



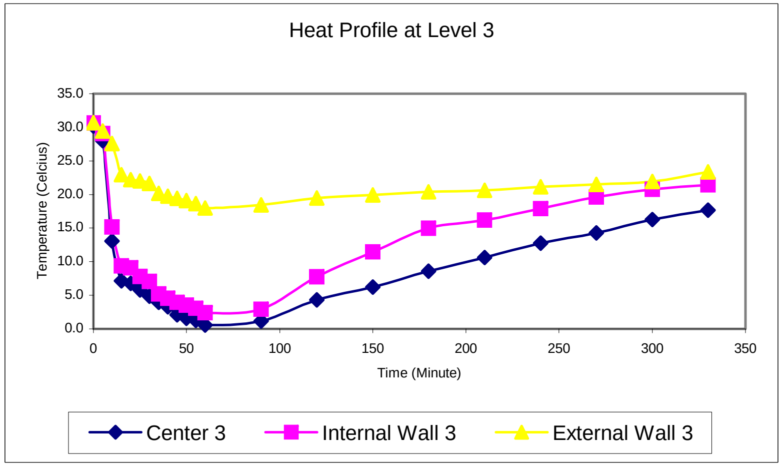
Heat Distribution at 70 liter/minute and 30 Celcius
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6



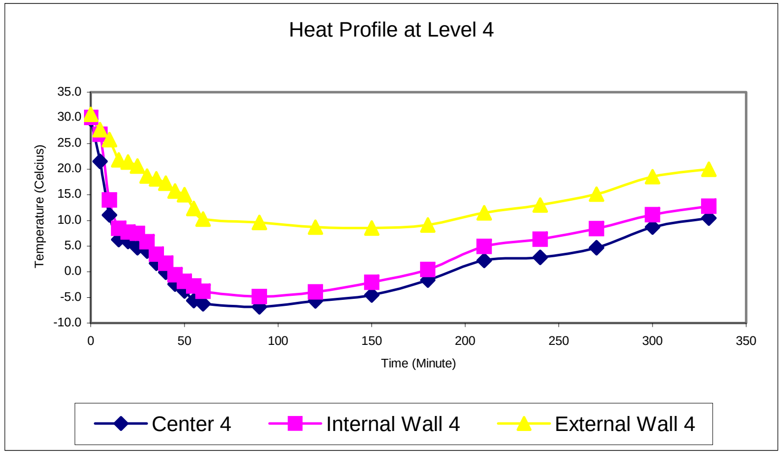
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1

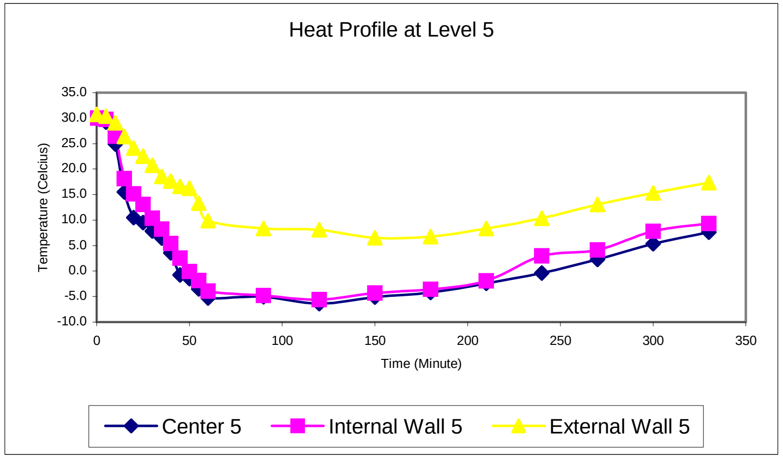


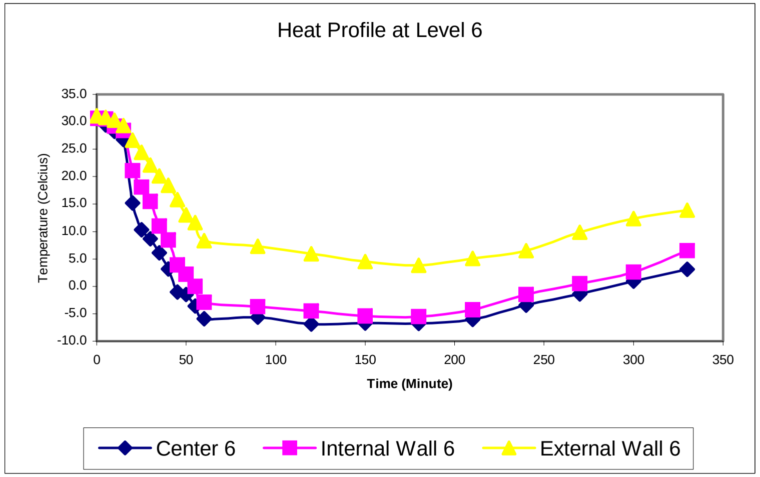
Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2

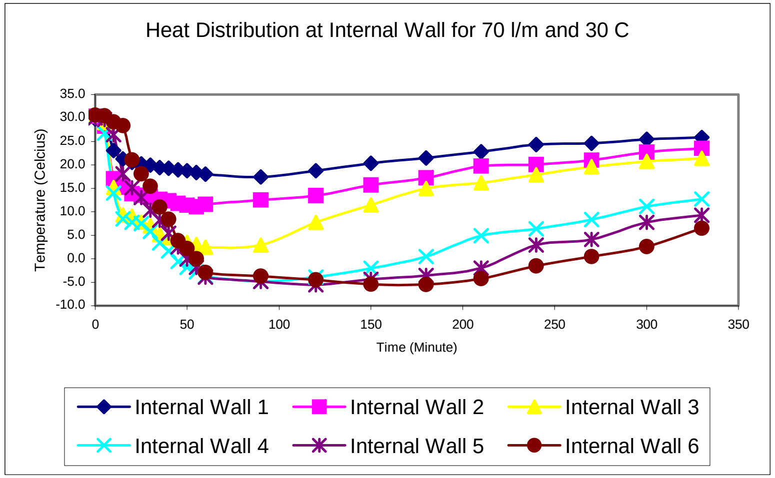


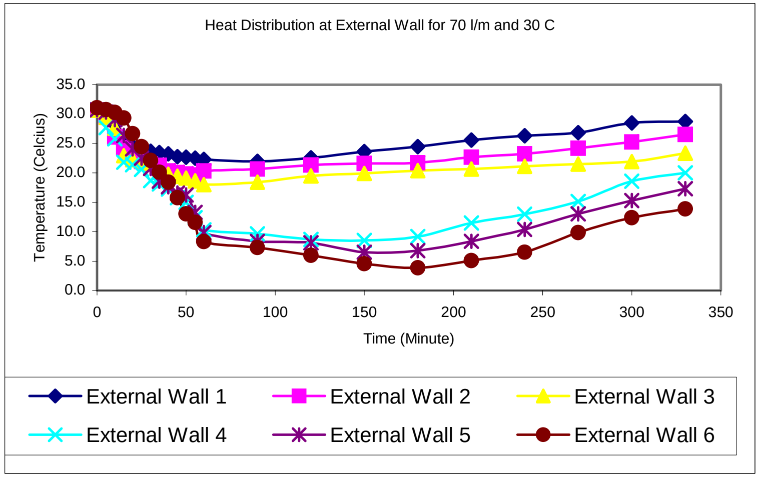
Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3


Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

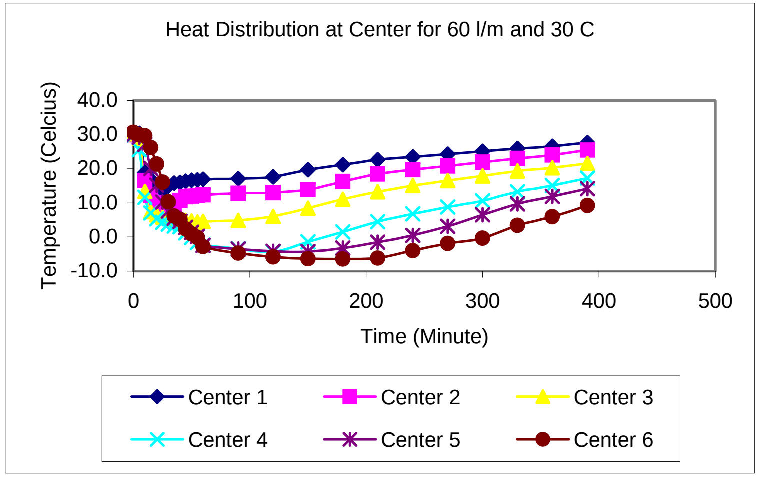

Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

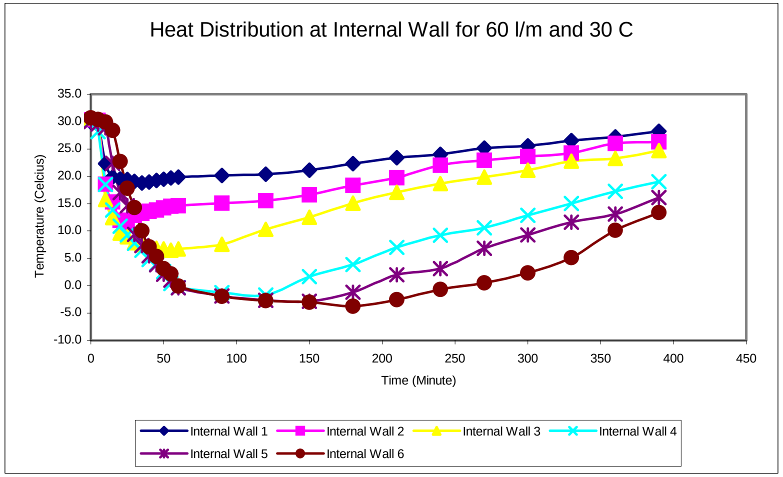

Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

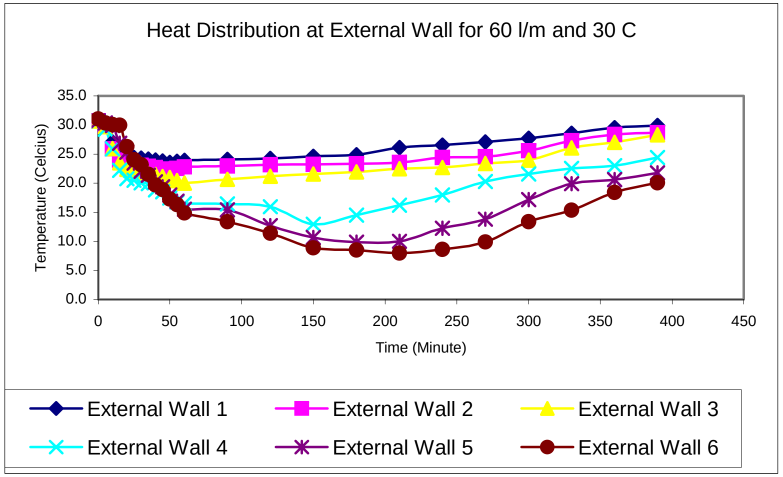

Heat Distribution at Internal Wall for 70 l/m and 30 C
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6


Heat Distribution at External Wall for 70 l/m and 30 C
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

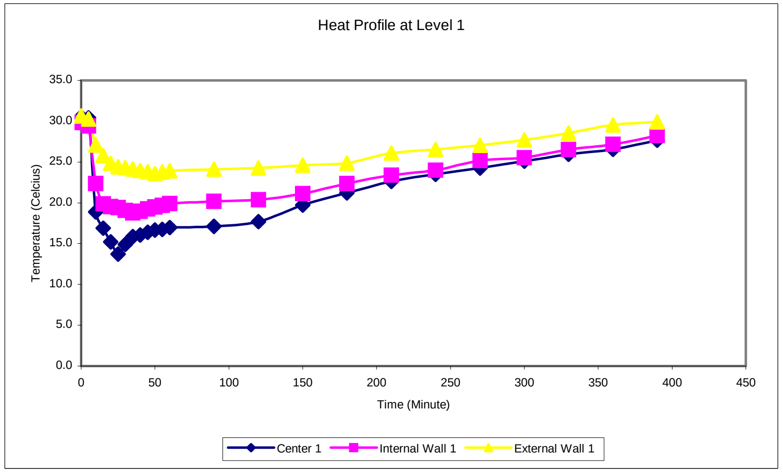
Q = 60 L/M


Heat Distribution at Center for 60 l/m and 30 C
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

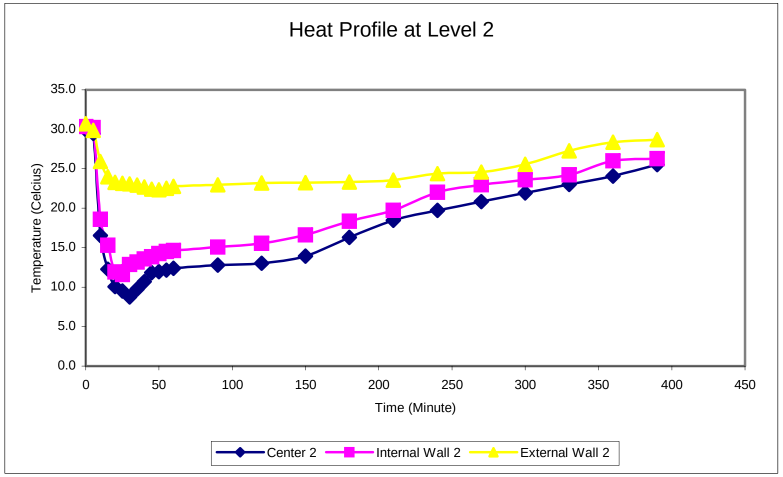

Heat Distribution at Internal Wall for 60 l/m and 30 C
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6



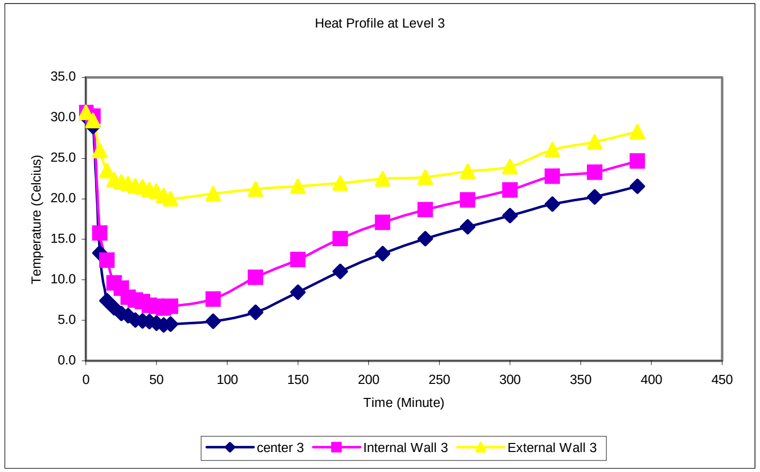
Heat Distribution at External Wall for 60 l/m and 30 C
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6



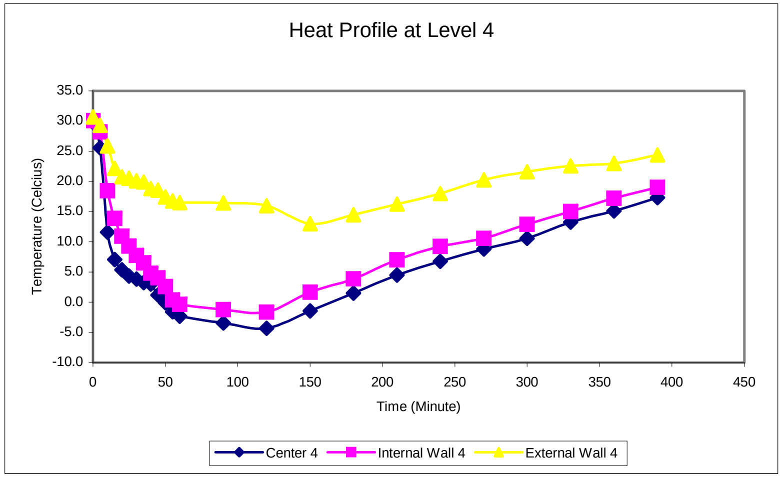
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1



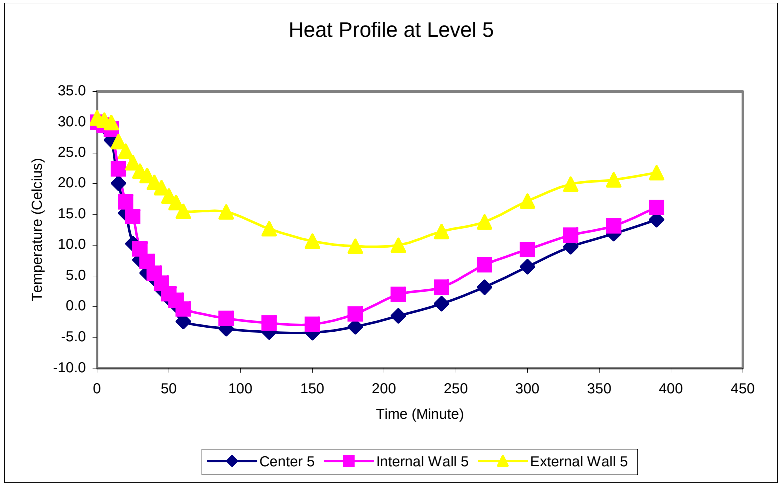
Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2



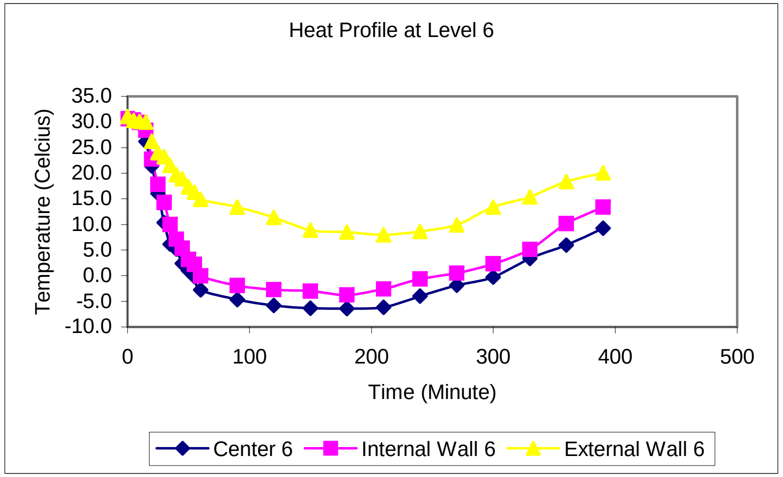
Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
center 3
Internal Wall 3
External Wall 3



Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

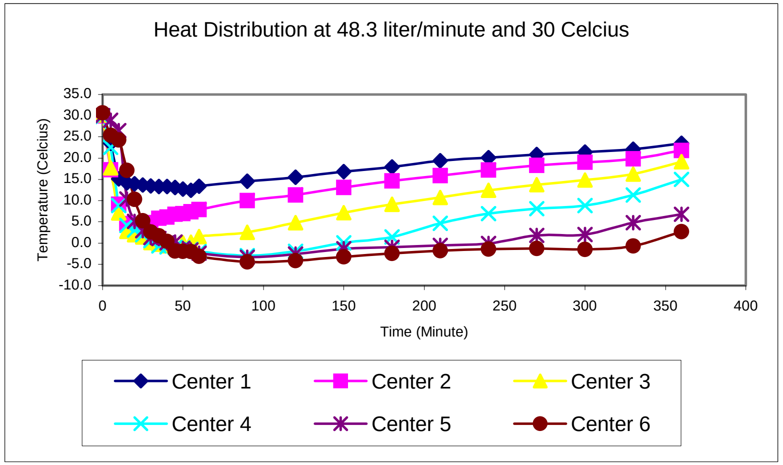


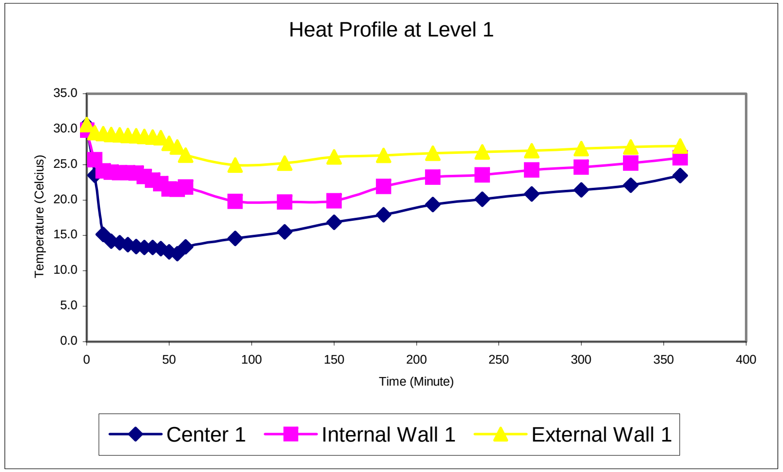
Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

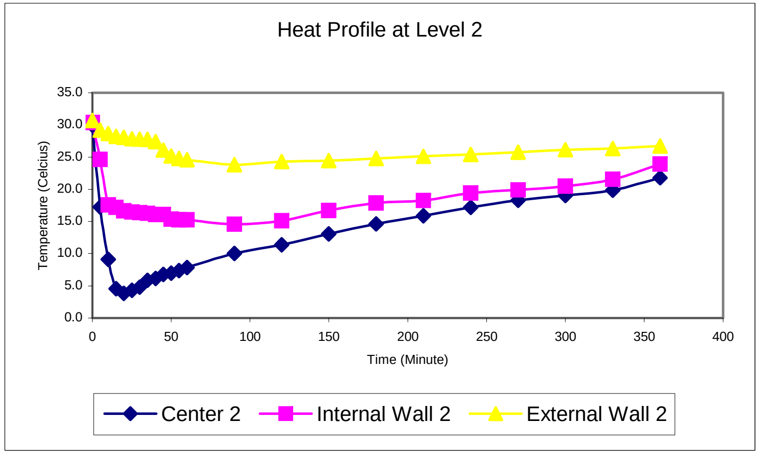


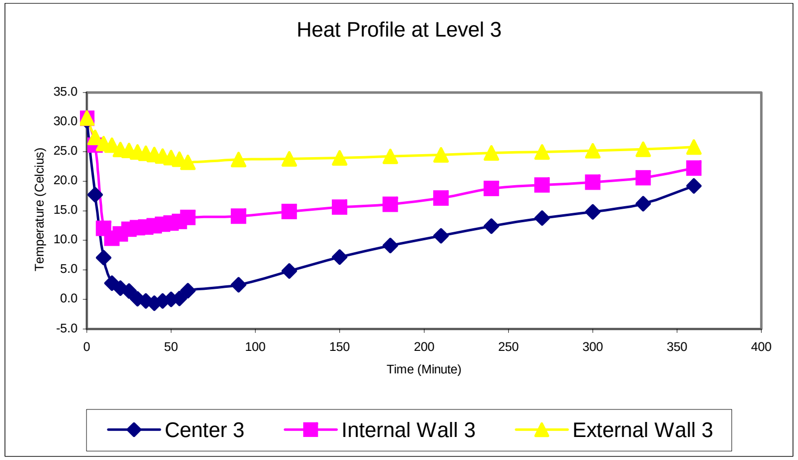
Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

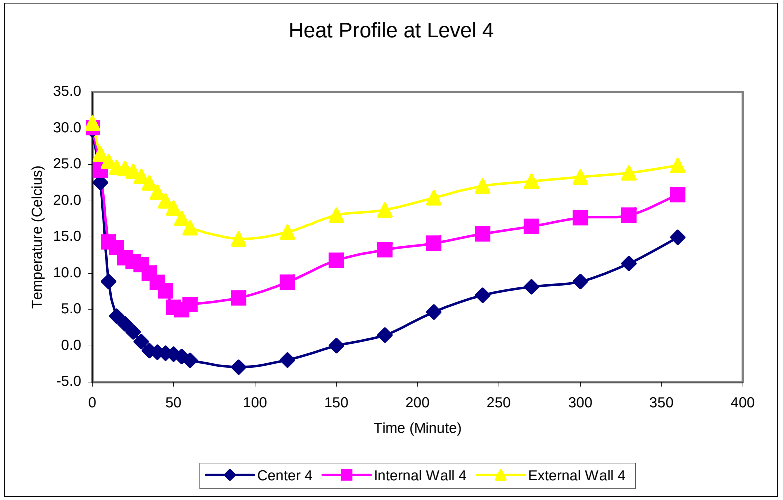
Q = 48 **L/M**

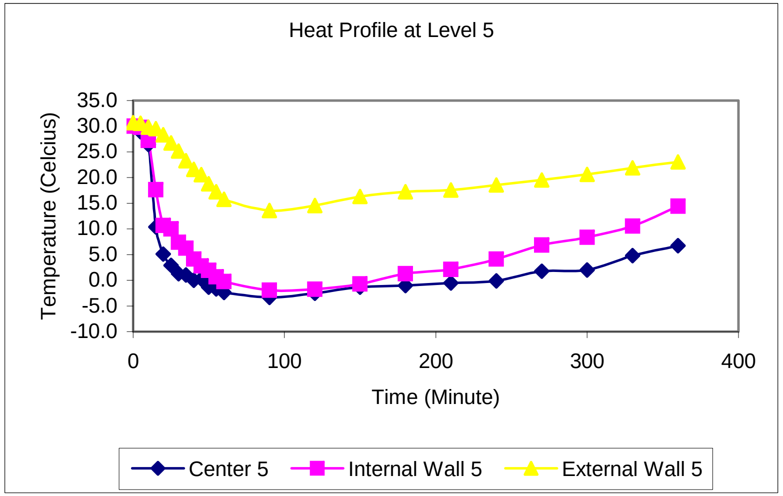

Heat Distribution at 48.3 liter/minute and 30 Celcius
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

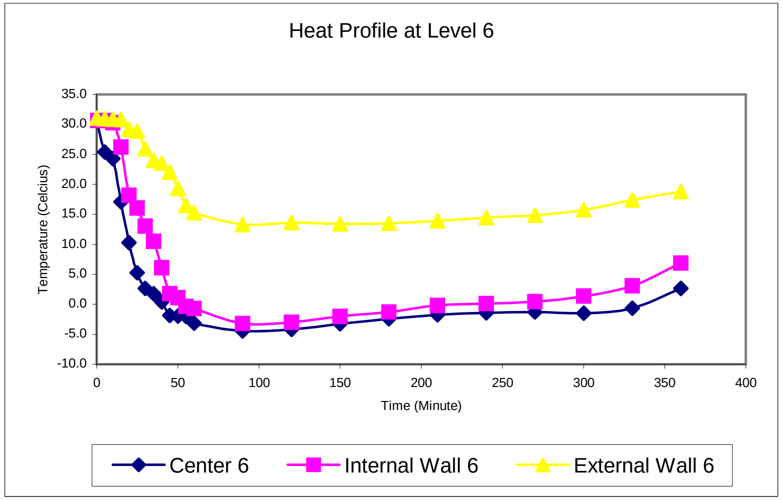

Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2

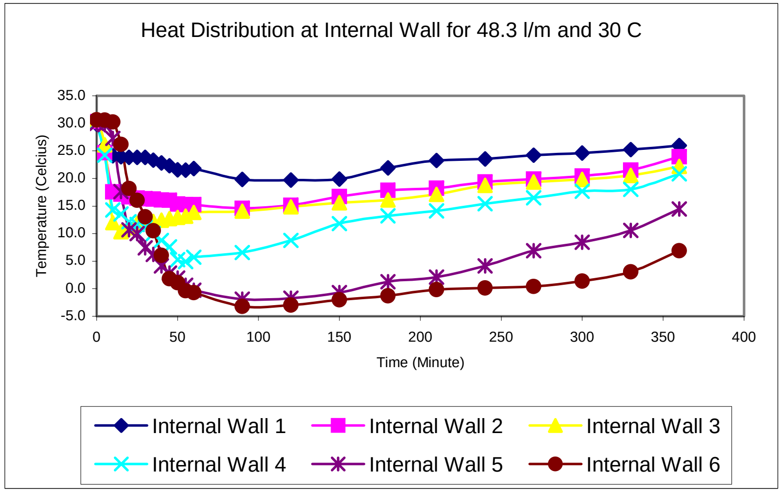

Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3


Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

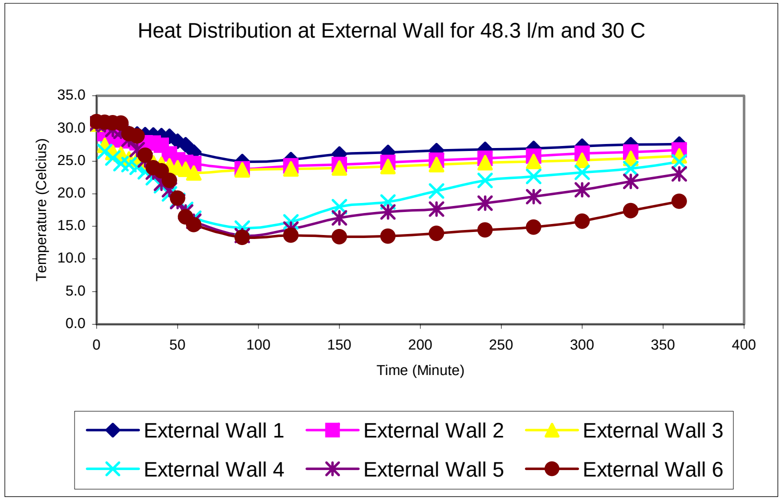

Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5



Heat Profile at Level 6
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
50
100
150
200
250
300
350
400
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

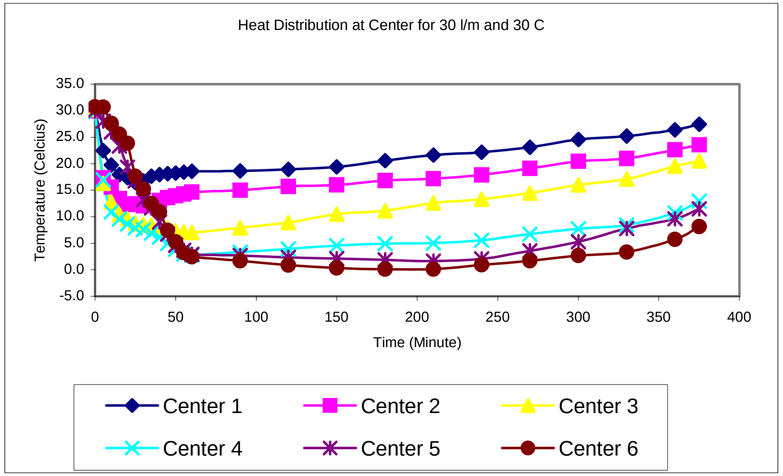


Heat Distribution at Internal Wall for 48.3 l/m and 30 C
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0
50
100
150
200
250
300
350
400
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

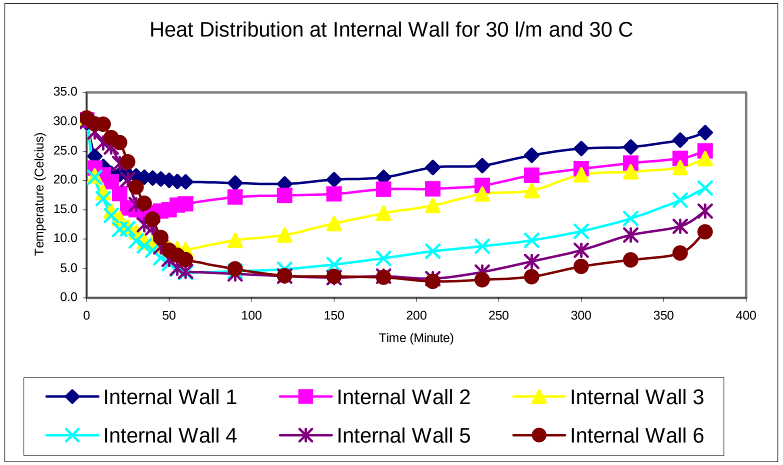


Heat Distribution at External Wall for 48.3 l/m and 30 C
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
250
300
350
400
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

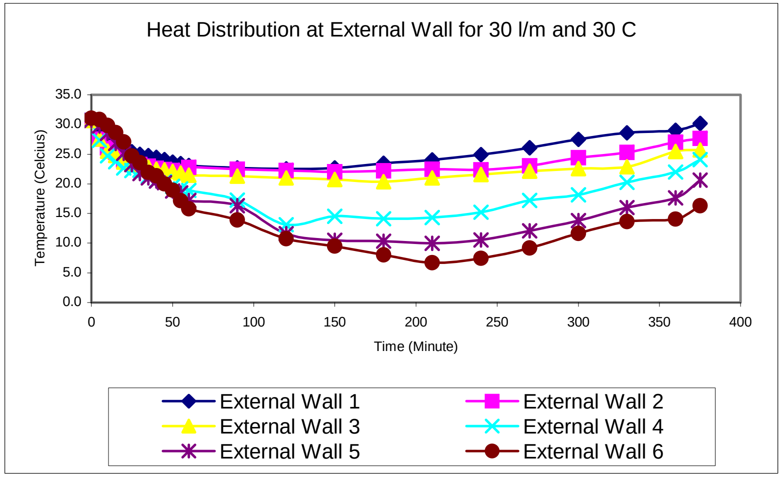
Q = 30 L/M



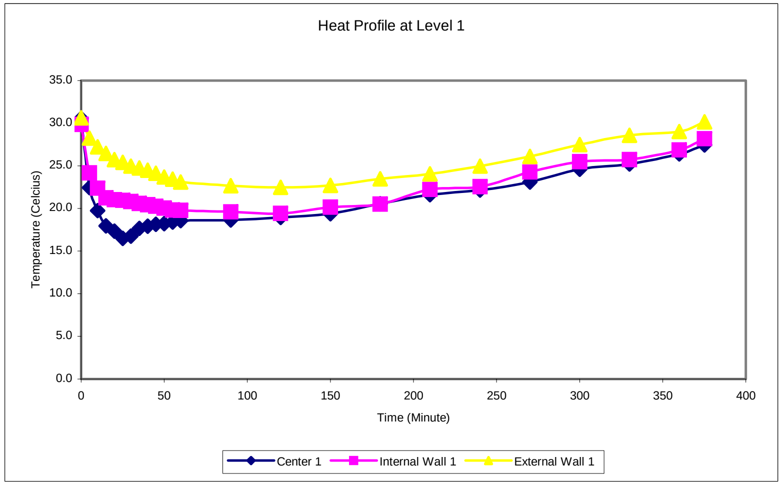
Heat Distribution at Center for 30 l/m and 30 C
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6



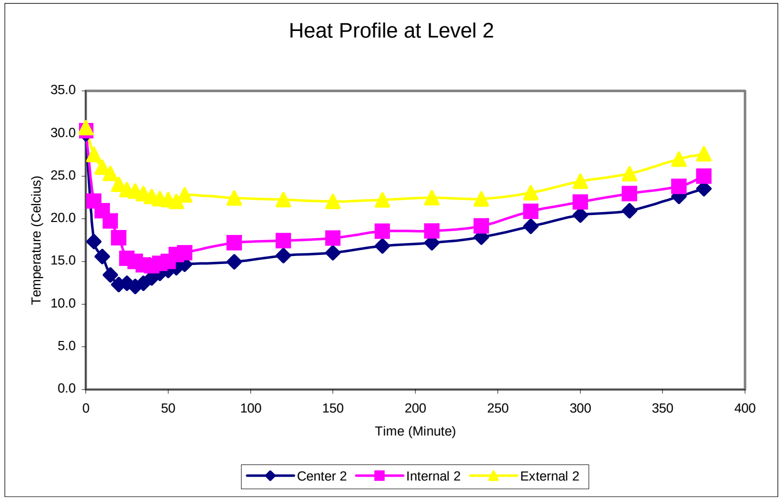
Heat Distribution at Internal Wall for 30 l/m and 30 C
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

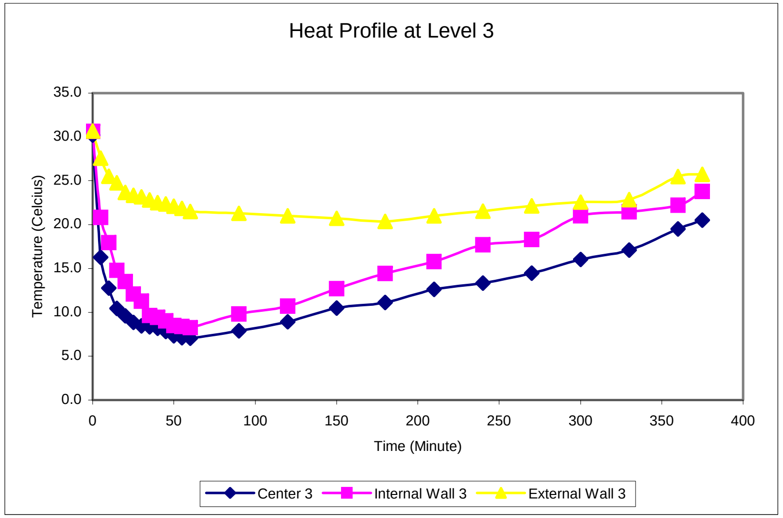


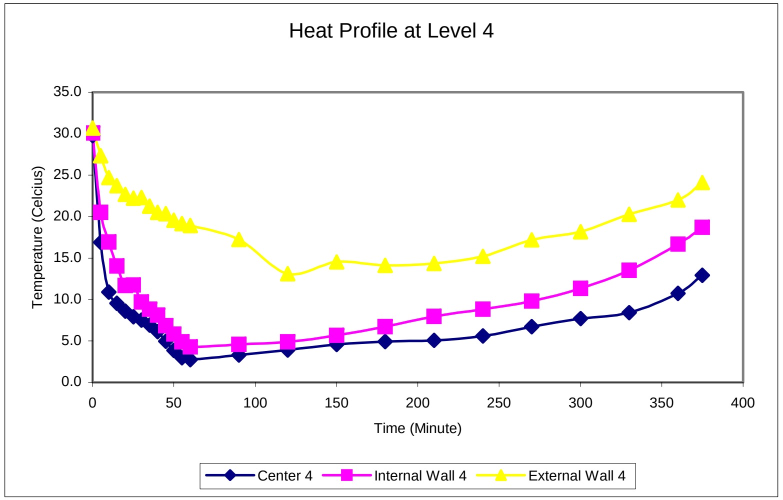
Heat Distribution at External Wall for 30 l/m and 30 C
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

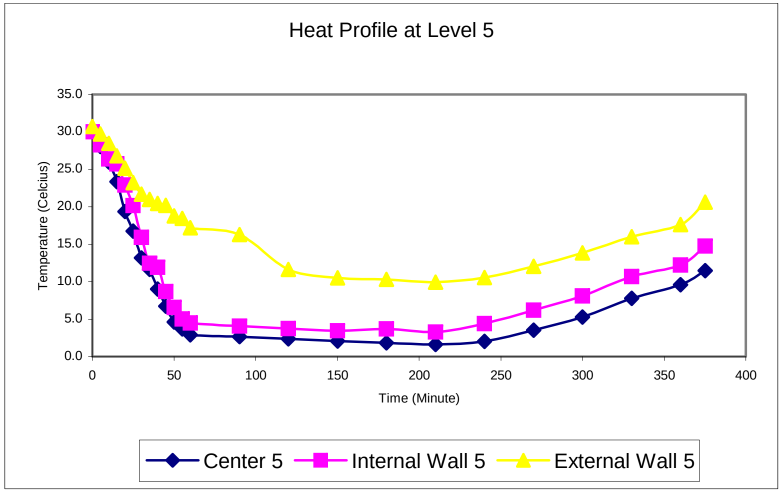


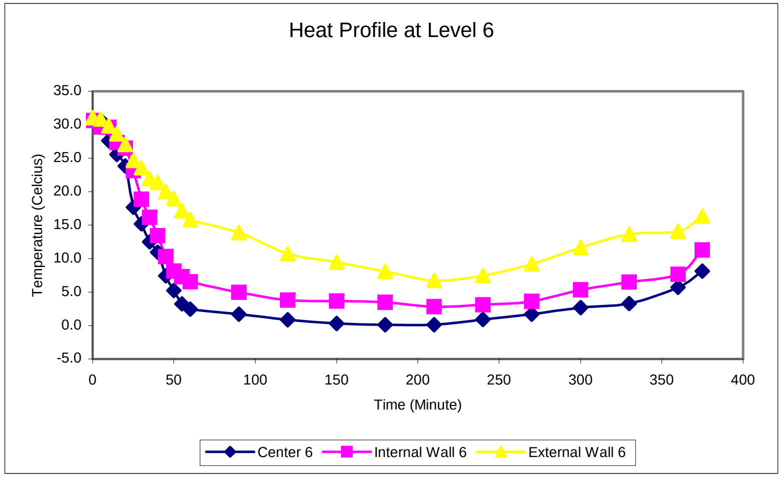
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal 2
External 2


Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3

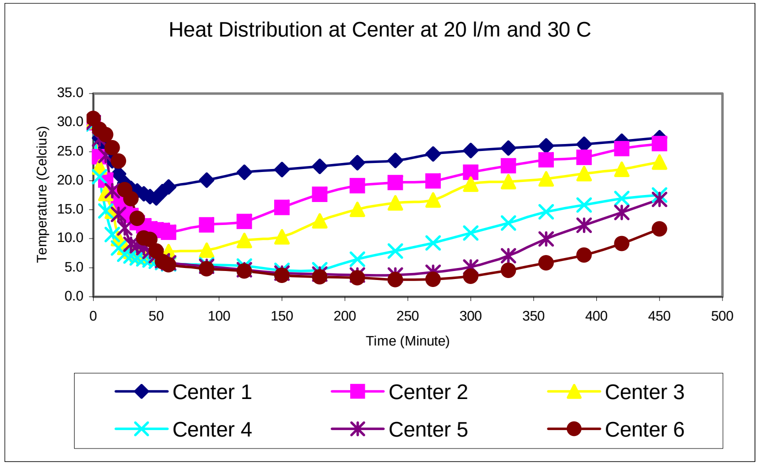

Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4


Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

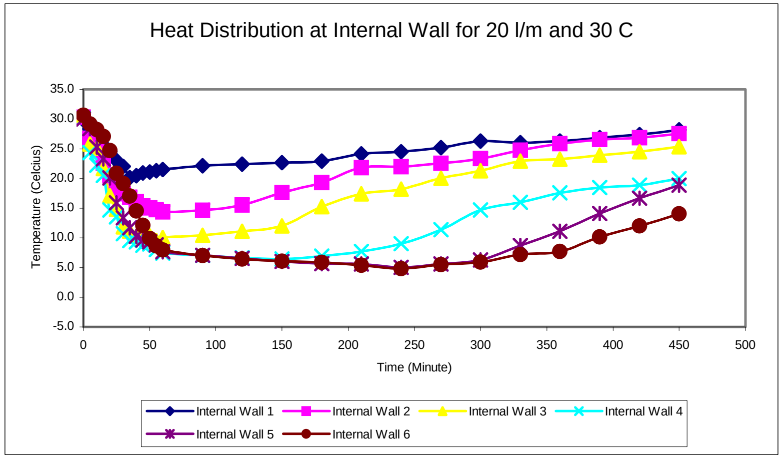


Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

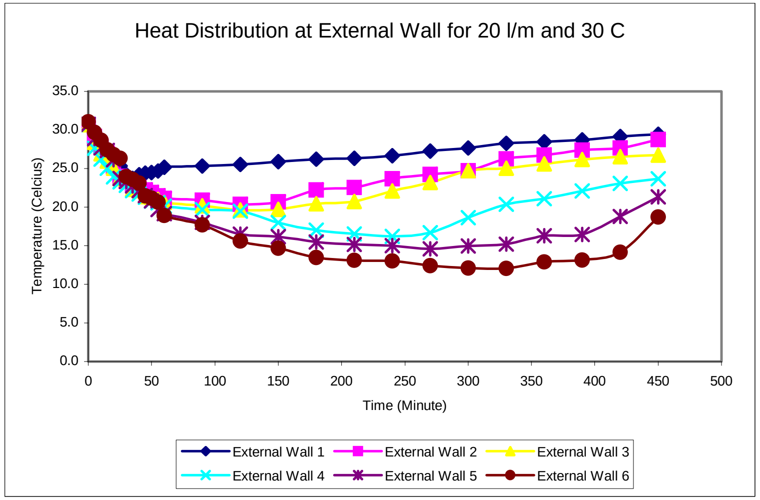
Q = 20 L/M



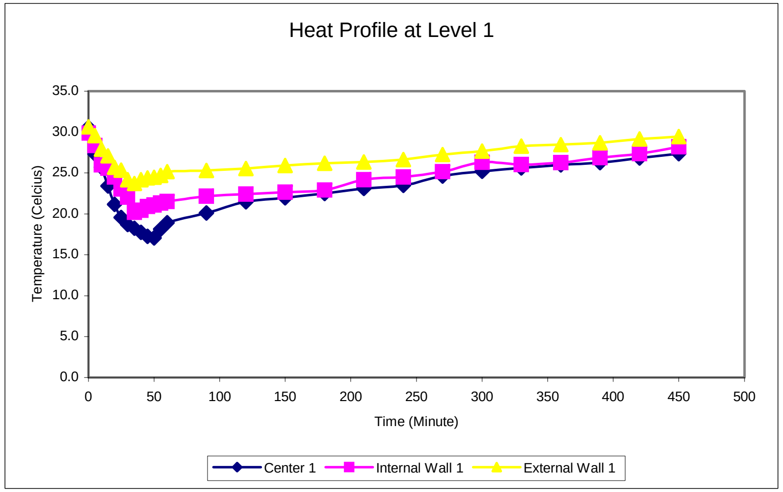
Heat Distribution at Center at 20 l/m and 30 C
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6



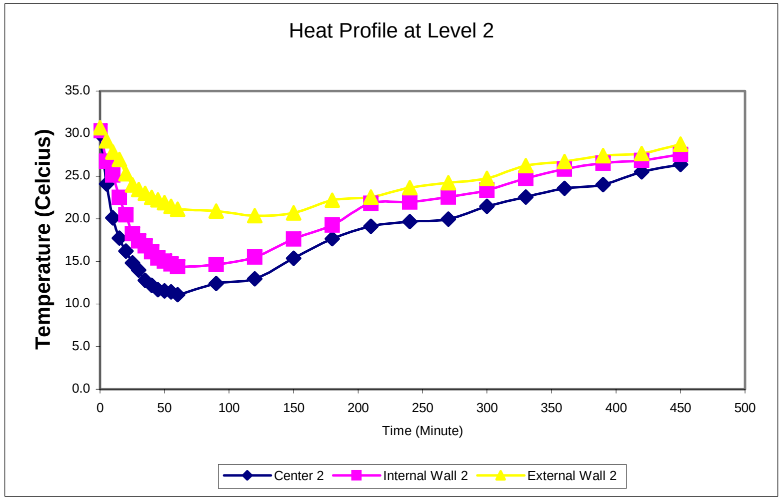
Heat Distribution at Internal Wall for 20 l/m and 30 C
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6



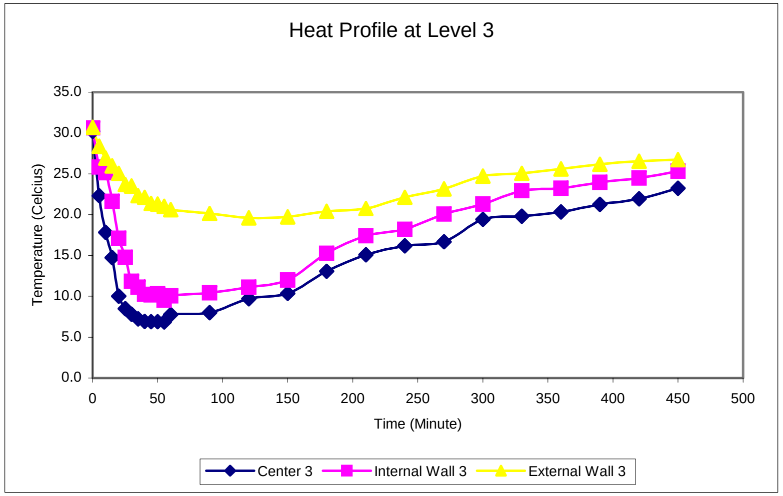
Heat Distribution at External Wall for 20 l/m and 30 C
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6



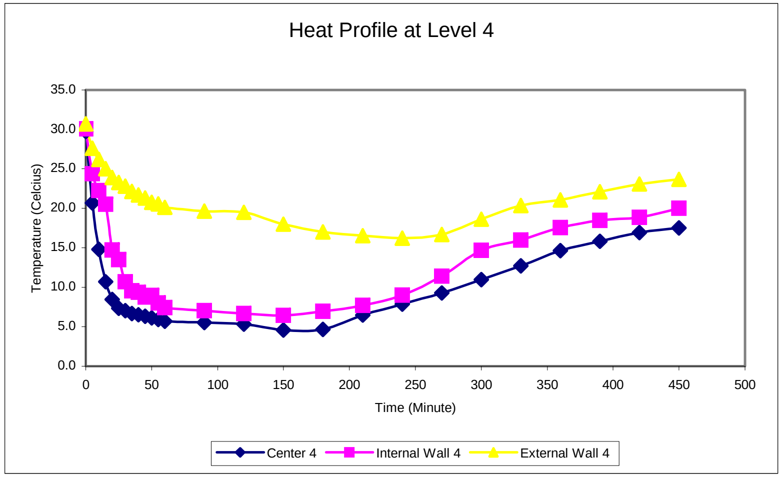
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1

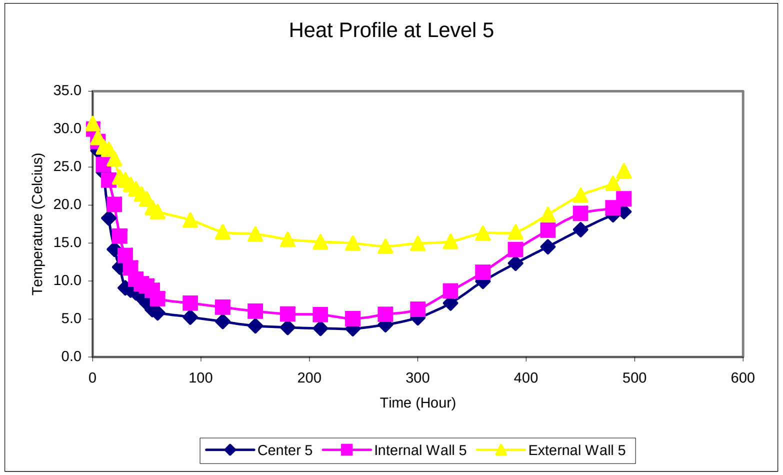


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2



Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3


Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4


Heat Profile at Level 5
Temperature (Celcius)
Time (Hour)
Center 5
Internal Wall 5
External Wall 5

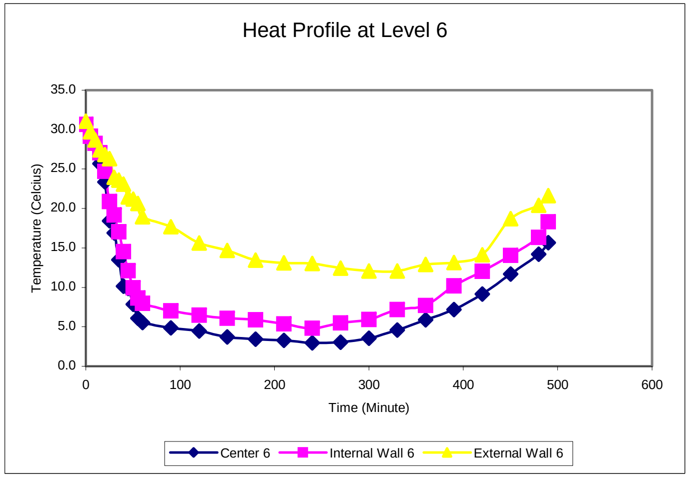

Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

Table A6: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 70 Liter per Minute and Weight 6 kg

Time (min)	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	30.1	28.9	28.0	21.5	29.2	29.4	29.5	28.3	29.0	26.8	29.7	30.5	29.8	29.5	29.5	27.7	30.4	30.0
10	19.1	15.4	12.7	8.9	26.5	27.3	22.1	17.0	15.7	14.0	26.5	29.2	27.3	26.1	25.6	24.8	27.7	29.3
15	17.9	12.7	7.1	6.3	15.5	26.8	21.3	15.3	9.4	8.5	18.1	28.4	25.9	24.2	22.9	21.8	26.4	29.3
20	16.9	11.8	6.8	5.9	10.5	15.2	20.5	13.9	9.1	7.7	15.1	21.1	24.5	22.8	22.2	21.4	24.1	26.7
25	15.6	11.3	5.8	4.7	9.5	10.3	20.3	13.5	7.8	7.5	13.0	18.1	24.2	22.9	22.0	20.6	22.5	24.4
30	15.4	7.8	5.1	2.6	7.3	9.6	20.0	12.2	7.0	5.8	8.4	13.1	23.7	22.5	21.7	18.7	20.8	22.1
35	15.4	10.5	4.0	1.7	6.4	6.1	19.4	12.7	5.2	3.4	8.2	11.0	23.5	21.3	20.1	18.1	18.6	20.1
40	14.1	10.3	3.3	-0.1	3.6	3.2	19.3	12.3	4.5	1.6	5.4	8.4	23.2	20.3	19.7	17.3	17.6	18.4
45	13.8	9.6	2.1	-2.4	-0.8	-1.1	18.9	11.8	4.0	-0.6	2.5	3.9	22.8	20.0	19.4	15.8	16.6	15.8
50	13.5	9.5	1.6	-3.7	-1.5	-1.5	18.7	11.4	3.5	-1.8	-0.1	2.2	22.7	19.8	19.1	15.0	16.2	13.0
55	13.4	9.4	1.3	-5.6	-3.5	-3.6	18.4	11.1	3.1	-2.7	-1.9	0.0	22.5	19.6	18.6	12.4	13.3	11.6
60	13.4	7.8	0.5	-5.0	-5.3	-5.9	18.0	11.6	2.4	-3.8	-3.9	-2.9	22.3	20.3	18.0	10.3	9.9	8.3
90	14.6	10.0	1.1	-4.8	-5.8	-6.3	17.4	12.5	2.9	-4.3	-4.1	-3.7	22.0	20.6	18.4	9.6	8.3	7.3
120	16.5	11.6	4.3	-4.4	-6.1	-6.5	18.1	13.5	5.8	-3.9	-5.6	-4.5	22.6	21.3	19.5	8.7	8.1	6.0
150	17.9	12.6	6.2	-3.5	-5.1	-6.7	19.3	14.7	7.5	-2.0	-4.3	-5.4	23.6	21.6	19.9	8.5	6.5	4.5
180	20.4	15.3	8.6	-1.6	-4.2	-6.8	21.5	16.3	9.5	0.4	-3.6	-5.5	24.4	21.7	20.4	10.1	6.8	3.9
210	21.4	16.1	9.6	2.2	-2.4	-6.0	22.8	19.8	11.2	3.9	-2.0	-4.3	25.6	22.7	20.6	11.5	8.4	5.1
240	22.0	18.0	12.7	2.8	-0.4	-4.0	24.3	20.1	14.9	5.4	0.3	-2.5	26.3	23.3	21.1	13.0	10.4	6.5
270	22.6	18.8	14.3	4.7	1.8	-1.9	24.6	21.0	16.6	6.4	3.1	0.5	26.9	24.2	21.5	15.1	12.0	8.9
300	22.8	19.3	15.2	5.7	2.7	-1.5	25.4	22.8	20.8	7.1	4.8	1.6	27.3	25.3	22.9	17.6	14.3	11.4
330	23.1	20.3	16.7	7.5	4.5	-0.7	25.9	23.5	21.4	9.8	5.3	2.5	27.8	26.5	23.4	19.1	16.3	13.9
360	25.0	22.6	19.2	12.4	6.8	2.7	26.6	24.5	22.7	13.7	7.3	4.2	28.3	27.0	25.2	23.2	18.8	15.4
380	25.6	23.3	20.4	14.0	11.2	4.6	27.1	25.2	23.7	15.1	12.6	6.1	28.6	27.7	26.4	24.9	21.3	17.4

Table A7: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 60 Liter per Minute and Weight 6 kg

Time (min)	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	28.4	27.5	24.0	25.5	27.3	29.9	29.4	28.2	26.2	28.2	29.6	30.4	30.3	28.9	27.7	28.7	30.3	30.5
10	19.9	16.5	13.3	9.6	27.1	29.7	22.3	18.6	16.8	14.9	27.9	28.9	28.1	26.9	25.3	24.9	28.1	29.4
15	16.9	12.3	7.4	7.0	20.1	26.2	19.9	15.3	12.4	13.9	22.4	28.4	25.8	24.0	23.5	22.2	26.9	29.0
20	15.2	10.1	6.5	5.4	15.2	21.4	19.5	11.9	9.6	10.9	17.0	22.7	24.8	23.3	22.4	20.8	25.3	26.3
25	13.7	9.5	5.8	4.3	10.3	16.1	19.4	11.6	9.0	9.3	14.6	17.8	24.4	23.1	22.1	20.5	23.4	24.0
30	14.9	8.7	5.6	3.8	8.6	10.3	19.1	12.9	7.9	7.7	9.4	14.3	24.3	23.1	21.9	20.1	21.7	23.2
35	15.9	9.8	5.0	3.2	5.5	6.2	18.8	13.2	7.5	6.5	7.4	10.0	24.2	22.9	21.6	19.9	21.4	21.5
40	16.0	10.7	4.9	3.0	4.6	5.2	19.0	13.6	7.3	4.8	5.4	7.1	24.0	22.7	21.5	18.8	20.2	19.7
45	16.4	11.8	4.8	1.2	2.8	2.4	19.2	13.9	6.9	4.0	3.8	5.4	23.8	22.4	21.1	18.5	17.4	17.9
50	16.6	12.0	4.7	-0.1	1.4	1.0	19.5	14.2	6.7	2.6	2.1	3.2	23.6	22.3	21.0	17.4	15.0	15.3
55	16.7	12.1	4.4	-1.6	0.3	-0.2	19.7	14.5	6.5	0.4	1.0	2.2	23.3	22.5	20.4	14.8	12.9	12.3
60	16.9	12.4	4.6	-2.3	-2.4	-2.8	19.9	13.6	5.7	-2.1	-1.4	-1.6	23.1	21.8	20.0	12.5	11.5	9.9
90	17.1	12.8	4.9	-3.4	-3.6	-4.7	20.2	14.1	5.6	-2.2	-3.0	-2.9	24.1	22.0	20.6	11.4	10.4	9.4
120	17.7	13.0	5.3	-4.3	-4.1	-5.8	20.4	15.5	6.3	-2.7	-3.6	-3.7	24.3	22.5	21.2	9.9	9.7	8.4
150	19.7	13.9	6.8	-2.4	-4.2	-6.3	21.1	16.6	7.5	-1.6	-2.9	-3.0	24.6	22.7	21.6	9.3	8.7	6.9
180	20.9	15.9	9.1	-0.5	-3.3	-6.4	22.3	17.3	10.1	1.9	-3.2	-3.8	24.9	23.3	21.9	12.5	9.8	5.5
210	21.6	16.5	10.2	2.5	-2.0	-5.7	23.4	18.7	12.1	3.7	-0.9	-2.9	26.1	23.6	22.5	13.2	8.4	5.1
240	22.5	18.7	13.1	3.8	0.5	-3.4	24.0	20.0	15.7	5.2	1.1	-1.2	26.5	24.4	22.7	15.0	12.2	8.6
270	23.3	19.2	14.6	5.2	2.6	-1.4	25.2	21.0	17.9	7.6	3.8	1.5	27.1	24.6	23.4	16.3	13.8	9.9
300	24.1	20.9	15.9	6.6	3.5	-0.9	25.5	22.6	19.1	8.9	5.3	2.4	27.5	25.6	24.2	18.3	15.2	12.6
330	24.9	22.0	17.4	7.3	4.7	0.4	26.5	23.2	20.8	9.5	6.6	3.7	28.1	26.8	25.1	21.6	17.4	15.1
360	25.6	23.1	19.8	13.1	7.9	3.3	27.2	24.6	21.3	15.2	9.1	5.1	28.8	28.4	26.7	23.0	20.6	18.4
390	26.7	24.5	21.6	16.3	10.1	5.3	27.6	25.3	22.7	18.5	13.1	8.4	29.1	28.7	28.3	24.4	21.8	20.1

Table A8: Temperatures Data of 4060 Composition for Surrounding Temperature of 30°C, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.5	17.2	17.7	22.5	28.9	25.4	25.7	24.7	26.1	24.2	29.8	30.6	29.5	29.2	27.4	26.4	30.6	30.9
10	15.1	9.1	7.0	8.9	26.5	24.3	24.1	17.6	12.0	14.3	27.3	30.3	29.4	28.7	26.3	25.4	29.8	30.8
15	14.2	4.6	2.8	4.1	10.4	17.1	23.9	17.2	10.3	13.5	17.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	13.9	3.8	1.9	3.0	5.1	10.3	23.9	16.7	11.1	12.1	10.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	13.7	4.3	1.4	1.9	2.9	5.3	23.8	16.4	11.9	11.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	13.4	4.8	0.1	0.6	1.3	2.6	23.8	16.3	12.1	11.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	13.3	5.8	-0.3	-0.7	1.1	1.8	23.3	16.2	12.2	10.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	13.3	6.1	-0.6	-0.9	0.0	0.4	22.8	16.1	12.4	8.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	6.8	-0.3	-1.0	0.3	-1.8	22.3	16.1	12.7	7.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	12.7	7.0	0.0	-1.1	-1.3	-1.9	21.6	15.3	12.9	5.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	12.4	7.3	0.2	-1.5	-1.7	-2.0	21.5	15.3	13.2	4.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	13.4	7.8	1.5	-2.0	-2.3	-3.1	21.8	15.2	13.9	5.7	-0.3	-0.7	26.4	24.6	23.2	16.3	15.8	15.3
90	14.6	10.0	2.5	-3.0	-3.3	-4.4	19.8	14.6	14.1	6.6	-1.9	-3.2	25.0	23.8	23.7	14.7	13.6	13.3
120	15.5	11.4	4.8	-2.0	-2.6	-4.2	19.7	15.1	14.8	8.8	-1.7	-3.0	25.2	24.3	23.8	15.7	14.6	13.6
150	16.9	13.1	7.2	0.0	-1.4	-3.2	19.9	16.7	15.6	11.8	-0.7	-2.0	26.1	24.5	23.9	18.0	16.3	13.4
180	17.9	14.6	9.1	1.5	-1.0	-2.4	21.9	17.9	16.1	13.2	1.3	-1.3	26.3	24.8	24.2	18.7	17.2	13.5
210	19.4	15.9	10.8	4.7	-0.5	-1.8	23.2	18.2	17.1	14.2	2.1	-0.2	26.6	25.1	24.5	20.4	17.6	13.9
240	20.1	17.2	12.4	7.0	-0.1	-1.4	23.5	19.4	18.8	15.4	4.2	0.1	26.8	25.4	24.7	22.0	18.6	14.4
270	20.8	18.3	13.8	8.1	1.8	-1.3	24.2	19.9	19.4	16.5	6.9	0.4	26.9	25.7	24.9	22.7	19.5	14.9
300	21.4	19.0	14.8	8.8	2.0	-1.5	24.6	20.5	19.8	17.7	8.4	1.4	27.3	26.2	25.2	23.3	20.6	15.8
330	22.1	19.9	16.2	11.4	4.8	-0.7	25.2	21.5	20.6	18.0	10.6	3.1	27.5	26.4	25.4	23.9	21.9	17.4
360	23.5	21.8	19.2	15.0	6.8	2.7	26.0	23.9	22.2	20.8	14.4	6.9	27.6	26.7	25.8	24.9	23.0	18.8

Table A9: Temperatures Data of 4060 Composition for Surrounding Temperature of 30°C, Flowrate of 30 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.3	26.3	25.9	28.0	28.7	28.9	28.1	27.8	26.5	28.3	29.7	29.3	28.5	28.6	27.3	29.7	30.9
10	25.1	19.6	17.1	14.2	26.0	27.6	26.4	24.9	23.4	18.5	27.8	29.0	28.8	28.1	25.5	26.7	28.5	29.7
15	23.9	16.4	10.4	9.5	23.4	24.6	24.2	22.8	14.8	14.0	25.7	27.3	27.5	25.3	24.8	23.7	26.8	28.6
20	21.3	15.3	9.6	8.6	19.4	20.8	22.0	20.8	13.5	12.7	20.9	25.5	26.7	24.0	23.7	22.7	25.1	27.1
25	19.5	14.4	8.8	7.9	16.8	17.6	21.9	18.4	12.1	10.8	18.1	23.1	26.4	23.4	23.3	22.2	23.2	26.7
30	17.8	13.7	8.1	7.5	12.8	15.2	22.8	17.0	11.3	9.7	15.9	18.9	25.7	23.3	23.2	22.3	23.7	25.6
35	17.7	12.4	8.3	6.9	11.6	12.5	19.6	14.6	9.6	8.8	12.5	16.1	25.4	23.0	22.8	21.2	21.0	21.9
40	17.9	13.1	8.2	6.5	9.0	10.9	18.4	14.5	9.4	7.1	11.9	13.4	25.5	22.6	22.5	20.5	20.4	21.4
45	18.1	13.6	7.8	6.3	7.7	8.4	18.6	14.8	9.0	8.2	9.7	10.3	25.1	22.4	22.3	20.4	20.2	20.0
50	18.2	13.9	7.3	6.0	5.6	6.2	19.1	15.0	8.5	7.8	7.6	8.1	25.3	22.3	22.1	19.6	18.8	19.0
55	18.4	14.3	7.1	5.5	4.7	5.2	19.8	15.8	8.4	6.9	6.0	7.3	25.4	23.0	22.8	19.1	18.5	17.1
60	18.6	14.1	7.1	5.1	4.9	4.8	20.3	15.3	8.2	6.3	5.5	6.5	25.1	23.8	22.5	18.9	17.2	15.8
90	19.6	15.0	7.9	4.9	3.7	2.7	21.2	17.2	9.8	4.6	4.1	5.0	24.7	23.4	22.3	17.2	16.3	13.9
120	20.9	15.7	9.9	4.1	2.6	1.9	21.5	17.5	10.7	4.9	3.7	3.8	24.5	23.3	22.5	15.1	14.6	12.7
150	21.4	16.0	10.5	3.3	1.5	1.3	22.1	17.7	11.7	5.7	3.5	3.7	24.7	24.2	23.2	14.5	13.5	11.5
180	22.6	17.1	11.1	2.9	0.8	0.1	22.9	18.5	14.4	6.1	3.7	3.9	25.5	23.2	22.8	15.1	12.3	9.1
210	23.6	19.2	14.6	5.1	2.1	0.9	23.9	19.6	15.2	7.8	4.3	4.1	26.6	24.5	23.7	15.3	14.4	10.7
240	23.9	19.9	15.3	6.9	3.8	1.9	24.5	20.4	16.7	8.8	5.4	4.7	27.3	25.8	24.2	17.2	15.6	11.8
270	24.1	20.2	16.5	8.7	4.8	1.7	24.9	20.9	17.3	9.8	6.2	5.6	27.5	26.1	25.1	20.2	17.6	14.2
300	24.9	21.4	18.6	9.7	6.3	2.7	25.5	22.0	19.7	11.3	8.1	6.3	27.5	24.4	22.6	18.2	13.8	11.6
330	25.2	21.9	19.1	10.4	7.8	3.3	26.8	23.0	20.5	13.5	10.7	6.5	28.2	25.3	25.6	22.2	18.8	16.6
360	26.4	22.6	21.5	12.7	9.6	6.3	27.9	26.8	22.2	16.7	13.2	7.6	28.6	27.9	26.9	24.3	21.6	19.7
375	27.4	23.6	22.5	15.9	11.5	8.1	28.2	27.2	23.8	18.7	14.8	11.3	29.2	28.6	27.7	25.1	22.6	20.3

Table A10: Temperatures Data of 4060 Composition for Surrounding Temperature of 30^{o}C, Flowrate of 20 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	27.3	24.1	22.3	20.7	27.2	28.8	28.3	26.8	25.8	24.4	28.4	29.2	29.6	29.1	28.4	27.6	28.9	29.7
10	25.7	20.1	17.8	14.8	26.3	27.9	26.0	25.2	25.1	22.2	27.3	28.2	28.9	28.3	27.9	27.2	28.7	29.7
15	23.4	17.7	14.7	12.7	23.3	25.7	25.6	22.5	21.6	20.5	23.3	27.1	28.1	27.0	26.0	25.0	27.3	27.4
20	21.2	16.2	12.0	10.4	19.2	23.4	24.5	20.5	17.1	14.7	20.1	24.7	27.7	26.3	25.0	23.9	26.1	26.8
25	19.6	14.8	10.5	8.3	16.8	18.4	24.0	18.3	14.8	13.5	18.9	20.9	27.0	25.8	23.7	23.3	25.7	26.3
30	18.7	14.0	8.6	7.8	13.2	16.9	23.4	17.4	11.8	10.7	16.4	19.2	26.2	25.6	23.5	22.8	24.3	25.0
35	18.2	12.8	8.2	6.7	8.8	13.5	20.2	17.2	11.1	9.6	11.7	17.0	23.7	25.4	22.3	22.1	22.7	23.6
40	17.8	10.2	7.9	6.5	8.5	10.1	20.4	17.1	10.3	9.4	10.3	14.5	24.2	24.9	22.1	21.7	22.1	23.1
45	17.3	11.7	7.5	6.3	7.8	9.9	20.9	16.8	10.2	8.8	9.6	12.1	24.4	24.5	21.4	21.3	21.5	21.5
50	17.0	12.5	7.4	6.1	7.1	7.9	21.1	16.6	10.3	8.9	9.3	9.9	24.5	24.3	21.3	20.8	20.8	21.2
55	18.1	13.4	7.2	5.9	6.2	6.1	21.3	16.5	9.5	8.0	8.8	8.6	24.7	24.2	21.0	20.6	19.7	20.7
60	18.9	14.7	6.8	5.7	5.8	5.5	21.5	16.4	10.1	7.4	7.7	8.0	25.2	24.1	21.6	20.1	19.1	18.9
90	20.1	15.4	8.0	5.5	5.2	4.8	22.2	17.6	10.4	7.9	7.1	7.0	25.3	23.9	21.8	18.7	17.8	14.7
120	21.5	16.8	11.7	5.3	4.7	3.5	22.4	18.5	11.1	6.7	6.6	6.5	25.5	24.4	22.0	17.5	16.5	15.6
150	21.9	16.4	10.8	4.9	2.1	1.7	22.6	18.9	12.0	6.4	5.6	5.1	25.9	24.2	22.4	15.8	14.2	13.7
180	22.5	17.7	13.1	3.6	1.1	0.6	22.9	19.3	15.3	6.9	5.6	5.9	26.2	24.5	22.7	17.0	15.5	12.5
210	23.1	19.8	15.1	6.5	3.8	3.3	23.8	20.8	16.4	8.2	6.6	6.4	26.3	24.7	23.1	16.5	15.2	12.1
240	24.1	20.4	16.2	7.5	4.7	3.9	24.5	21.2	17.2	9.0	7.5	6.8	26.6	25.2	24.5	17.9	16.5	13.2
270	24.4	20.6	16.7	9.3	5.2	3.0	25.2	22.5	19.1	11.4	7.9	6.9	27.2	25.7	24.8	18.7	17.6	14.4
300	25.2	21.5	19.4	10.3	6.5	3.6	26.3	23.4	20.3	13.7	8.3	7.2	27.7	26.3	25.2	23.1	19.5	15.1
330	25.6	22.3	19.8	11.7	8.1	4.6	26.0	24.7	21.9	15.3	11.7	7.8	27.9	26.7	25.5	25.4	22.2	16.7
360	26.0	23.6	20.3	14.6	10.2	6.9	26.3	25.8	23.2	17.6	13.1	8.5	27.8	26.9	26.0	29.1	26.3	17.6
390	26.3	24.0	21.2	15.8	12.4	7.2	26.9	26.5	23.9	18.5	14.1	10.2	28.1	27.4	26.2	22.1	16.5	18.1
420	26.8	25.5	21.9	16.9	14.5	9.2	27.4	26.9	24.5	18.9	16.7	12.0	29.3	27.7	26.5	23.1	18.8	19.1
450	27.4	26.4	23.2	17.5	16.8	11.7	28.2	27.6	25.3	20.0	18.9	14.1	29.6	28.7	26.7	23.7	21.3	19.7
480	27.7	26.6	24.2	18.6	18.7	14.2	28.8	27.7	26.8	21.4	19.6	16.3	29.9	29.4	27.6	24.3	22.9	20.4
490	28.0	26.9	24.8	20.9	19.1	15.7	28.9	28.8	28.0	22.5	20.8	18.3	30.0	29.6	28.7	25.2	24.5	21.6

Table A11: Temperatures Data of Surrounding Temperature of 35°C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	35.9	35.0	35.5	34.9	35.0	35.9	35.1	35.5	36.0	35.2	35.0	35.1	35.1	35.5	35.2	35.2	35.0	35.1
5	33.0	28.2	25.3	23.0	30.7	32.9	33.7	30.6	28.9	24.6	32.8	33.8	33.8	31.5	30.3	26.5	33.3	34.5
10	17.8	12.5	7.7	9.3	23.2	27.5	24.8	18.6	14.5	18.9	31.4	30.3	31.7	31.5	31.2	31.1	31.5	31.7
15	18.3	12.1	7.2	9.6	11.2	25.3	24.5	18.3	11.6	11.7	12.5	19.1	31.3	30.6	29.6	27.6	27.8	31.4
20	17.4	11.6	7.1	8.4	10.3	12.7	24.3	18.1	10.9	10.9	11.1	14.6	31.2	30.0	29.4	27.1	28.5	29.6
25	18.3	14.1	6.1	7.3	9.3	9.8	24.2	17.9	11.3	10.5	10.6	12.5	31.0	29.8	29.4	26.7	27.2	27.7
30	18.1	14.1	6.1	6.7	8.3	8.5	24.0	17.7	11.7	10.2	9.3	9.2	30.8	29.6	29.3	26.1	25.0	24.9
35	18.2	15.1	6.7	5.8	6.2	6.7	23.8	17.6	11.8	9.8	8.5	8.6	30.5	29.2	29.2	25.9	24.1	23.2
40	18.5	15.4	6.9	4.4	4.9	4.2	23.6	17.5	13.5	8.5	7.9	5.8	30.1	29.0	28.9	25.8	23.0	22.4
45	19.1	16.1	7.5	3.5	3.2	2.6	23.5	17.4	13.0	7.9	7.1	3.6	30.2	28.9	28.5	24.7	22.3	20.9
50	19.3	16.6	7.5	1.8	2.3	1.1	23.3	17.1	13.8	7.2	5.0	3.0	29.9	28.0	28.4	23.1	20.8	19.4
55	19.3	17.2	8.1	0.3	1.6	0.3	23.2	16.7	14.2	8.3	3.1	2.3	30.3	29.2	28.1	21.9	18.5	17.9
60	19.3	17.5	8.8	-0.1	0.5	-0.5	23.1	16.5	14.3	9.0	2.7	1.5	30.5	29.2	28.5	19.7	16.1	14.3
90	20.3	18.6	9.2	1.5	0.9	-1.2	24.4	16.8	15.6	10.0	1.7	0.4	30.8	29.2	27.8	18.2	15.1	13.7
120	20.7	19.3	9.6	3.6	1.1	-1.6	25.0	17.3	16.1	10.2	0.6	-1.1	30.8	29.4	26.8	20.1	17.7	15.1
150	21.1	19.6	11.0	7.1	1.6	-1.1	26.4	21.3	17.6	11.5	3.8	0.4	31.1	29.8	26.5	20.8	18.7	16.2
180	22.5	20.3	12.8	9.2	2.2	-0.9	27.3	22.5	19.1	13.5	5.1	0.5	31.3	30.0	27.8	21.9	19.2	17.0
210	23.8	21.1	14.7	11.3	4.9	-0.4	28.0	23.5	20.5	15.5	7.7	1.7	31.5	30.4	29.8	24.7	20.8	17.7
240	25.7	22.1	16.6	14.4	6.1	0.1	29.4	25.2	22.6	18.2	10.5	2.6	31.7	30.7	30.3	24.9	22.5	18.3
270	26.1	23.0	18.8	16.0	7.6	0.6	29.6	25.5	23.4	19.5	12.3	1.8	31.9	31.4	30.5	25.9	23.0	18.9
300	26.3	23.4	19.4	17.0	8.7	1.6	29.7	25.8	23.7	20.0	13.9	5.1	32.5	31.7	30.9	27.8	26.3	21.1
310	26.8	24.1	20.7	18.8	9.8	2.5	29.9	26.3	24.8	21.7	16.2	9.9	32.9	32.5	31.3	29.0	26.9	21.8

Table A12: Temperatures Data of Surrounding Temperature of 30^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.2	25.7	24.5	26.9	29.4	28.7	27.7	25.8	25.2	27.8	29.6	29.5	29.2	27.4	26.4	30.6	30.9
10	27.1	22.1	21.7	18.9	23.5	24.3	25.4	23.6	20.2	20.7	24.3	24.9	24.4	26.7	25.3	24.4	26.8	29.6
15	25.2	23.6	19.8	18.1	20.4	21.1	24.9	23.2	19.3	19.5	21.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	20.9	18.8	14.9	13.0	15.1	16.3	23.9	22.7	18.1	16.1	18.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	18.7	16.3	11.4	11.9	8.9	7.3	22.8	21.4	17.9	14.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	16.4	14.8	6.1	9.6	5.3	4.6	21.8	20.3	14.1	12.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	15.3	13.8	4.3	8.7	3.1	1.8	20.3	18.2	10.2	9.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	14.3	11.1	3.6	5.9	1.0	0.4	20.8	16.1	8.4	7.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	10.8	2.3	3.0	0.3	-1.8	19.3	14.1	6.7	4.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	14.7	12.0	3.0	2.1	-0.3	-1.9	18.6	13.3	4.9	2.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	15.4	13.3	3.2	0.5	-1.0	-2.0	17.5	14.3	4.2	1.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	17.8	14.8	4.5	1.2	-1.3	-3.1	18.8	15.2	5.1	2.1	-0.3	-2.7	26.4	24.6	23.2	16.3	15.8	15.3
90	18.6	15.7	8.5	2.9	-2.4	-3.4	19.8	16.6	8.8	0.6	-1.9	-2.9	25.6	23.8	20.7	14.7	13.6	13.3
120	19.5	16.4	9.8	3.9	-2.6	-3.8	20.7	17.1	10.8	1.8	-1.1	-3.2	26.2	24.3	22.8	16.7	14.6	13.6
150	19.9	17.6	13.1	4.5	-2.1	-4.4	20.9	18.7	12.6	3.8	-1.4	-3.6	26.5	24.5	23.9	18.0	16.3	12.4
180	20.4	19.9	14.8	5.7	-1.0	-2.8	21.9	17.9	14.1	5.2	-1.6	-3.9	27.3	25.8	24.2	18.7	17.2	13.0
210	21.1	20.2	15.4	8.7	1.1	-1.8	22.2	18.2	15.5	6.2	0.1	-2.2	27.6	26.1	24.5	20.4	17.6	12.9
240	22.8	21.2	16.4	10.1	4.8	-0.9	23.5	19.4	16.8	9.4	2.2	-1.1	27.8	25.4	24.7	22.0	18.6	13.4
270	23.4	21.9	17.8	11.8	5.2	0.0	24.2	20.9	18.4	11.5	5.9	0.4	27.9	25.7	24.9	22.7	19.5	14.9
300	24.1	22.2	18.2	12.4	6.8	1.1	24.6	21.5	19.8	13.7	8.4	1.4	28.0	26.2	25.2	23.3	20.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	23.5	20.6	15.0	10.6	3.1	28.2	26.4	25.4	23.9	21.9	17.4
360	25.5	23.4	20.8	14.8	8.9	3.7	26.0	24.9	21.2	17.8	12.4	6.9	28.6	26.7	25.8	24.9	23.0	18.8

Table A13: Temperatures Data of Surrounding Temperature of 25^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	25.2	24.9	24.9	24.7	25.0	25.6	24.6	25.1	25.3	24.9	25.0	25.6	25.6	25.5	25.6	25.7	25.6	25.7
5	15.7	12.2	12.0	13.4	22.6	23.0	23.0	15.3	13.2	16.7	24.5	24.7	25.0	23.3	23.7	23.4	25.3	25.2
10	11.4	6.6	4.8	7.5	18.1	22.1	20.4	13.6	12.6	14.4	22.5	24.3	23.8	21.2	20.6	21.2	24.6	24.5
15	8.7	4.7	1.5	6.0	19.8	20.8	19.8	13.3	12.2	13.5	20.1	21.8	22.5	20.2	19.6	19.5	22.8	23.6
20	8.3	4.8	1.3	5.4	15.9	17.0	19.7	12.9	12.0	13.1	16.4	17.4	22.4	20.0	19.3	19.2	20.9	22.1
25	9.0	5.1	1.0	4.3	5.1	5.3	19.8	12.7	11.5	10.4	9.8	7.3	22.3	19.8	19.1	19.0	20.0	20.9
30	9.3	5.3	0.8	2.6	3.0	3.5	19.6	12.7	11.4	9.5	8.3	5.5	22.2	19.7	19.0	18.6	19.3	19.7
35	9.5	5.6	0.1	0.9	1.9	1.8	19.3	12.5	10.8	8.9	6.5	3.1	22.1	19.6	19.0	18.3	18.1	18.2
40	9.7	5.8	-0.6	-0.5	0.4	0.3	19.2	12.5	10.7	7.5	3.2	1.5	22.0	19.5	18.8	17.9	17.6	16.8
45	10.1	6.1	-0.7	-0.7	-0.4	-1.0	19.2	12.1	10.5	6.3	2.1	1.0	21.9	19.4	18.7	17.6	17.3	15.5
50	10.3	6.4	-1.2	-2.0	-1.6	-2.1	19.1	12.0	10.1	5.8	1.2	0.1	21.7	19.4	18.6	17.5	16.9	14.1
55	10.6	6.5	-1.7	-3.1	-2.6	-3.4	18.9	11.9	9.7	5.1	0.6	-2.2	21.6	19.2	18.6	16.3	14.3	12.6
60	10.7	6.6	-2.4	-4.6	-4.0	-4.6	18.0	10.7	8.6	4.6	-0.1	-3.0	21.4	19.0	18.5	14.7	11.5	9.8
90	11.1	7.2	-1.7	-6.0	-5.3	-7.2	17.4	9.8	7.2	1.9	-2.3	-4.1	20.3	18.8	17.4	13.0	9.3	6.3
120	11.4	8.1	0.4	-4.0	-5.1	-7.4	17.7	11.1	6.5	-0.9	-4.0	-5.2	21.2	19.0	18.9	12.7	8.5	6.1
150	13.2	9.4	3.4	-1.7	-5.3	-6.9	18.9	13.1	9.2	4.1	-2.9	-4.7	21.3	19.1	19.2	11.9	9.9	6.9
180	14.8	10.7	5.6	2.2	-3.7	-6.0	19.1	15.5	10.9	6.2	-1.5	-3.9	21.8	20.5	19.5	13.2	10.4	7.2
210	14.7	10.8	6.9	3.9	-2.5	-5.2	19.5	17.7	12.0	8.1	0.0	-2.8	22.0	20.6	20.1	14.2	11.4	8.5
240	15.9	11.8	8.3	5.7	0.4	-4.2	20.7	18.5	13.7	9.4	2.2	-1.8	22.2	20.9	20.4	15.4	12.7	9.0
270	16.4	13.3	10.3	6.7	2.0	-3.4	21.3	19.1	13.9	9.8	3.8	-0.5	22.4	21.1	20.5	16.0	13.8	10.6
300	16.7	14.0	12.9	8.0	2.2	-3.1	21.5	19.5	14.2	11.0	5.2	0.0	22.7	21.3	20.8	17.5	14.7	11.8
330	19.7	16.5	14.3	10.6	5.0	-2.8	21.7	16.7	15.3	12.5	6.9	1.0	22.9	21.5	21.2	18.5	15.0	12.1
360	21.8	18.5	16.1	12.6	6.3	-1.2	22.3	19.3	16.8	13.2	8.1	2.3	23.2	21.8	21.4	18.7	16.0	13.0
390	22.7	20.3	17.3	14.0	7.0	-0.2	23.1	20.8	17.7	14.6	9.4	3.1	23.6	22.1	22.1	19.3	16.7	14.6
420	24.3	21.3	19.5	15.8	9.8	1.0	24.5	21.9	19.9	16.8	11.9	4.7	24.8	22.7	22.4	20.1	17.6	16.3

Table A14: Temperatures Data of Surrounding Temperature of 20^oC for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	19.8	19.8	19.6	19.5	20.0	20.4	19.4	19.9	20.0	19.8	20.0	20.6	20.7	20.3	20.6	20.7	20.5	20.4
5	10.4	7.2	5.2	7.9	16.7	18.1	15.1	9.3	4.5	8.8	19.9	19.6	19.2	17.5	16.8	16.4	19.8	19.1
10	7.5	3.1	1.1	3.3	15.6	17.4	13.7	7.3	2.6	6.2	18.4	19.5	18.1	16.1	15.2	13.4	19.0	19.0
15	6.0	1.9	0.4	2.7	9.9	15.0	12.5	6.3	2.0	4.2	2.6	16.2	17.4	15.0	14.1	12.6	17.7	18.8
20	5.3	1.5	-0.6	1.4	8.1	11.8	13.0	5.9	1.8	2.9	2.8	13.1	17.2	14.9	13.3	12.4	16.3	18.1
25	6.7	2.3	-1.2	0.6	1.8	1.8	12.8	5.4	1.6	1.5	3.5	3.4	17.0	14.7	13.1	12.1	15.4	16.4
30	7.0	2.7	-1.9	-1.4	0.6	-0.7	12.7	5.1	1.4	0.4	1.4	1.3	16.9	14.7	12.6	11.6	14.7	15.7
35	7.0	3.1	-2.7	-2.4	-1.1	-2.4	12.3	5.0	1.3	-0.9	-0.5	-0.4	16.6	14.5	12.5	10.8	14.0	15.0
40	7.0	3.2	-3.4	-3.0	-2.9	-4.0	12.2	4.8	1.0	-1.2	-1.5	-2.0	16.5	14.4	12.2	9.8	11.9	12.6
45	7.3	3.4	-3.9	-4.0	-3.1	-5.2	12.2	5.1	0.9	-1.8	-2.2	-3.4	16.5	14.3	11.9	9.6	10.7	10.3
50	7.2	3.5	-4.2	-5.1	-5.4	-6.4	12.3	5.4	1.1	-2.2	-3.1	-4.4	16.3	14.2	12.4	9.3	9.5	8.8
55	7.4	3.9	-4.3	-6.4	-6.4	-7.2	12.4	5.9	1.3	-2.4	-3.6	-5.2	16.2	14.0	12.8	9.1	8.3	7.1
60	7.3	4.3	-4.3	-7.0	-6.8	-8.0	12.5	6.3	1.4	-2.9	-3.8	-6.1	16.1	14.1	13.1	9.0	7.3	5.6
90	7.8	4.5	-2.9	-8.0	-7.9	-10.3	12.7	6.9	2.8	-3.6	-4.2	-7.9	16.0	14.3	13.3	8.9	6.3	4.2
120	8.1	5.3	-1.6	-6.2	-7.6	-10.2	13.9	7.6	3.9	-3.9	-6.4	-9.3	15.9	14.4	13.4	8.8	4.9	3.9
150	10.0	6.0	1.2	-2.7	-6.9	-10.4	14.1	9.4	6.1	1.1	-5.7	-8.1	16.2	14.6	13.6	8.3	4.5	3.0
180	10.5	7.7	3.1	-0.8	-5.6	-9.4	14.4	10.8	7.4	3.5	-4.9	-6.8	16.6	15.0	13.8	9.8	7.4	5.4
210	11.5	8.2	4.4	0.1	-4.1	-8.1	15.5	11.3	9.1	5.2	-3.1	-5.7	16.7	15.1	14.5	10.7	7.8	6.2
240	12.0	9.2	5.3	2.4	-2.9	-7.4	15.7	11.8	9.7	6.3	-1.6	-4.9	16.8	15.3	15.1	11.1	8.1	6.6
270	13.2	10.2	6.5	3.4	-1.5	-6.3	15.8	12.4	10.2	7.2	-0.2	-3.4	17.0	15.5	15.3	12.9	9.1	7.2
300	14.9	11.3	9.2	6.0	0.1	-5.4	16.5	12.8	11.2	8.5	1.1	-2.5	17.1	15.7	15.5	13.3	10.3	7.5
330	15.3	12.9	10.8	7.9	1.8	-4.9	16.6	13.0	11.7	9.4	2.1	-2.1	17.3	15.9	15.6	13.8	10.8	7.7
360	15.8	13.2	12.9	8.1	2.7	-3.4	16.9	13.3	12.4	10.2	3.5	-0.8	17.4	16.2	15.9	14.0	11.5	9.1
390	16.3	14.5	13.3	8.2	1.0	-3.3	16.4	13.6	12.2	10.3	4.6	0.1	17.5	16.3	16.1	15.2	12.0	10.1
420	16.8	15.7	13.8	8.9	2.1	-2.7	16.9	13.8	12.7	11.0	6.6	1.9	17.8	16.4	16.4	15.5	13.1	11.5
450	17.6	16.2	14.6	9.7	4.3	-1.4	17.1	14.4	13.3	11.8	7.7	2.1	17.8	16.5	16.5	13.8	13.6	12.3
470	18.7	17.7	14.9	10.8	5.9	0.1	17.7	14.9	14.1	12.7	9.4	3.9	18.9	18.2	16.8	15.1	14.0	13.6

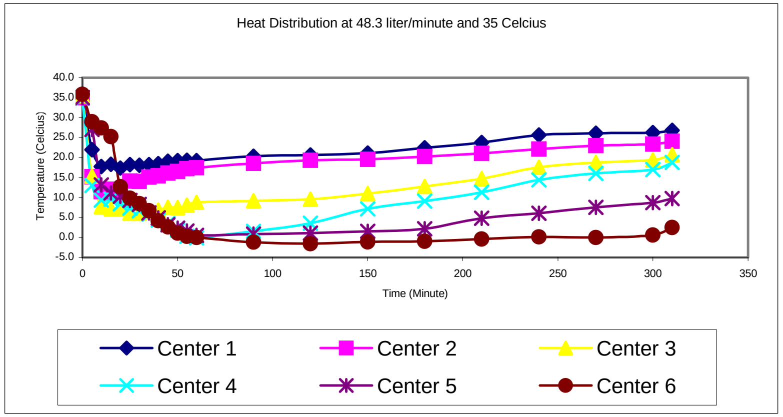
Table A15: Temperatures Data of Surrounding Temperature of 15^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	14.4	14.7	14.3	14.4	15	15.2	14.2	14.7	14.7	14.6	15.0	15.6	15.7	15.1	15.6	15.7	15.4	15.0
5	3.8	1.4	-0.2	2.9	13.7	13.9	9.4	3.7	2.3	3.5	14.9	15.5	14.3	12.5	13.2	12.4	15.0	13.9
10	1.0	-2.6	-8.5	-5.9	10.7	13.4	7.2	-0.8	-6.0	-3.2	12.4	14.7	13.2	10.8	10.1	9.7	14.4	13.8
15	-0.6	-4.6	-9.7	-7.2	6.7	9.9	5.8	-2.4	-7.6	-5.8	10.6	11.4	12.2	10.7	9.3	9.2	13.3	13.4
20	-2.4	-5.4	-9.6	-7.7	4.1	6.1	5.3	-3.0	-8.4	-6.1	6.5	7.4	11.7	10.5	9.0	8.7	12.0	12.5
25	-2.2	-6.4	-8.9	-8.1	1.9	3.3	5.4	-2.3	-6.7	-6.7	-5.8	-4.9	11.6	10.2	8.9	8.4	9.3	9.8
30	-1.4	-5.6	-8.2	-7.9	-4.5	-5.6	5.9	-0.8	-6.3	-7.1	-6.0	-5.7	11.5	10.0	8.6	8.0	7.8	8.6
35	-0.6	-4.4	-7.5	-7.9	-6.9	-6.4	5.8	-0.6	-5.9	-7.5	-6.5	-6.5	11.2	9.9	8.6	7.8	6.9	6.5
40	-0.1	-3.5	-7.2	-9.2	-7.7	-9.1	5.8	-0.5	-5.5	-7.7	-7.1	-7.3	11.1	9.8	8.7	7.7	6.8	5.0
45	0.4	-3.4	-6.9	-9.9	-9.7	-10.3	5.6	-0.7	-5.0	-8.9	-8.2	-8.5	11.0	9.7	8.8	7.6	6.5	4.7
50	0.7	-3.3	-6.6	-10.7	-10.9	-11.7	5.8	-0.4	-4.7	-9.7	-8.9	-9.4	10.9	9.6	9.0	7.5	6.4	4.5
55	0.9	-3.1	-6.4	-11.3	-10.3	-12.1	5.8	-0.5	-4.5	-10.3	-9.2	-10.1	10.7	9.5	9.1	7.2	6.0	4.1
60	1.3	-3.1	-5.7	-11.5	-11.1	-12.6	5.9	-0.3	-4.3	-10.9	-10.0	-11.3	10.5	9.7	9.1	7.0	5.8	3.9
90	2.1	-2.5	-5.1	-9.5	-12.3	-13.3	6.8	1.1	-2.6	-9.3	-10.6	-11.6	10.1	9.7	8.3	6.4	5.2	3.4
120	2.6	-1.3	-5.9	-9.1	-9.9	-13.0	7.2	2.1	-1.8	-6.3	-8.2	-11.8	11.1	9.9	8.4	6.2	4.3	2.2
150	3.1	0.4	-4.3	-6.5	-8.4	-12.5	7.4	4.6	-0.8	-5.4	-7.8	-10.7	11.3	10.3	9.1	7.3	4.4	2.4
180	5.1	1.7	-3.1	-5.9	-7.6	-11.0	8.2	6.8	2.8	-3.7	-6.7	-9.6	11.5	10.0	9.8	8.4	6.5	4.5
210	6.9	3.4	-1.3	-3.5	-6.7	-9.9	8.9	7.9	4.4	-2.6	-5.7	-8.6	11.8	10.3	9.9	8.7	6.6	4.6
240	7.9	3.9	2.4	-1.6	-4.1	-8.4	9.6	8.9	5.7	-0.5	-3.9	-7.3	11.9	10.5	10.2	9.1	6.7	4.7
270	8.2	5.5	4.1	-0.5	-3.3	-7.8	10.7	9.1	6.3	1.4	-2.3	-5.8	12.1	10.7	10.5	9.5	6.8	4.9
300	10.8	8.4	6.1	0.8	-1.0	-6.5	11.5	9.3	7.1	2.4	-0.3	-4.7	12.4	10.9	10.7	9.8	6.9	5.2
330	11.2	9.1	7.9	3.8	0.3	-6.3	11.7	9.7	8.7	4.5	-0.9	-3.2	12.6	11.1	11.0	8.7	7.0	5.5
360	11.4	9.5	9.4	5.9	1.4	-4.6	11.9	10.1	9.7	6.3	2.3	-1.3	12.7	11.6	11.2	9.1	7.2	5.8
390	12.7	10.8	10.3	6.7	3.0	-2.1	13.1	11.8	10.7	7.4	5.4	0.0	13.9	12.6	11.7	9.6	7.7	6.2
420	12.8	11.2	10.8	8.0	4.7	-0.8	13.5	12.2	11.3	8.7	6.4	3.1	14.1	13.2	12.5	9.9	8.3	6.9
450	13.1	12.5	11.6	10.2	6.5	2.6	13.8	13.1	12.1	11.8	8.8	5.7	14.3	13.9	12.9	10.2	9.3	7.3

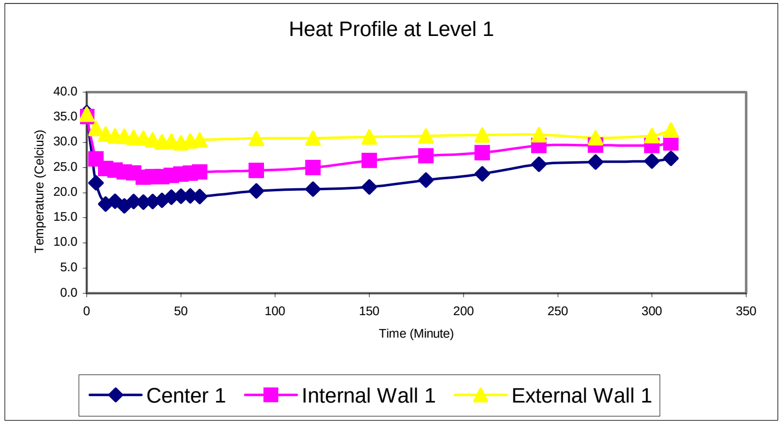
Table A16: Temperatures Data of Surrounding Temperature of 10^oC for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	10.0	10.6	10.0	10.3	10.0	10.1	10.0	10.5	10.4	10.5	10.0	10.6	10.7	10.0	10.5	10.6	10.3	10.6
5	4.8	2.4	1.8	3.8	8.0	9.5	8.7	4.4	2.7	4.7	9.0	10.4	9.6	8.7	9.1	9.5	9.6	9.8
10	0.3	-2.2	-4.1	4.6	6.9	8.1	7.1	1.5	-1.8	-1.7	7.3	8.9	9.3	8.3	7.1	8.1	9.0	9.6
15	-2.3	-2.6	-4.5	1.9	4.0	4.1	6.8	-0.9	-2.3	-2.2	5.2	6.8	8.9	8.0	7.2	8.2	8.1	7.6
20	-3.0	-2.7	-4.9	-0.4	0.7	2.8	5.1	-2.4	-2.7	1.1	3.0	5.0	8.7	7.8	6.0	7.7	8.2	7.6
25	-2.2	-2.9	-5.1	-1.6	0.0	0.2	4.5	-2.7	-3.2	-2.3	1.5	2.7	8.6	7.8	5.6	7.6	6.1	5.7
30	-1.7	-3.1	-4.6	-4.9	-3.2	-2.9	4.1	-3.0	-3.3	-3.1	-2.0	-0.8	8.5	7.6	5.3	7.4	5.8	4.6
35	-0.4	-3.3	-6.4	-5.2	-4.9	-4.8	3.9	-2.0	-3.7	-3.5	-3.7	-1.3	8.3	7.4	5.1	7.1	5.7	3.7
40	0.0	-3.5	-6.6	-5.4	-5.5	-6.0	3.5	-1.4	-3.4	-4.5	-4.7	-3.9	8.0	7.2	5.6	6.9	5.6	3.5
45	0.4	-3.6	-6.8	-8.5	-8.7	-8.0	3.3	0.5	-3.6	-5.7	-5.5	-5.5	8.1	6.7	5.7	6.6	5.5	3.2
50	0.7	-3.8	-7.0	-9.9	-9.9	-10.5	3.0	1.1	-3.5	-5.8	-6.9	-7.5	8.2	7.0	6.5	6.4	5.3	3.0
55	1.0	-3.9	-7.2	-11.0	-11.7	-12.8	2.8	1.4	-3.9	-6.3	-7.8	-9.5	8.3	7.2	6.4	6.3	5.2	2.9
60	1.3	-4.1	-7.5	-12.7	-12.5	-14.1	2.7	1.4	-4.1	-7.0	-8.9	-10.1	8.5	7.5	6.4	6.2	5.0	2.6
90	1.5	-4.5	-7.0	-10.2	-13.9	-14.7	2.6	1.5	-3.4	-7.7	-9.6	-12.8	8.7	7.7	6.2	5.1	4.7	2.2
120	1.9	-4.8	-6.8	-10.9	-12.4	-14.4	3.6	1.7	-4.7	-8.5	-11.1	-13.2	8.8	7.9	6.4	4.7	3.1	1.4
150	2.3	-3.1	-6.1	-8.6	-10.3	-13.8	4.7	2.2	-2.9	-7.8	-9.8	-12.1	8.9	8.1	7.8	5.9	2.9	1.2
180	2.5	-1.5	-5.4	-7.8	-9.3	-12.4	5.2	3.6	-1.2	-5.5	-8.5	-11.2	9.1	8.3	7.9	6.8	4.7	2.3
210	3.6	0.5	-4.2	-5.6	-8.5	-11.8	7.5	6.6	1.4	-3.3	-7.6	-9.9	9.3	8.6	8.1	7.3	5.6	2.5
240	4.7	1.1	-0.1	-3.2	-6.2	-10.9	7.4	6.8	2.3	-1.9	-6.9	-8.2	9.5	8.7	8.0	7.7	5.9	2.9
270	6.1	3.7	1.5	-2.4	-5.9	-8.9	7.5	7.0	3.4	0.4	-4.3	-6.6	9.5	8.8	8.1	7.9	6.1	3.5
300	7.6	6.4	3.2	-1.1	-3.4	-7.5	7.8	7.4	4.8	1.6	-3.6	-5.5	9.6	8.9	8.3	8.1	6.6	4.1
330	8.1	7.2	4.1	-0.1	-2.9	-6.2	8.2	7.8	5.0	2.4	-1.8	-4.1	9.7	9.1	8.5	8.3	6.9	4.5
360	8.5	7.8	5.7	3.2	0.9	-3.2	8.9	8.1	6.5	3.9	-0.6	-2.5	9.8	9.2	8.9	8.6	7.2	5.0
390	8.6	8.2	6.0	4.6	3.1	1.4	9.1	8.5	7.6	6.4	4.6	2.3	9.8	9.4	9.1	8.9	7.8	6.4

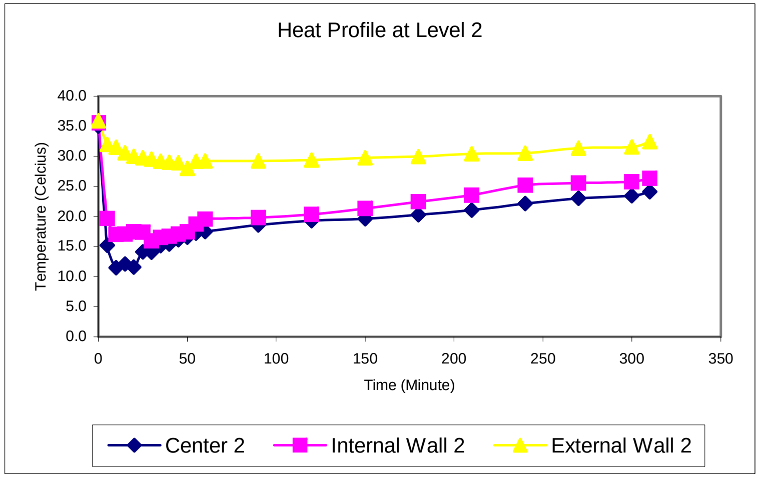
T= 35oC



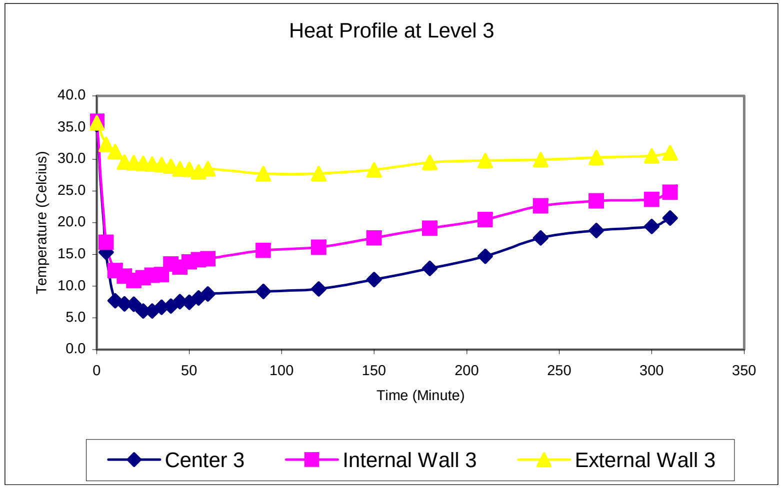
Heat Distribution at 48.3 liter/minute and 35 Celcius
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6



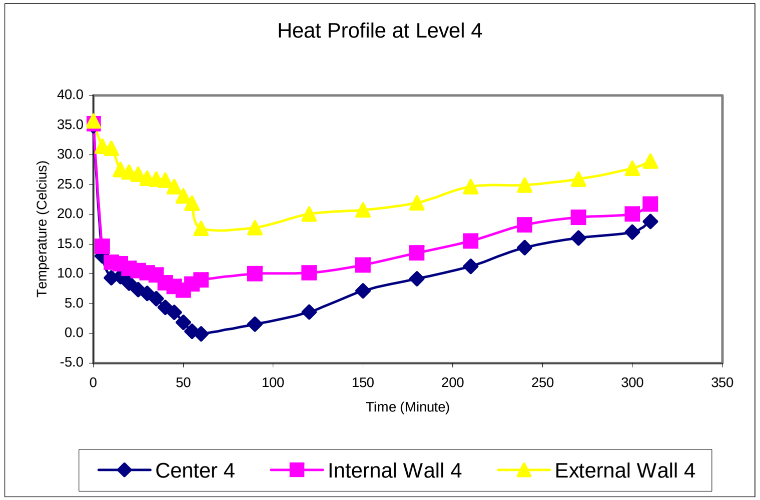
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1



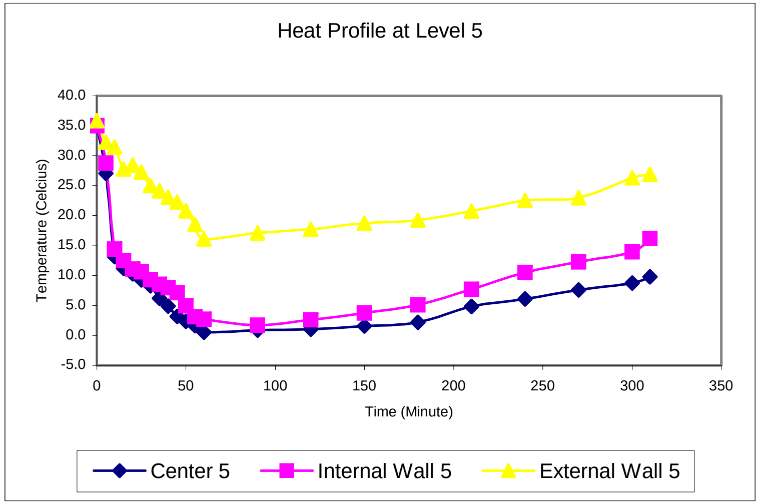
Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2



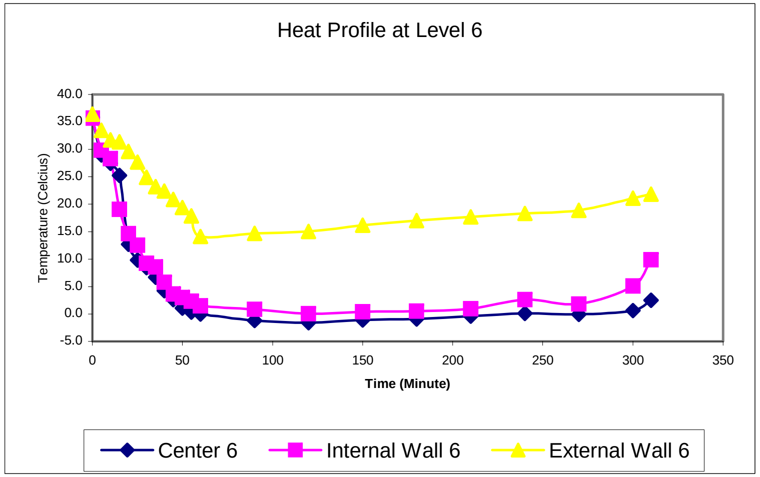
Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3



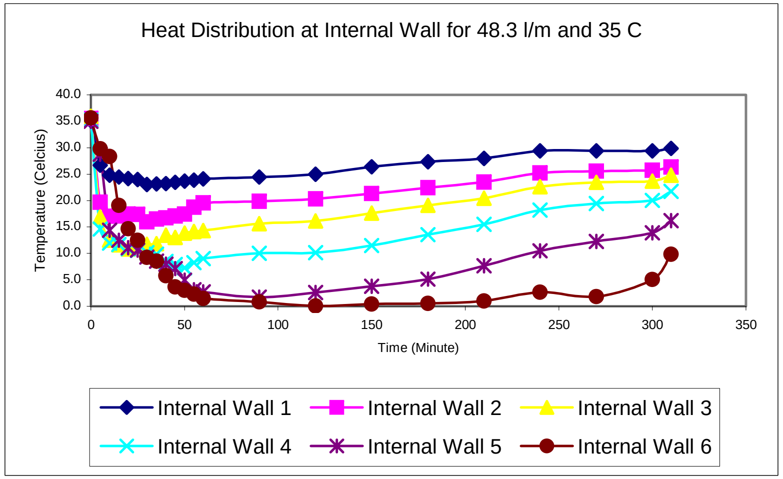
Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4



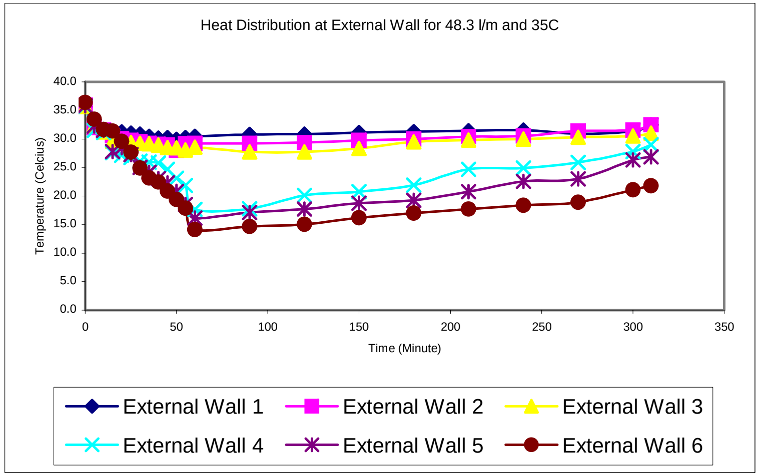
Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5



Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

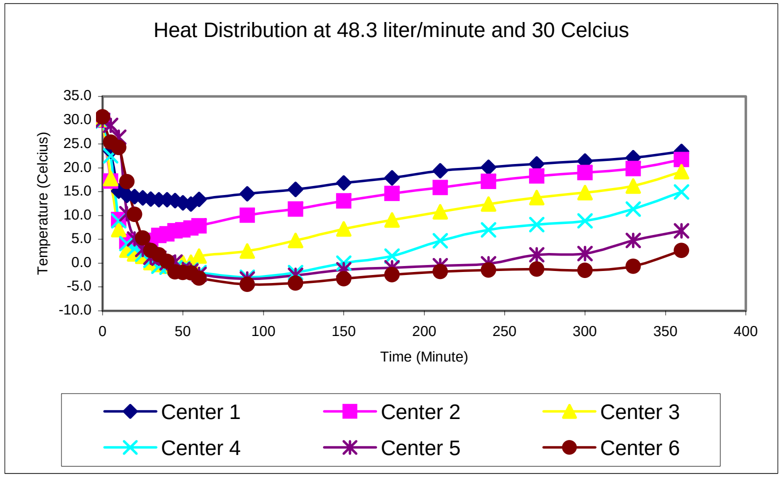


Heat Distribution at Internal Wall for 48.3 l/m and 35 C
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

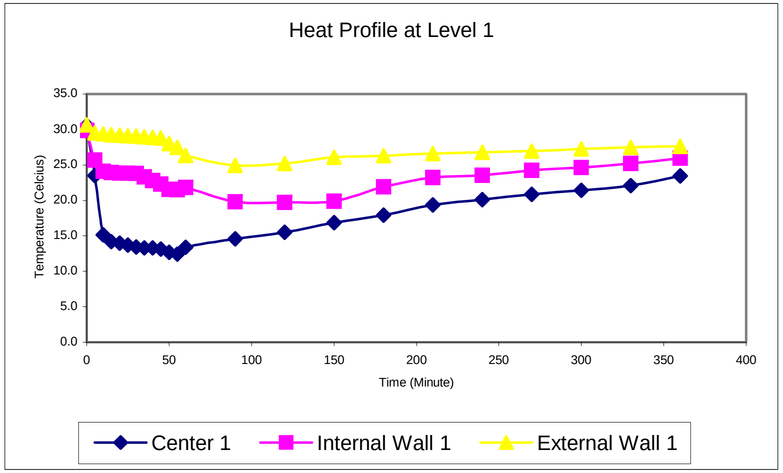


Heat Distribution at External Wall for 48.3 l/m and 35C
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

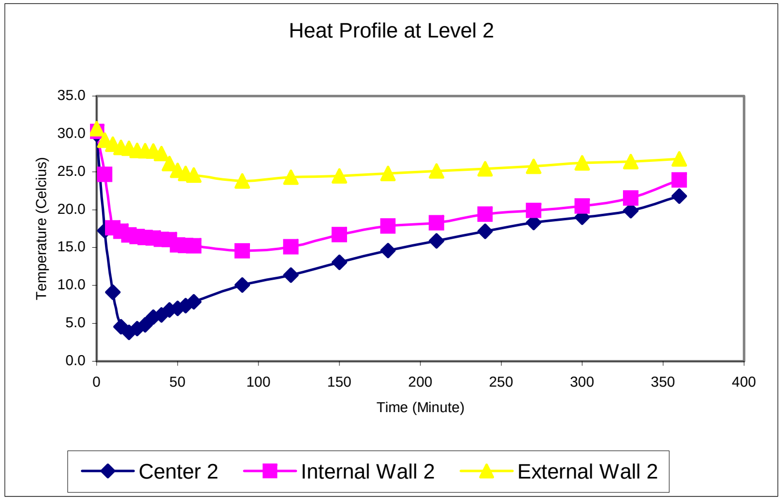
T= 30oC

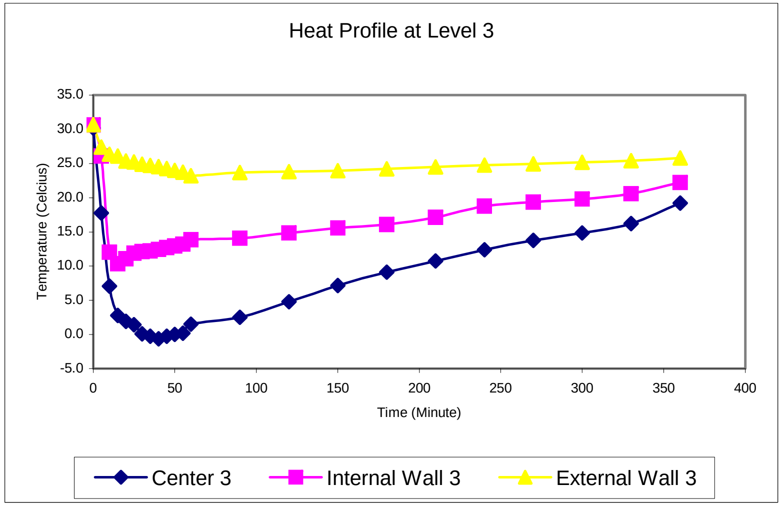


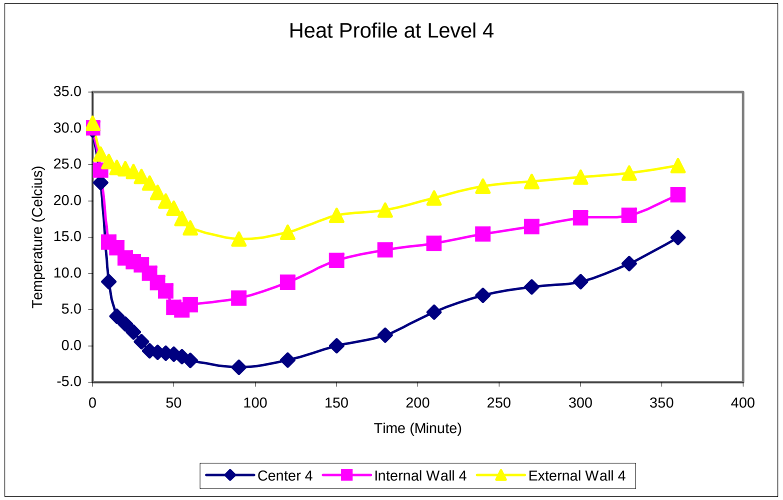
Heat Distribution at 48.3 liter/minute and 30 Celcius
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

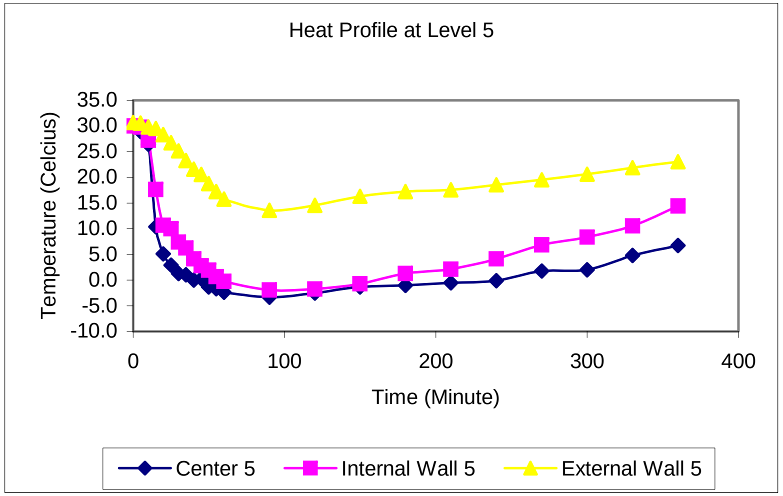


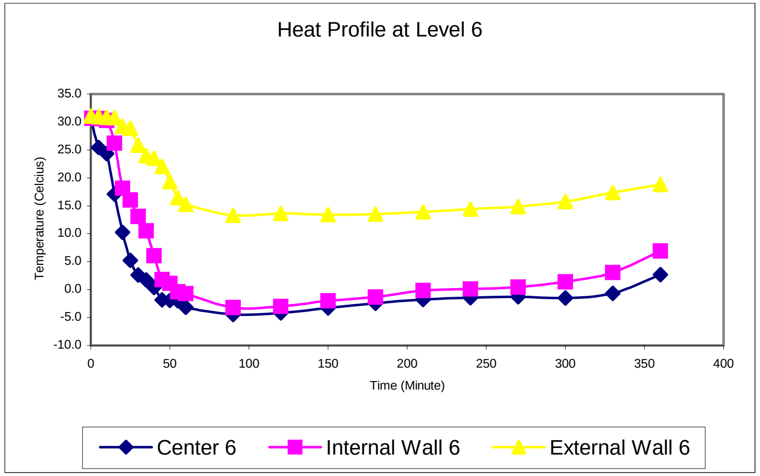
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1

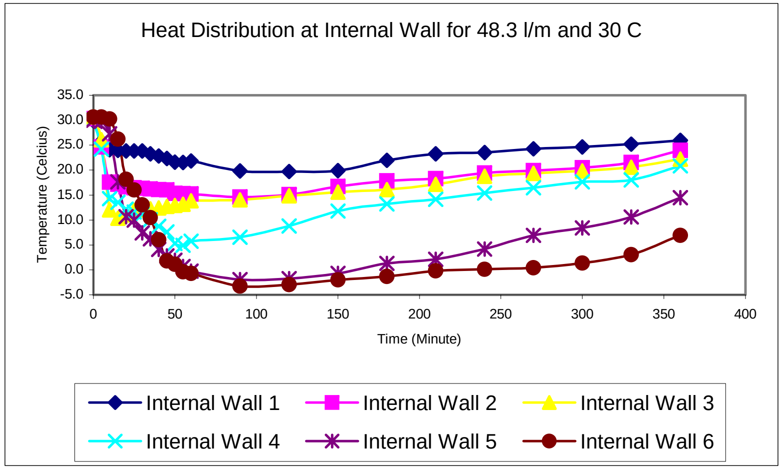

Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2

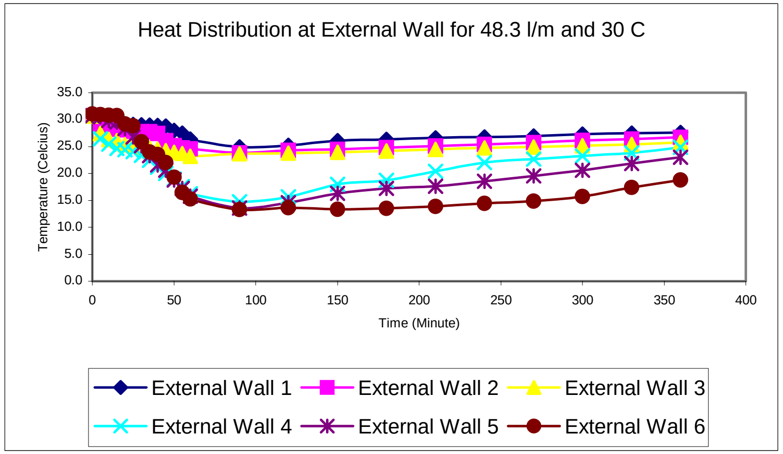

Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3


Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

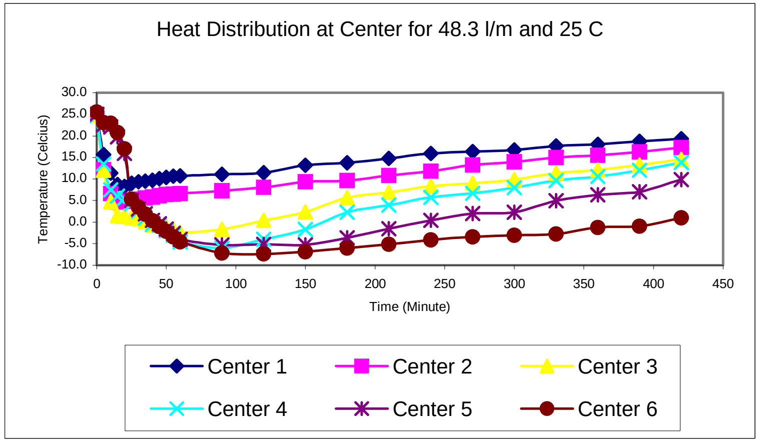

Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5


Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
50
100
150
200
250
300
350
400
Center 6
Internal Wall 6
External Wall 6

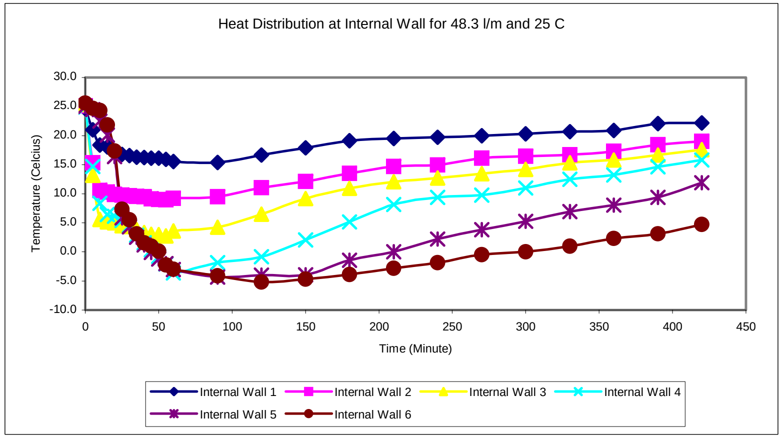

Heat Distribution at Internal Wall for 48.3 l/m and 30 C
Temperature (Celcius)
Time (Minute)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0
50
100
150
200
250
300
350
400
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6


Heat Distribution at External Wall for 48.3 l/m and 30 C
Temperature (Celcius)
Time (Minute)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
250
300
350
400
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

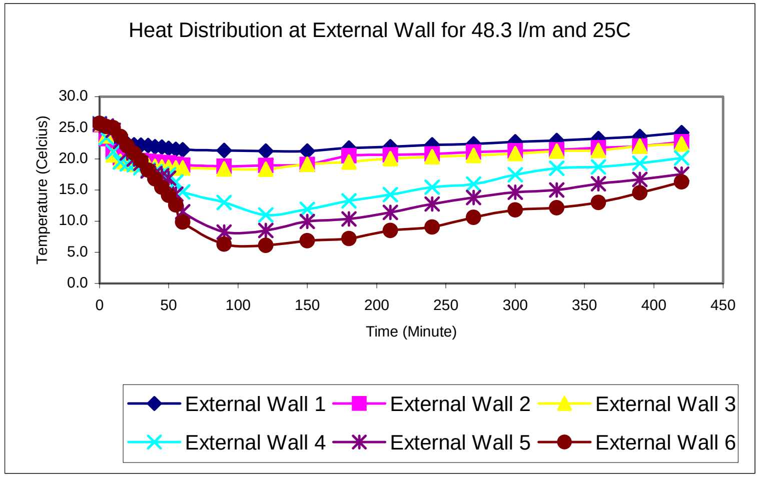
T= 25oC



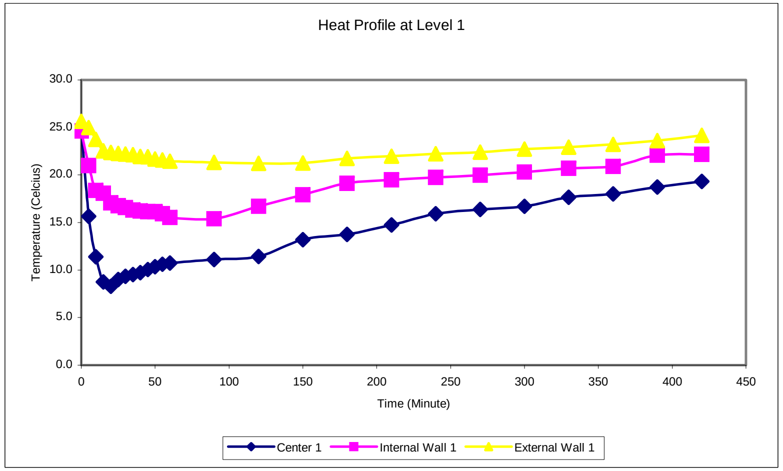
Heat Distribution at Center for 48.3 l/m and 25 C
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (Celcius)
0
50
100
150
200
250
300
350
400
450
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6



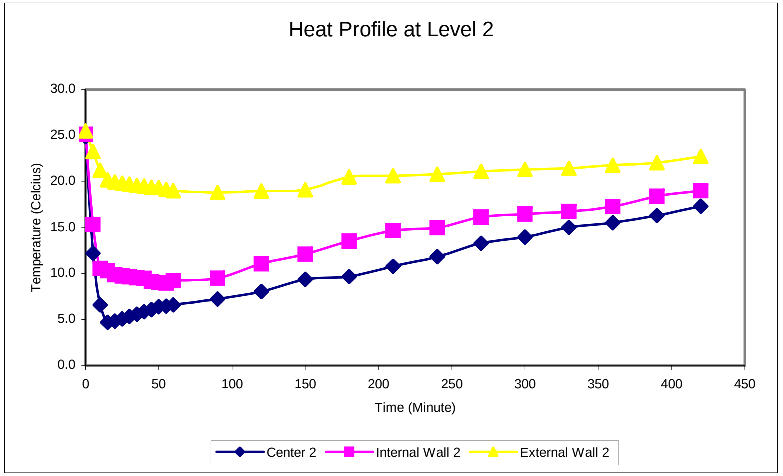
Heat Distribution at Internal Wall for 48.3 l/m and 25 C
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (Celcius)
0
50
100
150
200
250
300
350
400
450
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

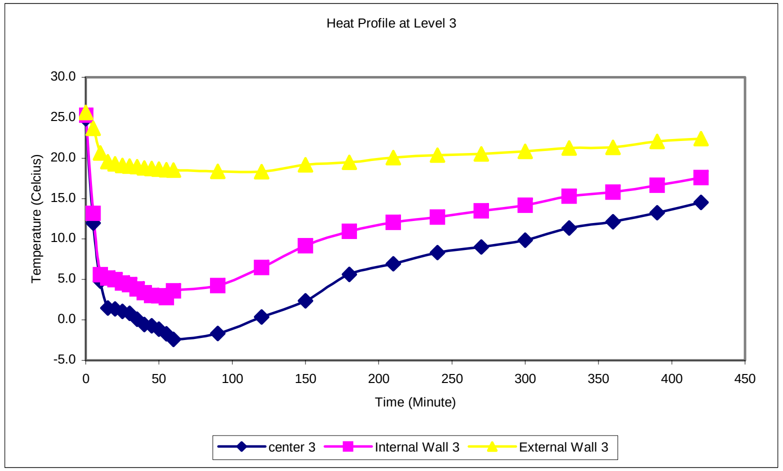


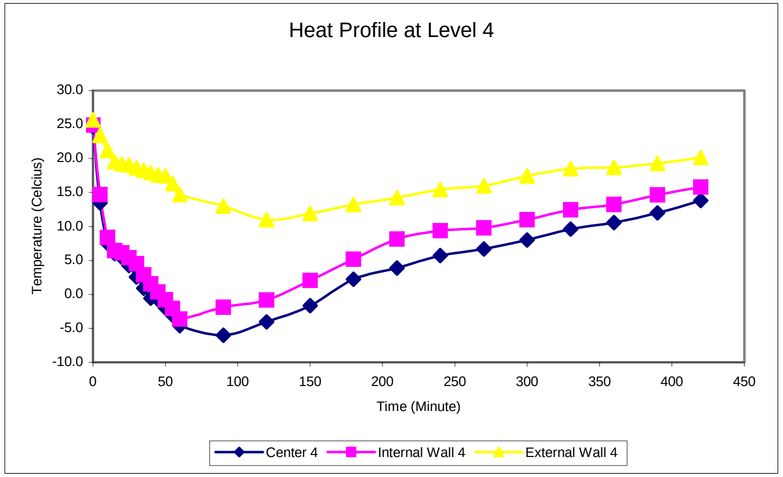
Heat Distribution at External Wall for 48.3 l/m and 25C
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (Celcius)
0
50
100
150
200
250
300
350
400
450
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

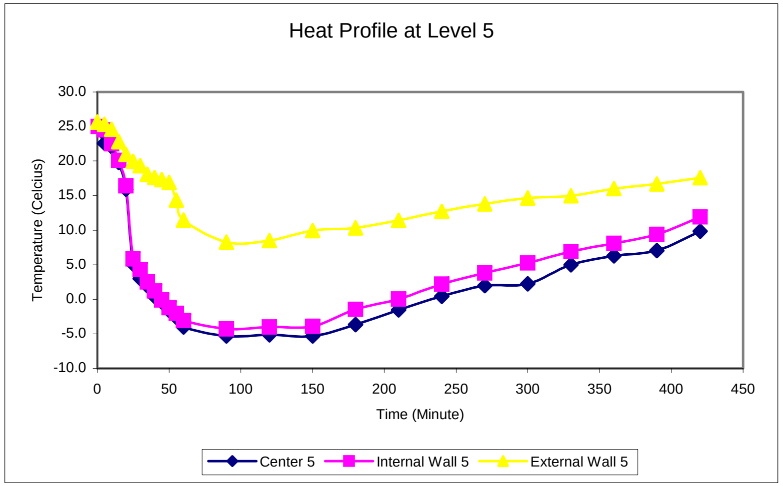


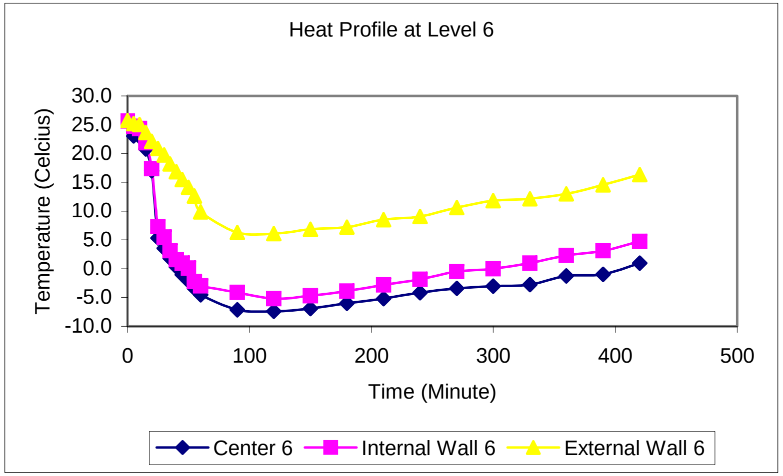
Heat Profile at Level 1
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (Celcius)
0
50
100
150
200
250
300
350
400
450
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2

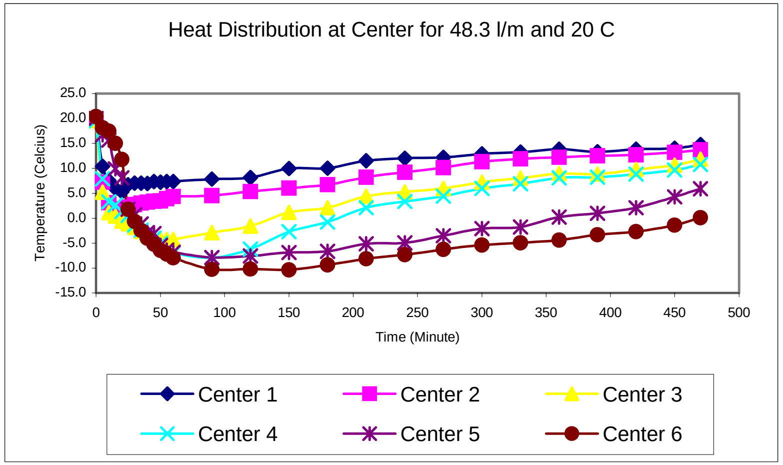

Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
center 3
Internal Wall 3
External Wall 3

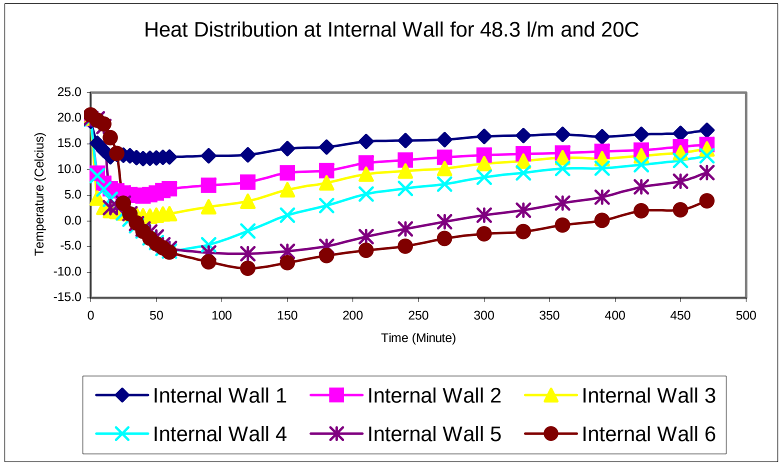

Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

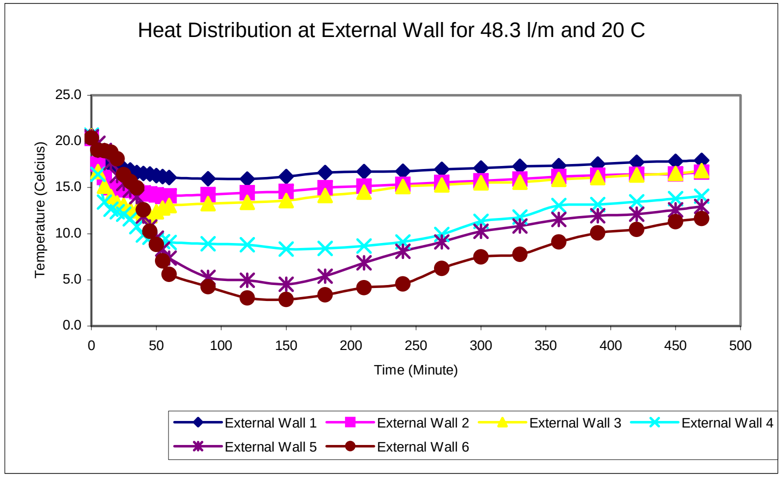

Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

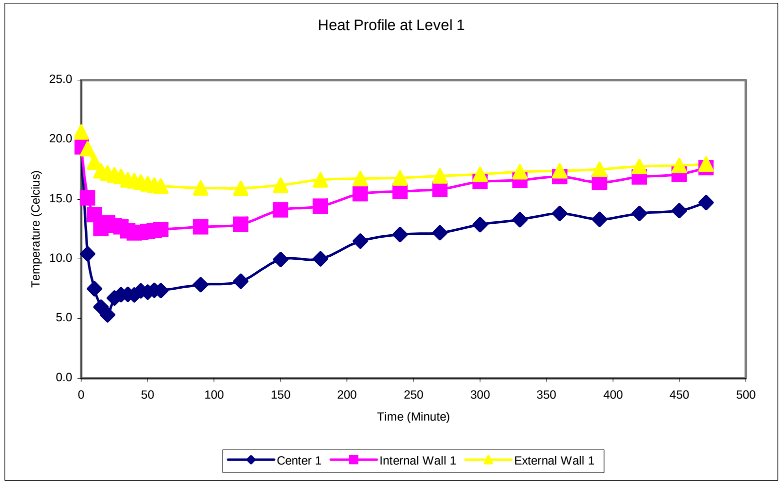

Heat Profile at Level 6
Temperature (Celcius)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
100
200
300
400
500
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

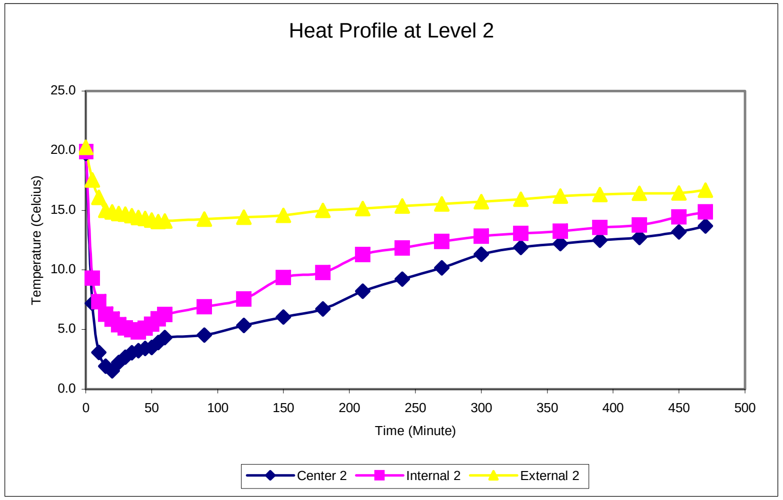
T= 20oC

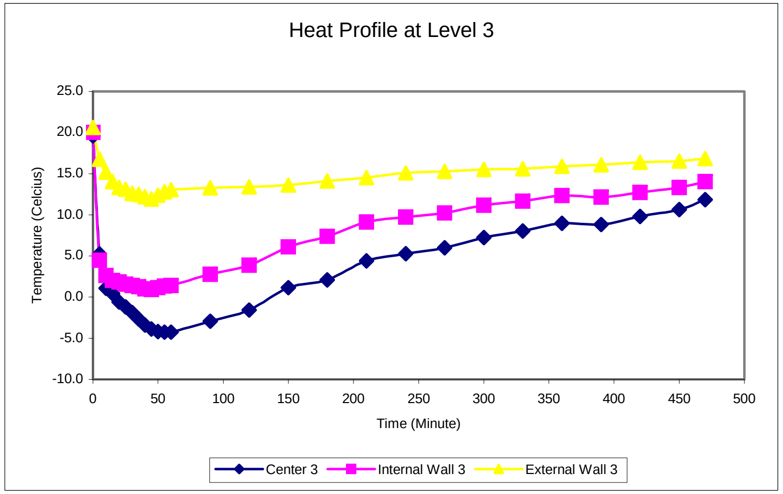

Heat Distribution at Center for 48.3 l/m and 20 C
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

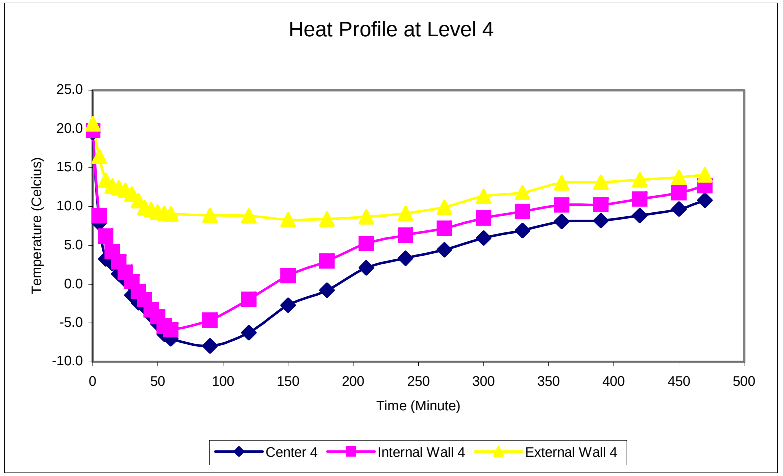

Heat Distribution at Internal Wall for 48.3 l/m and 20C
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

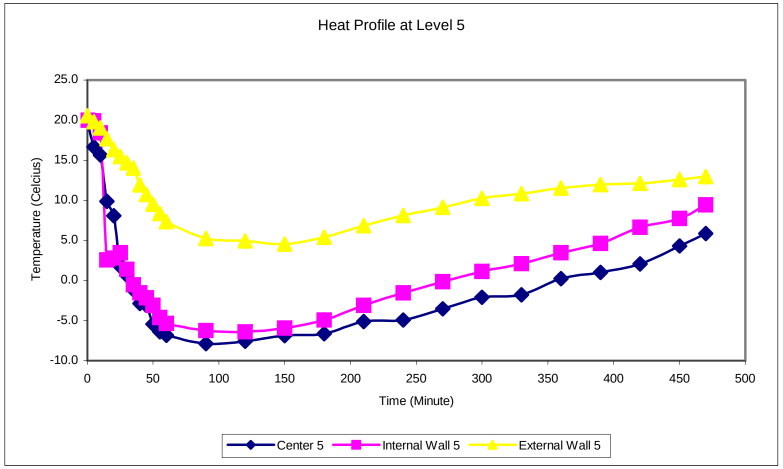

Heat Distribution at External Wall for 48.3 l/m and 20 C
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

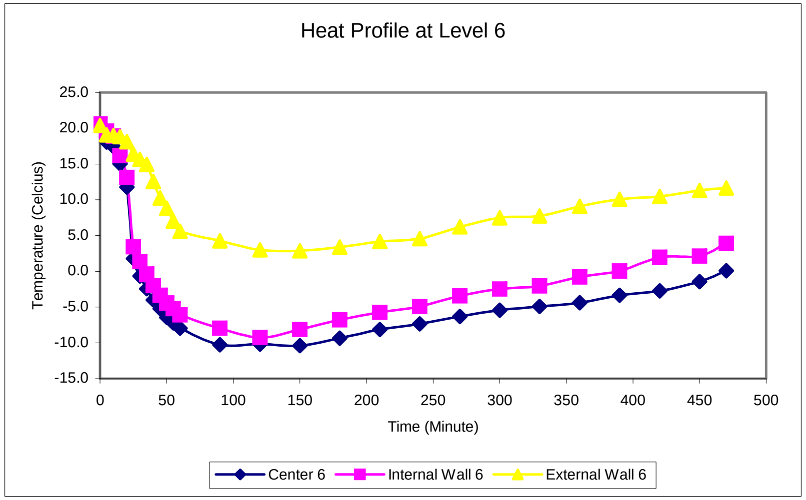

Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal 2
External 2

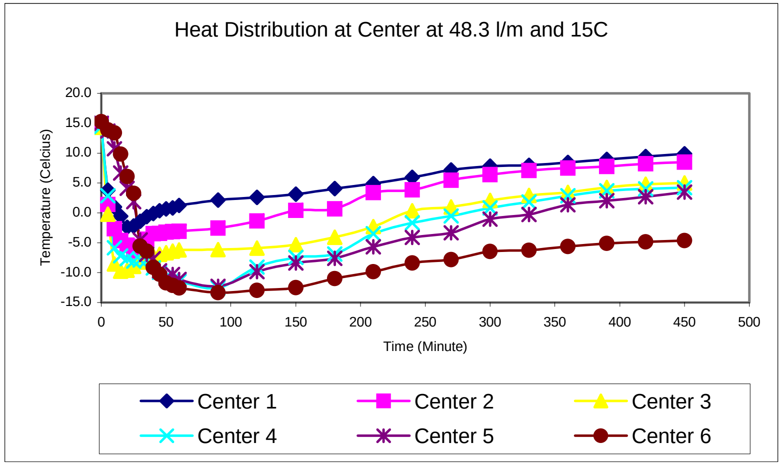

Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3

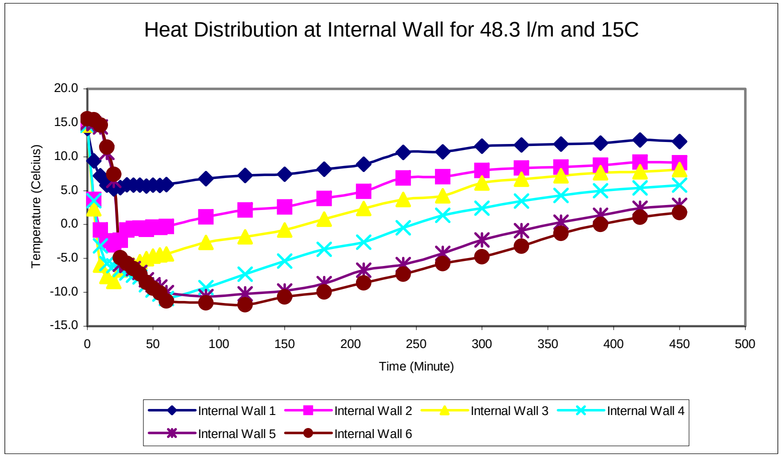

Heat Profile at Level 4
Temperature (Celcius)
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
50
100
150
200
250
300
350
400
450
500
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

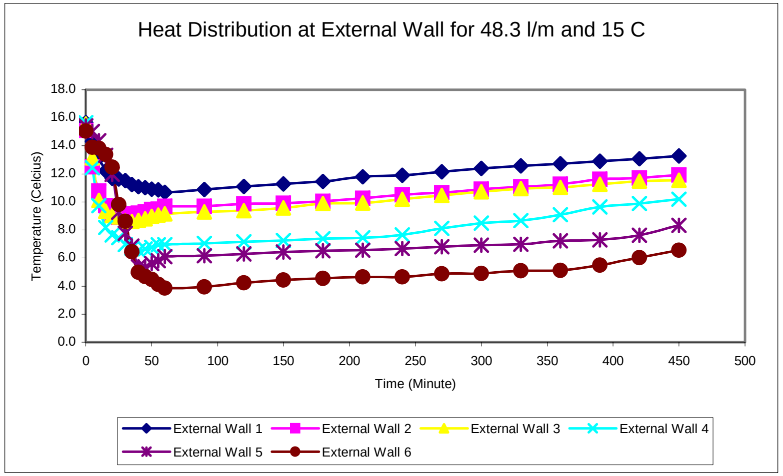

Heat Profile at Level 5
Temperature (Celcius)
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
50
100
150
200
250
300
350
400
450
500
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

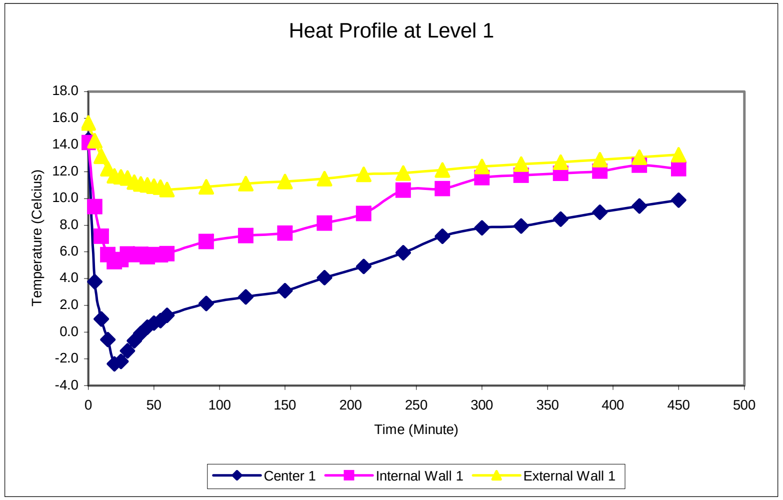

Heat Profile at Level 6
Temperature (Celcius)
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
0
50
100
150
200
250
300
350
400
450
500
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

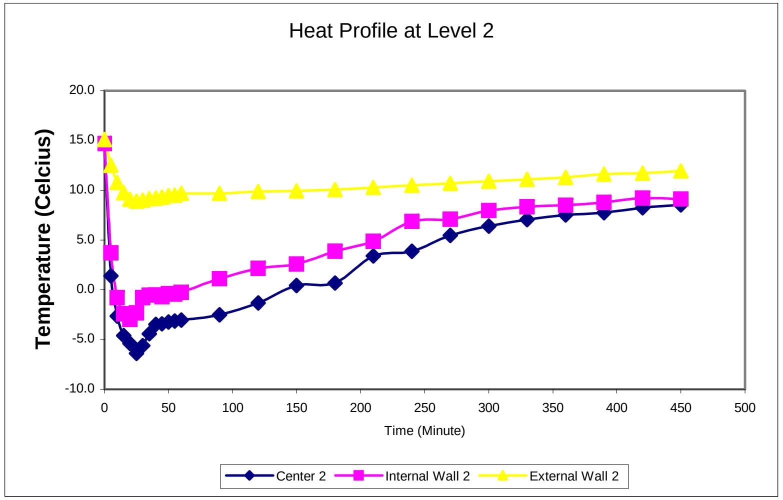
T= 15oC


Heat Distribution at Center at 48.3 l/m and 15C
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

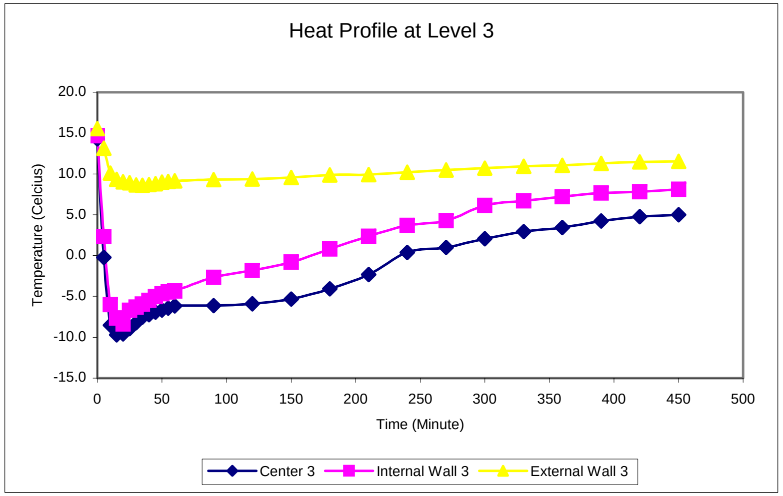

Heat Distribution at Internal Wall for 48.3 l/m and 15C
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6


Heat Distribution at External Wall for 48.3 l/m and 15 C
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

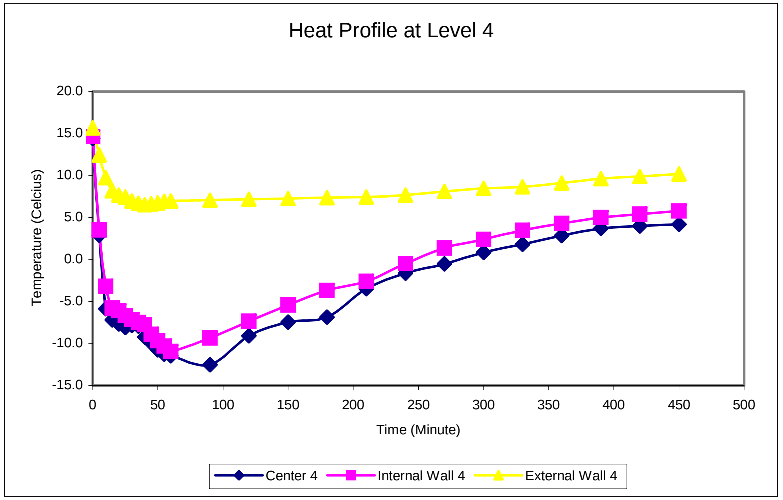

Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1



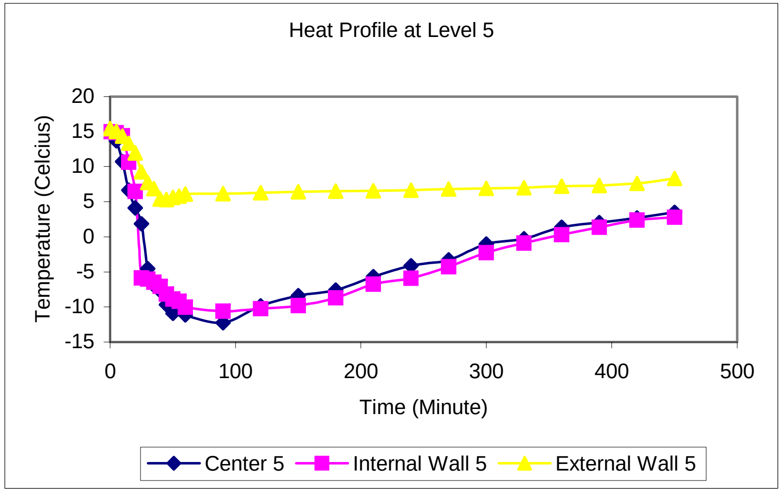
Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2



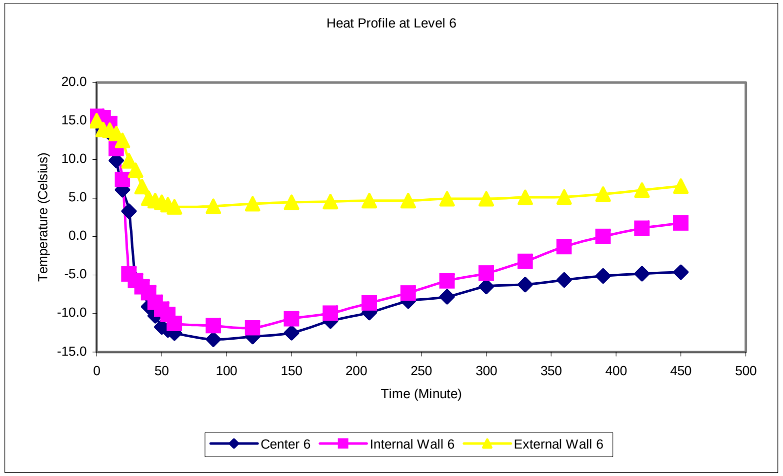
Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3



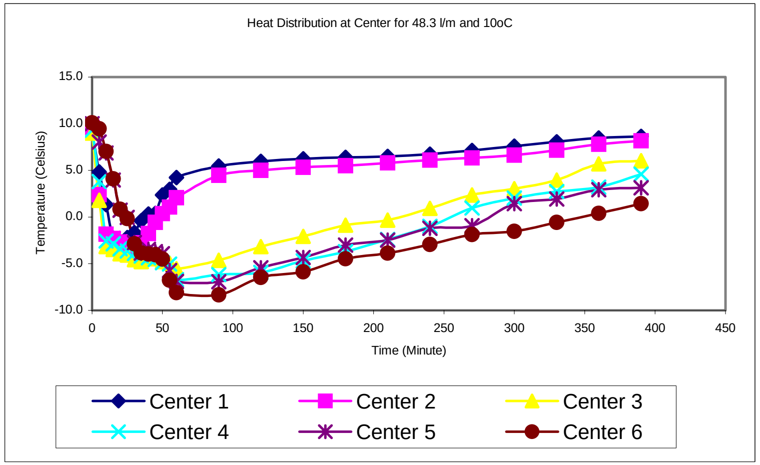
Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

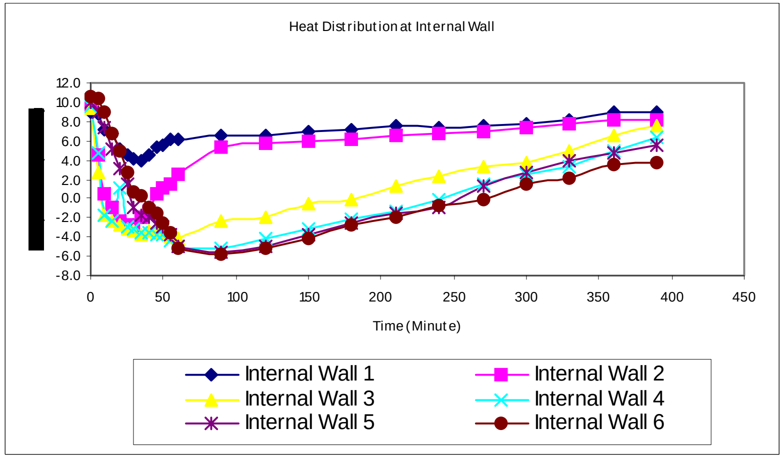


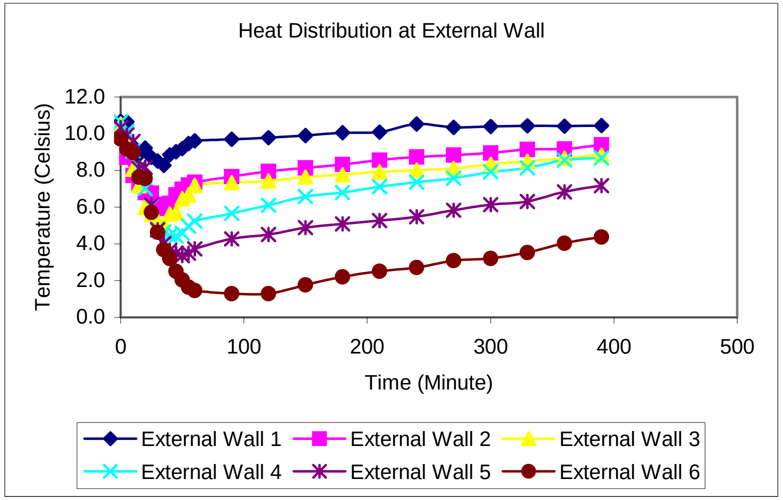
Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

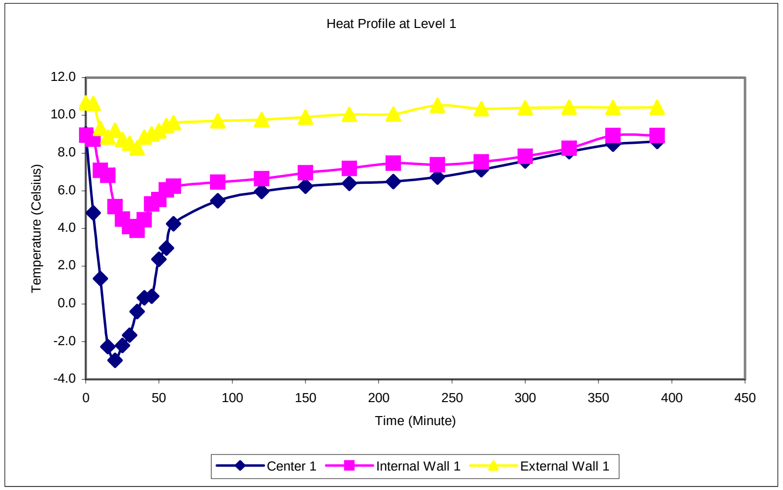

Heat Profile at Level 6
Temperature (Celsius)
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
0
50
100
150
200
250
300
350
400
450
500
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

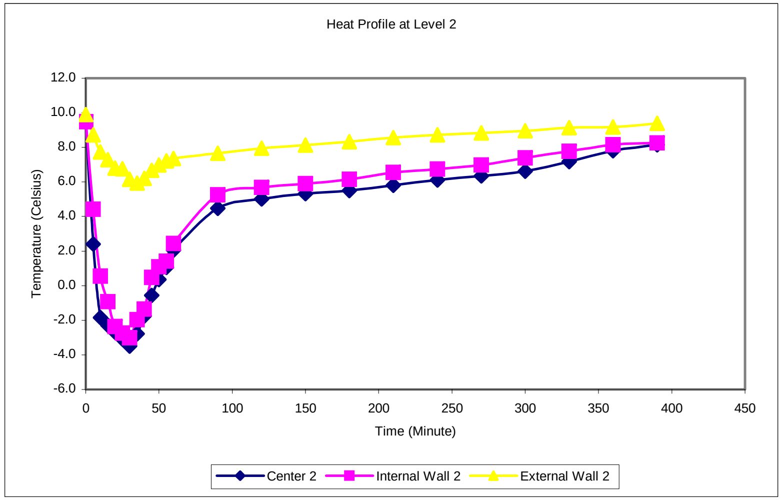
T= 10oC

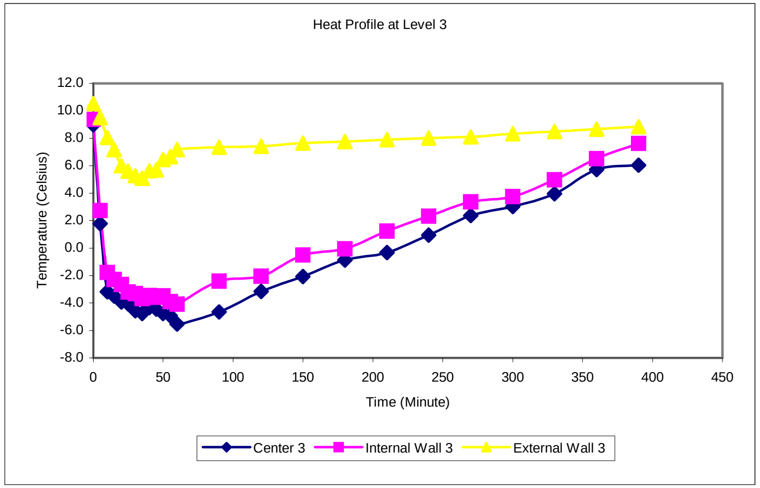

Heat Distribution at Center for 48.3 l/m and 10oC
Temperature (Celsius)
15.0
10.0
5.0
0.0
-5.0
-10.0
0
50
100
150
200
250
300
350
400
450
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

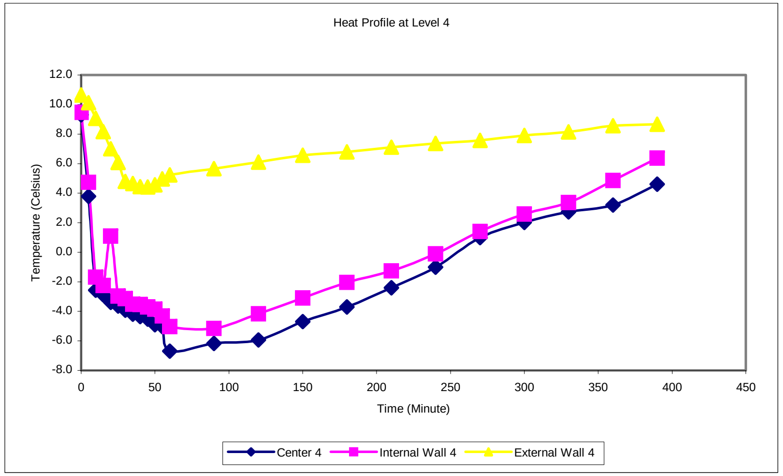

Heat Distribution at Internal Wall
[redacted]
12.0
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
0
50
100
150
200
250
300
350
400
450
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

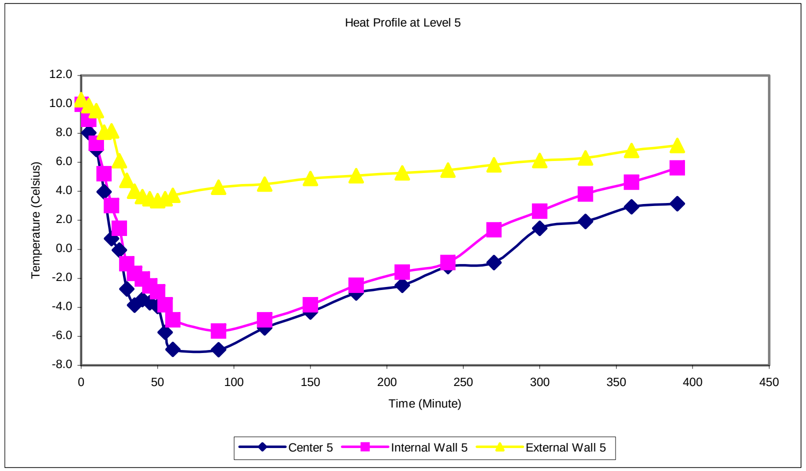

Heat Distribution at External Wall
Temperature (Celsius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6


Heat Profile at Level 1
Temperature (Celsius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celsius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2


Heat Profile at Level 3
Temperature (Celsius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3


Heat Profile at Level 4
Temperature (Celsius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4


Heat Profile at Level 5
Temperature (Celsius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

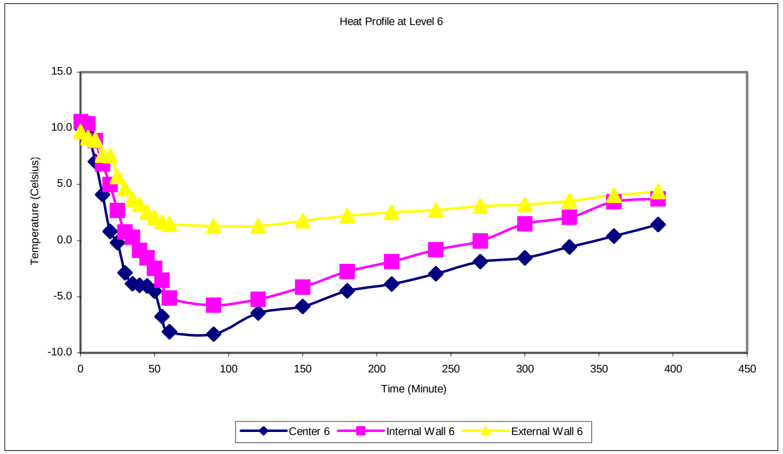

Heat Profile at Level 6
Temperature (Celsius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

Table A11: Temperatures Data of Surrounding Temperature of 35^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	35.9	35.0	35.5	34.9	35.0	35.9	35.1	35.5	36.0	35.2	35.0	35.1	35.1	35.5	35.2	35.2	35.0	35.1
5	33.0	28.2	25.3	23.0	30.7	32.9	33.7	30.6	28.9	24.6	32.8	33.8	33.8	31.5	30.3	26.5	33.3	34.5
10	17.8	12.5	7.7	9.3	23.2	27.5	24.8	18.6	14.5	18.9	31.4	30.3	31.7	31.5	31.2	31.1	31.5	31.7
15	18.3	12.1	7.2	9.6	11.2	25.3	24.5	18.3	11.6	11.7	12.5	19.1	31.3	30.6	29.6	27.6	27.8	31.4
20	17.4	11.6	7.1	8.4	10.3	12.7	24.3	18.1	10.9	10.9	11.1	14.6	31.2	30.0	29.4	27.1	28.5	29.6
25	18.3	14.1	6.1	7.3	9.3	9.8	24.2	17.9	11.3	10.5	10.6	12.5	31.0	29.8	29.4	26.7	27.2	27.7
30	18.1	14.1	6.1	6.7	8.3	8.5	24.0	17.7	11.7	10.2	9.3	9.2	30.8	29.6	29.3	26.1	25.0	24.9
35	18.2	15.1	6.7	5.8	6.2	6.7	23.8	17.6	11.8	9.8	8.5	8.6	30.5	29.2	29.2	25.9	24.1	23.2
40	18.5	15.4	6.9	4.4	4.9	4.2	23.6	17.5	13.5	8.5	7.9	5.8	30.1	29.0	28.9	25.8	23.0	22.4
45	19.1	16.1	7.5	3.5	3.2	2.6	23.5	17.4	13.0	7.9	7.1	3.6	30.2	28.9	28.5	24.7	22.3	20.9
50	19.3	16.6	7.5	1.8	2.3	1.1	23.3	17.1	13.8	7.2	5.0	3.0	29.9	28.0	28.4	23.1	20.8	19.4
55	19.3	17.2	8.1	0.3	1.6	0.3	23.2	16.7	14.2	8.3	3.1	2.3	30.3	29.2	28.1	21.9	18.5	17.9
60	19.3	17.5	8.8	-0.1	0.5	-0.5	23.1	16.5	14.3	9.0	2.7	1.5	30.5	29.2	28.5	19.7	16.1	14.3
90	20.3	18.6	9.2	1.5	0.9	-1.2	24.4	16.8	15.6	10.0	1.7	0.4	30.8	29.2	27.8	18.2	15.1	13.7
120	20.7	19.3	9.6	3.6	1.1	-1.6	25.0	17.3	16.1	10.2	0.6	-1.1	30.8	29.4	26.8	20.1	17.7	15.1
150	21.1	19.6	11.0	7.1	1.6	-1.1	26.4	21.3	17.6	11.5	3.8	0.4	31.1	29.8	26.5	20.8	18.7	16.2
180	22.5	20.3	12.8	9.2	2.2	-0.9	27.3	22.5	19.1	13.5	5.1	0.5	31.3	30.0	27.8	21.9	19.2	17.0
210	23.8	21.1	14.7	11.3	4.9	-0.4	28.0	23.5	20.5	15.5	7.7	1.7	31.5	30.4	29.8	24.7	20.8	17.7
240	25.7	22.1	16.6	14.4	6.1	0.1	29.4	25.2	22.6	18.2	10.5	2.6	31.7	30.7	30.3	24.9	22.5	18.3
270	26.1	23.0	18.8	16.0	7.6	0.6	29.6	25.5	23.4	19.5	12.3	1.8	31.9	31.4	30.5	25.9	23.0	18.9
300	26.3	23.4	19.4	17.0	8.7	1.6	29.7	25.8	23.7	20.0	13.9	5.1	32.5	31.7	30.9	27.8	26.3	21.1
310	26.8	24.1	20.7	18.8	9.8	2.5	29.9	26.3	24.8	21.7	16.2	9.9	32.9	32.5	31.3	29.0	26.9	21.8

Table A12: Temperatures Data of Surrounding Temperature of 30^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	28.5	27.2	25.7	24.5	26.9	29.4	28.7	27.7	25.8	25.2	27.8	29.6	29.5	29.2	27.4	26.4	30.6	30.9
10	27.1	22.1	21.7	18.9	23.5	24.3	25.4	23.6	20.2	20.7	24.3	24.9	24.4	26.7	25.3	24.4	26.8	29.6
15	25.2	23.6	19.8	18.1	20.4	21.1	24.9	23.2	19.3	19.5	21.6	26.2	29.3	28.2	26.1	24.6	29.5	30.8
20	20.9	18.8	14.9	13.0	15.1	16.3	23.9	22.7	18.1	16.1	18.7	18.2	29.2	28.1	25.3	24.4	28.3	29.2
25	18.7	16.3	11.4	11.9	8.9	7.3	22.8	21.4	17.9	14.6	10.0	16.0	29.1	27.8	25.2	24.1	26.8	28.9
30	16.4	14.8	6.1	9.6	5.3	4.6	21.8	20.3	14.1	12.2	7.4	13.1	29.1	27.8	24.9	23.4	25.2	25.9
35	15.3	13.8	4.3	8.7	3.1	1.8	20.3	18.2	10.2	9.0	6.3	10.5	29.0	27.7	24.7	22.5	23.3	24.0
40	14.3	11.1	3.6	5.9	1.0	0.4	20.8	16.1	8.4	7.7	4.1	6.1	28.9	27.4	24.5	21.2	21.6	23.5
45	13.1	10.8	2.3	3.0	0.3	-1.8	19.3	14.1	6.7	4.6	2.8	1.8	28.8	26.1	24.3	20.0	20.6	22.0
50	14.7	12.0	3.0	2.1	-0.3	-1.9	18.6	13.3	4.9	2.3	1.9	1.1	28.0	25.2	24.0	19.0	18.8	19.3
55	15.4	13.3	3.2	0.5	-1.0	-2.0	17.5	14.3	4.2	1.9	0.7	-0.4	27.5	24.8	23.7	17.6	17.2	16.5
60	17.8	14.8	4.5	1.2	-1.3	-3.1	18.8	15.2	5.1	2.1	-0.3	-2.7	26.4	24.6	23.2	16.3	15.8	15.3
90	18.6	15.7	8.5	2.9	-2.4	-3.4	19.8	16.6	8.8	0.6	-1.9	-2.9	25.6	23.8	20.7	14.7	13.6	13.3
120	19.5	16.4	9.8	3.9	-2.6	-3.8	20.7	17.1	10.8	1.8	-1.1	-3.2	26.2	24.3	22.8	16.7	14.6	13.6
150	19.9	17.6	13.1	4.5	-2.1	-4.4	20.9	18.7	12.6	3.8	-1.4	-3.6	26.5	24.5	23.9	18.0	16.3	12.4
180	20.4	19.9	14.8	5.7	-1.0	-2.8	21.9	17.9	14.1	5.2	-1.6	-3.9	27.3	25.8	24.2	18.7	17.2	13.0
210	21.1	20.2	15.4	8.7	1.1	-1.8	22.2	18.2	15.5	6.2	0.1	-2.2	27.6	26.1	24.5	20.4	17.6	12.9
240	22.8	21.2	16.4	10.1	4.8	-0.9	23.5	19.4	16.8	9.4	2.2	-1.1	27.8	25.4	24.7	22.0	18.6	13.4
270	23.4	21.9	17.8	11.8	5.2	0.0	24.2	20.9	18.4	11.5	5.9	0.4	27.9	25.7	24.9	22.7	19.5	14.9
300	24.1	22.2	18.2	12.4	6.8	1.1	24.6	21.5	19.8	13.7	8.4	1.4	28.0	26.2	25.2	23.3	20.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	23.5	20.6	15.0	10.6	3.1	28.2	26.4	25.4	23.9	21.9	17.4
360	25.5	23.4	20.8	14.8	8.9	3.7	26.0	24.9	21.2	17.8	12.4	6.9	28.6	26.7	25.8	24.9	23.0	18.8

Table A13: Temperatures Data of Surrounding Temperature of 25^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	25.2	24.9	24.9	24.7	25.0	25.6	24.6	25.1	25.3	24.9	25.0	25.6	25.6	25.5	25.6	25.7	25.6	25.7
5	15.7	12.2	12.0	13.4	22.6	23.0	23.0	15.3	13.2	16.7	24.5	24.7	25.0	23.3	23.7	23.4	25.3	25.2
10	11.4	6.6	4.8	7.5	18.1	22.1	20.4	13.6	12.6	14.4	22.5	24.3	23.8	21.2	20.6	21.2	24.6	24.5
15	8.7	4.7	1.5	6.0	19.8	20.8	19.8	13.3	12.2	13.5	20.1	21.8	22.5	20.2	19.6	19.5	22.8	23.6
20	8.3	4.8	1.3	5.4	15.9	17.0	19.7	12.9	12.0	13.1	16.4	17.4	22.4	20.0	19.3	19.2	20.9	22.1
25	9.0	5.1	1.0	4.3	5.1	5.3	19.8	12.7	11.5	10.4	9.8	7.3	22.3	19.8	19.1	19.0	20.0	20.9
30	9.3	5.3	0.8	2.6	3.0	3.5	19.6	12.7	11.4	9.5	8.3	5.5	22.2	19.7	19.0	18.6	19.3	19.7
35	9.5	5.6	0.1	0.9	1.9	1.8	19.3	12.5	10.8	8.9	6.5	3.1	22.1	19.6	19.0	18.3	18.1	18.2
40	9.7	5.8	-0.6	-0.5	0.4	0.3	19.2	12.5	10.7	7.5	3.2	1.5	22.0	19.5	18.8	17.9	17.6	16.8
45	10.1	6.1	-0.7	-0.7	-0.4	-1.0	19.2	12.1	10.5	6.3	2.1	1.0	21.9	19.4	18.7	17.6	17.3	15.5
50	10.3	6.4	-1.2	-2.0	-1.6	-2.1	19.1	12.0	10.1	5.8	1.2	0.1	21.7	19.4	18.6	17.5	16.9	14.1
55	10.6	6.5	-1.7	-3.1	-2.6	-3.4	18.9	11.9	9.7	5.1	0.6	-2.2	21.6	19.2	18.6	16.3	14.3	12.6
60	10.7	6.6	-2.4	-4.6	-4.0	-4.6	18.0	10.7	8.6	4.6	-0.1	-3.0	21.4	19.0	18.5	14.7	11.5	9.8
90	11.1	7.2	-1.7	-6.0	-5.3	-7.2	17.4	9.8	7.2	1.9	-2.3	-4.1	20.3	18.8	17.4	13.0	9.3	6.3
120	11.4	8.1	0.4	-4.0	-5.1	-7.4	17.7	11.1	6.5	-0.9	-4.0	-5.2	21.2	19.0	18.9	12.7	8.5	6.1
150	13.2	9.4	3.4	-1.7	-5.3	-6.9	18.9	13.1	9.2	4.1	-2.9	-4.7	21.3	19.1	19.2	11.9	9.9	6.9
180	14.8	10.7	5.6	2.2	-3.7	-6.0	19.1	15.5	10.9	6.2	-1.5	-3.9	21.8	20.5	19.5	13.2	10.4	7.2
210	14.7	10.8	6.9	3.9	-2.5	-5.2	19.5	17.7	12.0	8.1	0.0	-2.8	22.0	20.6	20.1	14.2	11.4	8.5
240	15.9	11.8	8.3	5.7	0.4	-4.2	20.7	18.5	13.7	9.4	2.2	-1.8	22.2	20.9	20.4	15.4	12.7	9.0
270	16.4	13.3	10.3	6.7	2.0	-3.4	21.3	19.1	13.9	9.8	3.8	-0.5	22.4	21.1	20.5	16.0	13.8	10.6
300	16.7	14.0	12.9	8.0	2.2	-3.1	21.5	19.5	14.2	11.0	5.2	0.0	22.7	21.3	20.8	17.5	14.7	11.8
330	19.7	16.5	14.3	10.6	5.0	-2.8	21.7	16.7	15.3	12.5	6.9	1.0	22.9	21.5	21.2	18.5	15.0	12.1
360	21.8	18.5	16.1	12.6	6.3	-1.2	22.3	19.3	16.8	13.2	8.1	2.3	23.2	21.8	21.4	18.7	16.0	13.0
390	22.7	20.3	17.3	14.0	7.0	-0.2	23.1	20.8	17.7	14.6	9.4	3.1	23.6	22.1	22.1	19.3	16.7	14.6
420	24.3	21.3	19.5	15.8	9.8	1.0	24.5	21.9	19.9	16.8	11.9	4.7	24.8	22.7	22.4	20.1	17.6	16.3

Table A14: Temperatures Data of Surrounding Temperature of 20^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	19.8	19.8	19.6	19.5	20.0	20.4	19.4	19.9	20.0	19.8	20.0	20.6	20.7	20.3	20.6	20.7	20.5	20.4
5	10.4	7.2	5.2	7.9	16.7	18.1	15.1	9.3	4.5	8.8	19.9	19.6	19.2	17.5	16.8	16.4	19.8	19.1
10	7.5	3.1	1.1	3.3	15.6	17.4	13.7	7.3	2.6	6.2	18.4	19.5	18.1	16.1	15.2	13.4	19.0	19.0
15	6.0	1.9	0.4	2.7	9.9	15.0	12.5	6.3	2.0	4.2	2.6	16.2	17.4	15.0	14.1	12.6	17.7	18.8
20	5.3	1.5	-0.6	1.4	8.1	11.8	13.0	5.9	1.8	2.9	2.8	13.1	17.2	14.9	13.3	12.4	16.3	18.1
25	6.7	2.3	-1.2	0.6	1.8	1.8	12.8	5.4	1.6	1.5	3.5	3.4	17.0	14.7	13.1	12.1	15.4	16.4
30	7.0	2.7	-1.9	-1.4	0.6	-0.7	12.7	5.1	1.4	0.4	1.4	1.3	16.9	14.7	12.6	11.6	14.7	15.7
35	7.0	3.1	-2.7	-2.4	-1.1	-2.4	12.3	5.0	1.3	-0.9	-0.5	-0.4	16.6	14.5	12.5	10.8	14.0	15.0
40	7.0	3.2	-3.4	-3.0	-2.9	-4.0	12.2	4.8	1.0	-1.2	-1.5	-2.0	16.5	14.4	12.2	9.8	11.9	12.6
45	7.3	3.4	-3.9	-4.0	-3.1	-5.2	12.2	5.1	0.9	-1.8	-2.2	-3.4	16.5	14.3	11.9	9.6	10.7	10.3
50	7.2	3.5	-4.2	-5.1	-5.4	-6.4	12.3	5.4	1.1	-2.2	-3.1	-4.4	16.3	14.2	12.4	9.3	9.5	8.8
55	7.4	3.9	-4.3	-6.4	-6.4	-7.2	12.4	5.9	1.3	-2.4	-3.6	-5.2	16.2	14.0	12.8	9.1	8.3	7.1
60	7.3	4.3	-4.3	-7.0	-6.8	-8.0	12.5	6.3	1.4	-2.9	-3.8	-6.1	16.1	14.1	13.1	9.0	7.3	5.6
90	7.8	4.5	-2.9	-8.0	-7.9	-10.3	12.7	6.9	2.8	-3.6	-4.2	-7.9	16.0	14.3	13.3	8.9	6.3	4.2
120	8.1	5.3	-1.6	-6.2	-7.6	-10.2	13.9	7.6	3.9	-3.9	-6.4	-9.3	15.9	14.4	13.4	8.8	4.9	3.9
150	10.0	6.0	1.2	-2.7	-6.9	-10.4	14.1	9.4	6.1	1.1	-5.7	-8.1	16.2	14.6	13.6	8.3	4.5	3.0
180	10.5	7.7	3.1	-0.8	-5.6	-9.4	14.4	10.8	7.4	3.5	-4.9	-6.8	16.6	15.0	13.8	9.8	7.4	5.4
210	11.5	8.2	4.4	0.1	-4.1	-8.1	15.5	11.3	9.1	5.2	-3.1	-5.7	16.7	15.1	14.5	10.7	7.8	6.2
240	12.0	9.2	5.3	2.4	-2.9	-7.4	15.7	11.8	9.7	6.3	-1.6	-4.9	16.8	15.3	15.1	11.1	8.1	6.6
270	13.2	10.2	6.5	3.4	-1.5	-6.3	15.8	12.4	10.2	7.2	-0.2	-3.4	17.0	15.5	15.3	12.9	9.1	7.2
300	14.9	11.3	9.2	6.0	0.1	-5.4	16.5	12.8	11.2	8.5	1.1	-2.5	17.1	15.7	15.5	13.3	10.3	7.5
330	15.3	12.9	10.8	7.9	1.8	-4.9	16.6	13.0	11.7	9.4	2.1	-2.1	17.3	15.9	15.6	13.8	10.8	7.7
360	15.8	13.2	12.9	8.1	2.7	-3.4	16.9	13.3	12.4	10.2	3.5	-0.8	17.4	16.2	15.9	14.0	11.5	9.1
390	16.3	14.5	13.3	8.2	1.0	-3.3	16.4	13.6	12.2	10.3	4.6	0.1	17.5	16.3	16.1	15.2	12.0	10.1
420	16.8	15.7	13.8	8.9	2.1	-2.7	16.9	13.8	12.7	11.0	6.6	1.9	17.8	16.4	16.4	15.5	13.1	11.5
450	17.6	16.2	14.6	9.7	4.3	-1.4	17.1	14.4	13.3	11.8	7.7	2.1	17.8	16.5	16.5	13.8	13.6	12.3
470	18.7	17.7	14.9	10.8	5.9	0.1	17.7	14.9	14.1	12.7	9.4	3.9	18.9	18.2	16.8	15.1	14.0	13.6

Table A15: Temperatures Data of Surrounding Temperature of 15^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	14.4	14.7	14.3	14.4	15	15.2	14.2	14.7	14.7	14.6	15.0	15.6	15.7	15.1	15.6	15.7	15.4	15.0
5	3.8	1.4	-0.2	2.9	13.7	13.9	9.4	3.7	2.3	3.5	14.9	15.5	14.3	12.5	13.2	12.4	15.0	13.9
10	1.0	-2.6	-8.5	-5.9	10.7	13.4	7.2	-0.8	-6.0	-3.2	12.4	14.7	13.2	10.8	10.1	9.7	14.4	13.8
15	-0.6	-4.6	-9.7	-7.2	6.7	9.9	5.8	-2.4	-7.6	-5.8	10.6	11.4	12.2	10.7	9.3	9.2	13.3	13.4
20	-2.4	-5.4	-9.6	-7.7	4.1	6.1	5.3	-3.0	-8.4	-6.1	6.5	7.4	11.7	10.5	9.0	8.7	12.0	12.5
25	-2.2	-6.4	-8.9	-8.1	1.9	3.3	5.4	-2.3	-6.7	-6.7	-5.8	-4.9	11.6	10.2	8.9	8.4	9.3	9.8
30	-1.4	-5.6	-8.2	-7.9	-4.5	-5.6	5.9	-0.8	-6.3	-7.1	-6.0	-5.7	11.5	10.0	8.6	8.0	7.8	8.6
35	-0.6	-4.4	-7.5	-7.9	-6.9	-6.4	5.8	-0.6	-5.9	-7.5	-6.5	-6.5	11.2	9.9	8.6	7.8	6.9	6.5
40	-0.1	-3.5	-7.2	-9.2	-7.7	-9.1	5.8	-0.5	-5.5	-7.7	-7.1	-7.3	11.1	9.8	8.7	7.7	6.8	5.0
45	0.4	-3.4	-6.9	-9.9	-9.7	-10.3	5.6	-0.7	-5.0	-8.9	-8.2	-8.5	11.0	9.7	8.8	7.6	6.5	4.7
50	0.7	-3.3	-6.6	-10.7	-10.9	-11.7	5.8	-0.4	-4.7	-9.7	-8.9	-9.4	10.9	9.6	9.0	7.5	6.4	4.5
55	0.9	-3.1	-6.4	-11.3	-10.3	-12.1	5.8	-0.5	-4.5	-10.3	-9.2	-10.1	10.7	9.5	9.1	7.2	6.0	4.1
60	1.3	-3.1	-5.7	-11.5	-11.1	-12.6	5.9	-0.3	-4.3	-10.9	-10.0	-11.3	10.5	9.7	9.1	7.0	5.8	3.9
90	2.1	-2.5	-5.1	-9.5	-12.3	-13.3	6.8	1.1	-2.6	-9.3	-10.6	-11.6	10.1	9.7	8.3	6.4	5.2	3.4
120	2.6	-1.3	-5.9	-9.1	-9.9	-13.0	7.2	2.1	-1.8	-6.3	-8.2	-11.8	11.1	9.9	8.4	6.2	4.3	2.2
150	3.1	0.4	-4.3	-6.5	-8.4	-12.5	7.4	4.6	-0.8	-5.4	-7.8	-10.7	11.3	10.3	9.1	7.3	4.4	2.4
180	5.1	1.7	-3.1	-5.9	-7.6	-11.0	8.2	6.8	2.8	-3.7	-6.7	-9.6	11.5	10.0	9.8	8.4	6.5	4.5
210	6.9	3.4	-1.3	-3.5	-6.7	-9.9	8.9	7.9	4.4	-2.6	-5.7	-8.6	11.8	10.3	9.9	8.7	6.6	4.6
240	7.9	3.9	2.4	-1.6	-4.1	-8.4	9.6	8.9	5.7	-0.5	-3.9	-7.3	11.9	10.5	10.2	9.1	6.7	4.7
270	8.2	5.5	4.1	-0.5	-3.3	-7.8	10.7	9.1	6.3	1.4	-2.3	-5.8	12.1	10.7	10.5	9.5	6.8	4.9
300	10.8	8.4	6.1	0.8	-1.0	-6.5	11.5	9.3	7.1	2.4	-0.3	-4.7	12.4	10.9	10.7	9.8	6.9	5.2
330	11.2	9.1	7.9	3.8	0.3	-6.3	11.7	9.7	8.7	4.5	-0.9	-3.2	12.6	11.1	11.0	8.7	7.0	5.5
360	11.4	9.5	9.4	5.9	1.4	-4.6	11.9	10.1	9.7	6.3	2.3	-1.3	12.7	11.6	11.2	9.1	7.2	5.8
390	12.7	10.8	10.3	6.7	3.0	-2.1	13.1	11.8	10.7	7.4	5.4	0.0	13.9	12.6	11.7	9.6	7.7	6.2
420	12.8	11.2	10.8	8.0	4.7	-0.8	13.5	12.2	11.3	8.7	6.4	3.1	14.1	13.2	12.5	9.9	8.3	6.9
450	13.1	12.5	11.6	10.2	6.5	2.6	13.8	13.1	12.1	11.8	8.8	5.7	14.3	13.9	12.9	10.2	9.3	7.3

Table A16: Temperatures Data of Surrounding Temperature of 10^{o}C for Composition of 4060, Flowrate of 48 Liter per Minute and Weight 6 kg

Time	Internal Probe (Celcius)						Inside Wall Probe (Celcius)						Outside Wall Probe (Celcius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	10.0	10.6	10.0	10.3	10.0	10.1	10.0	10.5	10.4	10.5	10.0	10.6	10.7	10.0	10.5	10.6	10.3	10.6
5	4.8	2.4	1.8	3.8	8.0	9.5	8.7	4.4	2.7	4.7	9.0	10.4	9.6	8.7	9.1	9.5	9.6	9.8
10	0.3	-2.2	-4.1	4.6	6.9	8.1	7.1	1.5	-1.8	-1.7	7.3	8.9	9.3	8.3	7.1	8.1	9.0	9.6
15	-2.3	-2.6	-4.5	1.9	4.0	4.1	6.8	-0.9	-2.3	-2.2	5.2	6.8	8.9	8.0	7.2	8.2	8.1	7.6
20	-3.0	-2.7	-4.9	-0.4	0.7	2.8	5.1	-2.4	-2.7	1.1	3.0	5.0	8.7	7.8	6.0	7.7	8.2	7.6
25	-2.2	-2.9	-5.1	-1.6	0.0	0.2	4.5	-2.7	-3.2	-2.3	1.5	2.7	8.6	7.8	5.6	7.6	6.1	5.7
30	-1.7	-3.1	-4.6	-4.9	-3.2	-2.9	4.1	-3.0	-3.3	-3.1	-2.0	-0.8	8.5	7.6	5.3	7.4	5.8	4.6
35	-0.4	-3.3	-6.4	-5.2	-4.9	-4.8	3.9	-2.0	-3.7	-3.5	-3.7	-1.3	8.3	7.4	5.1	7.1	5.7	3.7
40	0.0	-3.5	-6.6	-5.4	-5.5	-6.0	3.5	-1.4	-3.4	-4.5	-4.7	-3.9	8.0	7.2	5.6	6.9	5.6	3.5
45	0.4	-3.6	-6.8	-8.5	-8.7	-8.0	3.3	0.5	-3.6	-5.7	-5.5	-5.5	8.1	6.7	5.7	6.6	5.5	3.2
50	0.7	-3.8	-7.0	-9.9	-9.9	-10.5	3.0	1.1	-3.5	-5.8	-6.9	-7.5	8.2	7.0	6.5	6.4	5.3	3.0
55	1.0	-3.9	-7.2	-11.0	-11.7	-12.8	2.8	1.4	-3.9	-6.3	-7.8	-9.5	8.3	7.2	6.4	6.3	5.2	2.9
60	1.3	-4.1	-7.5	-12.7	-12.5	-14.1	2.7	1.4	-4.1	-7.0	-8.9	-10.1	8.5	7.5	6.4	6.2	5.0	2.6
90	1.5	-4.5	-7.0	-10.2	-13.9	-14.7	2.6	1.5	-3.4	-7.7	-9.6	-12.8	8.7	7.7	6.2	5.1	4.7	2.2
120	1.9	-4.8	-6.8	-10.9	-12.4	-14.4	3.6	1.7	-4.7	-8.5	-11.1	-13.2	8.8	7.9	6.4	4.7	3.1	1.4
150	2.3	-3.1	-6.1	-8.6	-10.3	-13.8	4.7	2.2	-2.9	-7.8	-9.8	-12.1	8.9	8.1	7.8	5.9	2.9	1.2
180	2.5	-1.5	-5.4	-7.8	-9.3	-12.4	5.2	3.6	-1.2	-5.5	-8.5	-11.2	9.1	8.3	7.9	6.8	4.7	2.3
210	3.6	0.5	-4.2	-5.6	-8.5	-11.8	7.5	6.6	1.4	-3.3	-7.6	-9.9	9.3	8.6	8.1	7.3	5.6	2.5
240	4.7	1.1	-0.1	-3.2	-6.2	-10.9	7.4	6.8	2.3	-1.9	-6.9	-8.2	9.5	8.7	8.0	7.7	5.9	2.9
270	6.1	3.7	1.5	-2.4	-5.9	-8.9	7.5	7.0	3.4	0.4	-4.3	-6.6	9.5	8.8	8.1	7.9	6.1	3.5
300	7.6	6.4	3.2	-1.1	-3.4	-7.5	7.8	7.4	4.8	1.6	-3.6	-5.5	9.6	8.9	8.3	8.1	6.6	4.1
330	8.1	7.2	4.1	-0.1	-2.9	-6.2	8.2	7.8	5.0	2.4	-1.8	-4.1	9.7	9.1	8.5	8.3	6.9	4.5
360	8.5	7.8	5.7	3.2	0.9	-3.2	8.9	8.1	6.5	3.9	-0.6	-2.5	9.8	9.2	8.9	8.6	7.2	5.0
390	8.6	8.2	6.0	4.6	3.1	1.4	9.1	8.5	7.6	6.4	4.6	2.3	9.8	9.4	9.1	8.9	7.8	6.4

Table A17: Temperatures Data of Weight 7 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	26.7	24.0	18.4	20.1	27.2	29.5	27.2	25.5	20.9	23.0	28.1	29.9	26.4	23.3	20.4	22.9	28.8	29.1
10	18.5	13.7	8.1	10.3	23.4	29.3	22.9	18.9	12.5	14.8	27.9	29.5	23.3	20.3	14.2	15.8	28.4	29.2
15	17.4	12.3	7.8	12.3	16.4	20.4	20.2	15.6	12.6	13.3	14.6	23.8	24.5	19.7	13.5	15.2	26.4	29.0
20	16.9	11.7	7.6	10.3	12.7	13.7	18.0	14.1	12.1	12.2	12.8	14.6	24.3	19.5	12.7	15.0	24.9	26.8
25	16.4	11.2	6.9	7.1	8.4	10.3	17.5	13.6	10.9	10.1	10.6	11.9	24.0	19.3	11.9	14.8	23.7	25.7
30	16.1	11.1	6.3	6.1	7.3	8.1	17.3	12.2	8.6	7.8	7.7	8.2	23.9	18.7	12.5	14.6	22.8	25.0
35	15.9	10.3	6.0	5.0	6.6	7.3	17.1	11.8	7.9	6.1	6.3	6.4	23.6	18.4	12.9	14.5	21.7	22.2
40	15.5	9.7	5.9	5.5	5.0	5.6	15.7	10.6	7.5	5.5	4.3	3.7	23.5	18.0	13.2	14.2	21.3	21.5
45	15.3	9.4	5.5	5.0	3.7	3.3	15.5	8.1	6.8	4.7	2.1	2.4	23.1	18.2	13.8	14.0	17.7	18.6
50	14.8	9.3	5.3	4.6	2.8	2.5	15.3	7.9	6.3	3.4	1.2	1.0	22.7	18.3	14.2	13.9	17.2	18.0
55	14.6	9.0	5.2	4.0	1.8	1.4	15.2	7.7	5.9	2.7	0.7	0.3	21.6	18.5	14.5	13.7	16.9	17.4
60	14.4	8.3	4.9	3.4	0.6	-0.7	15.0	7.5	5.4	3.5	1.2	0.8	20.8	18.7	14.8	13.8	16.2	16.2
90	13.6	6.9	4.8	2.6	-1.5	-2.6	14.2	7.3	5.2	2.9	-1.0	-2.1	21.4	19.9	15.9	13.4	15.8	15.3
120	14.5	6.1	3.4	0.9	-2.5	-3.1	15.1	6.7	3.9	1.6	-2.0	-2.6	22.1	21.2	16.7	13.1	12.9	12.3
150	16.2	5.2	2.7	-0.6	-3.6	-4.2	16.7	5.8	3.3	-0.1	-3.0	-3.8	22.5	21.5	17.1	14.1	12.1	11.4
180	17.7	4.7	2.2	-2.5	-4.1	-4.8	18.1	5.2	2.7	-2.1	-3.7	-4.3	23.7	22.1	18.3	15.3	11.4	10.2
210	18.7	5.5	1.3	-3.8	-4.7	-5.3	19.2	5.9	1.9	-2.7	-4.2	-4.8	23.9	23.2	19.9	15.8	10.6	9.6
240	19.6	6.7	1.8	-4.5	-5.2	-5.9	20.1	7.2	2.3	-3.9	-4.8	-5.3	25.8	25.5	23.1	18.2	9.7	8.6
270	20.4	8.2	2.6	-3.6	-6.1	-6.4	20.8	8.8	3.1	-3.2	-5.7	-6.1	27.3	26.1	24.8	20.8	9.2	8.1
300	23.4	10.8	4.1	-1.3	-4.1	-5.8	23.9	11.3	4.7	-0.8	-3.6	-5.3	27.8	26.8	25.1	21.2	8.4	7.6
330	24.6	12.4	5.8	2.4	-2.4	-4.6	25.1	12.8	6.2	2.9	-2.0	-4.1	28.1	26.1	25.7	22.2	11.4	9.7
360	25.4	22.3	16.1	9.7	5.9	0.3	25.9	23.9	17.6	10.4	6.6	1.5	28.5	27.4	26.5	23.5	19.4	14.1
385	26.9	24.7	19.7	17.5	14.9	7.9	27.1	25.9	24.1	19.9	15.3	9.7	29.3	28.2	27.0	25.2	21.7	18.4

Table A18: Temperatures Data of Weight 6 kg for Surrounding Temperature of 30°C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	28.5	27.2	20.7	24.5	26.9	29.4	28.7	27.7	21.8	25.2	27.8	29.6	29.5	28.2	23.4	26.4	28.6	29.8
10	19.5	15.1	12.7	14.9	24.5	26.3	23.1	18.6	13.2	15.8	25.3	28.9	23.9	19.7	14.3	16.4	26.8	29.2
15	18.2	14.6	11.2	12.5	18.4	21.1	22.9	23.2	12.3	13.5	19.6	22.2	23.7	24.2	13.1	14.6	20.5	26.8
20	17.9	14.0	9.9	10.4	15.1	16.3	22.3	22.7	10.5	11.1	16.7	17.2	23.5	28.1	11.3	13.4	18.3	23.2
25	17.7	13.8	9.4	9.1	8.9	9.3	21.5	21.4	10.0	10.6	9.8	11.0	23.3	22.2	11.0	12.9	15.8	21.9
30	17.4	13.3	9.1	9.0	6.3	7.6	21.0	20.3	9.7	10.2	7.4	8.1	23.1	21.1	10.7	11.6	13.2	18.9
35	17.3	13.0	8.8	8.7	5.1	5.8	20.8	18.2	9.2	9.0	6.3	6.5	23.0	19.3	10.3	11.2	12.8	16.0
40	17.0	12.8	8.3	6.9	3.0	3.4	20.3	17.1	8.9	7.7	4.1	4.1	22.9	18.2	9.8	10.6	11.4	13.5
45	16.8	12.6	8.0	5.0	2.3	1.8	19.3	16.1	8.7	5.6	2.8	2.2	22.7	17.1	9.6	10.2	10.0	11.0
50	16.7	12.4	7.8	4.1	1.3	0.9	18.6	15.3	8.3	5.3	1.9	1.1	22.5	16.4	9.2	10.0	9.6	10.3
55	16.4	12.0	7.7	3.5	0.6	-0.7	18.5	14.3	8.0	3.9	0.7	-0.4	22.2	15.1	9.0	9.6	9.2	9.5
60	16.3	11.8	7.5	2.0	-0.3	-1.1	18.0	13.2	7.9	2.7	0.5	-0.9	22.0	14.4	8.8	9.3	8.8	8.3
90	15.5	12.6	8.9	1.3	-2.3	-3.4	16.8	13.7	9.4	1.6	-1.9	-2.9	25.6	14.9	10.1	8.7	8.5	8.2
120	16.5	13.4	9.8	0.3	-2.8	-3.8	17.5	14.5	10.6	0.8	-2.1	-3.2	26.2	15.3	10.9	9.7	8.1	7.6
150	17.9	14.1	10.7	-1.4	-3.8	-4.8	20.9	14.7	11.6	-1.1	-3.3	-4.1	26.5	15.9	12.2	11.0	9.3	7.4
180	18.9	15.6	11.1	0.1	-4.9	-5.4	21.9	16.9	12.1	0.6	-4.1	-4.9	27.3	17.7	12.9	11.7	10.2	8.0
210	21.1	16.2	12.4	3.2	-4.2	-5.8	22.2	17.8	13.5	3.9	-3.8	-5.2	27.6	18.5	14.3	13.4	11.6	8.9
240	22.8	18.2	15.4	7.1	-3.7	-6.4	23.5	18.7	16.8	7.7	-3.1	-6.0	27.8	19.4	17.7	16.1	12.6	10.4
270	23.4	19.9	17.8	9.8	-2.1	-5.5	24.2	20.5	18.4	10.5	-1.7	-4.9	27.9	21.2	19.9	18.7	14.5	11.9
300	24.1	20.2	18.2	11.4	-0.2	-2.7	24.6	20.8	19.8	11.7	0.4	-2.1	28.0	21.8	20.8	20.3	17.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	22.9	20.6	14.0	8.6	3.1	28.2	23.4	21.5	20.9	19.9	17.4
360	25.5	23.4	20.8	14.8	8.9	5.7	26.0	23.9	21.2	15.8	12.4	9.5	28.6	24.7	23.1	21.9	20.0	18.8

Table A19: Temperatures Data of Weight 5 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.2	19.1	13.6	15.2	25.3	28.1	25.0	23.1	22.0	23.9	26.1	30.0	28.6	28.2	28.0	27.1	29.2	31.0
10	21.1	16.5	10.1	11.8	18.3	24.1	23.6	19.7	17.1	15.2	22.1	27.0	25.5	21.9	18.6	16.8	26.1	28.1
15	20.1	17.7	12.3	12.1	14.3	16.2	23.8	19.5	16.3	15.0	16.5	17.2	25.0	21.6	17.2	16.2	20.9	23.3
20	19.9	17.5	12.1	10.5	10.1	11.9	23.3	19.1	13.9	13.4	12.1	13.4	24.8	21.3	17.0	15.7	18.3	21.1
25	19.7	17.4	11.1	7.7	8.3	9.2	23.0	18.7	13.1	10.7	9.4	10.8	24.7	20.9	16.7	14.5	17.4	19.4
30	19.5	16.7	10.7	4.8	5.1	5.8	22.7	18.5	11.6	7.2	6.7	8.4	24.6	20.3	16.5	13.9	15.9	16.3
35	19.3	16.3	9.9	4.1	4.2	4.9	22.3	18.0	10.7	5.4	5.3	6.5	24.2	19.9	16.6	13.3	14.0	15.4
40	19.1	16.0	9.4	2.9	3.2	2.2	22.1	17.8	10.4	4.7	4.8	4.8	24.1	19.5	16.8	13.0	13.3	14.9
45	19.0	15.8	9.0	2.1	2.1	1.7	21.8	17.5	10.3	3.4	3.4	3.4	23.8	19.2	17.1	14.2	13.0	14.5
50	20.3	15.6	8.8	1.3	1.0	0.7	21.6	17.3	9.8	3.2	2.4	2.3	23.7	20.0	17.7	14.8	12.9	14.1
55	20.1	15.2	8.7	1.0	0.4	-0.2	21.5	16.9	9.7	2.1	1.3	1.4	23.0	20.3	17.9	15.0	12.7	13.8
60	18.8	13.5	8.7	0.2	-1.2	-2.5	21.4	15.6	9.5	0.5	-0.8	-1.9	23.4	20.6	18.2	15.5	12.5	13.5
90	17.5	11.5	7.8	0.8	-2.9	-3.7	20.9	16.8	8.2	1.3	-2.2	-3.2	23.9	21.8	18.7	15.9	13.7	12.4
120	18.9	10.2	6.4	-0.6	-3.4	-4.2	21.7	17.0	7.5	-1.3	-3.7	-4.1	24.0	22.9	21.9	15.8	13.5	10.7
150	20.8	12.7	7.9	-2.0	-4.2	-5.3	22.3	17.9	8.8	-1.7	-3.6	-4.8	24.2	23.3	21.9	16.4	13.0	10.9
180	21.2	15.1	9.6	-3.9	-5.4	-6.3	23.1	19.0	10.7	-2.7	-4.7	-5.7	24.5	23.5	22.3	17.2	13.2	10.2
210	22.8	19.2	13.0	-1.1	-3.8	-6.2	23.3	20.2	13.5	-0.8	-3.1	-5.5	24.8	24.1	23.1	17.8	16.1	10.8
240	23.6	20.6	16.9	3.0	-1.8	-4.4	23.8	21.3	17.6	3.8	-0.9	-3.8	25.4	24.7	23.4	20.2	17.5	13.9
270	25.0	21.1	17.9	8.5	2.7	-1.1	24.8	22.6	18.9	9.9	3.5	-0.7	26.4	25.5	24.0	21.0	19.2	15.3
285	25.2	22.3	19.3	13.2	7.3	3.1	25.0	23.7	20.3	14.6	8.0	3.8	27.4	26.0	24.7	22.4	21.1	19.1

Table A20: Temperatures Data of Weight 4 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time (min)	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.7	20.7	18.4	15.5	26.8	27.4	28.8	21.5	21.2	16.3	27.1	29.8	27.2	26.9	26.8	24.4	27.0	28.7
10	22.5	18.8	15.2	12.4	15.7	20.3	24.3	20.9	15.6	12.8	16.9	21.5	25.8	22.9	20.4	19.5	22.5	26.7
15	21.3	16.1	10.4	9.8	10.8	18.7	22.1	17.3	14.9	10.3	11.2	21.0	24.5	21.6	19.9	19.1	20.0	27.7
20	20.8	15.5	10.0	8.1	8.9	10.8	21.7	16.2	12.7	8.8	10.0	12.7	24.1	21.1	18.6	17.8	19.2	24.7
25	20.6	15.3	9.1	6.8	6.2	8.0	21.6	15.8	11.0	7.2	7.9	9.9	23.9	20.5	17.7	17.4	18.1	22.8
30	20.3	15.1	8.9	5.5	5.8	6.7	21.3	15.6	9.7	5.9	6.7	7.8	23.5	20.1	17.2	16.8	17.3	20.9
35	19.8	14.9	8.6	4.9	4.0	5.7	21.6	15.7	9.4	5.0	5.3	6.2	23.2	19.8	16.9	16.5	16.5	18.7
40	19.5	14.7	8.0	3.0	2.3	2.8	21.8	16.3	9.0	4.5	3.7	3.3	23.1	19.4	16.6	16.4	14.6	16.3
45	19.2	14.9	7.4	2.5	1.9	-0.6	22.1	17.7	8.5	4.2	2.3	0.2	22.9	19.0	17.1	16.0	12.9	14.2
50	19.5	15.5	7.0	2.0	0.9	-1.2	22.3	17.5	8.1	3.7	1.9	-0.8	23.2	19.7	17.5	15.7	11.1	13.0
55	20.0	16.2	7.6	1.9	-1.1	-2.7	22.5	17.8	8.3	2.5	-0.6	-2.1	23.5	20.8	18.0	15.7	10.4	11.7
60	20.3	16.8	9.1	-0.3	-2.1	-3.5	22.6	18.4	11.8	0.7	-1.1	-2.8	23.8	21.6	18.5	15.9	9.2	9.1
90	21.6	17.2	9.8	-0.9	-3.5	-4.2	23.0	18.7	10.8	-0.1	-2.8	-3.7	24.4	22.3	19.2	16.8	8.6	8.1
120	21.9	18.6	10.8	-0.6	-3.4	-5.5	23.4	19.2	12.3	0.3	-2.7	-4.9	25.1	23.7	20.0	17.6	8.8	7.8
150	22.2	19.6	12.4	1.8	-4.8	-6.2	24.1	20.1	14.5	2.7	-3.7	-5.3	25.7	23.9	21.6	18.0	9.7	7.4
180	22.8	20.6	14.9	4.5	-4.2	-6.6	24.5	21.0	16.7	5.6	-3.1	-5.5	26.5	24.1	22.7	19.0	10.5	6.8
210	24.0	21.0	16.8	7.8	-2.8	-5.8	25.0	22.5	18.3	8.6	-2.0	-4.9	27.1	24.5	23.2	20.5	13.3	8.4
240	25.1	22.1	19.6	9.7	-1.8	-3.7	26.7	23.3	21.3	11.5	-0.9	-3.1	27.8	25.6	24.4	21.9	15.8	9.4

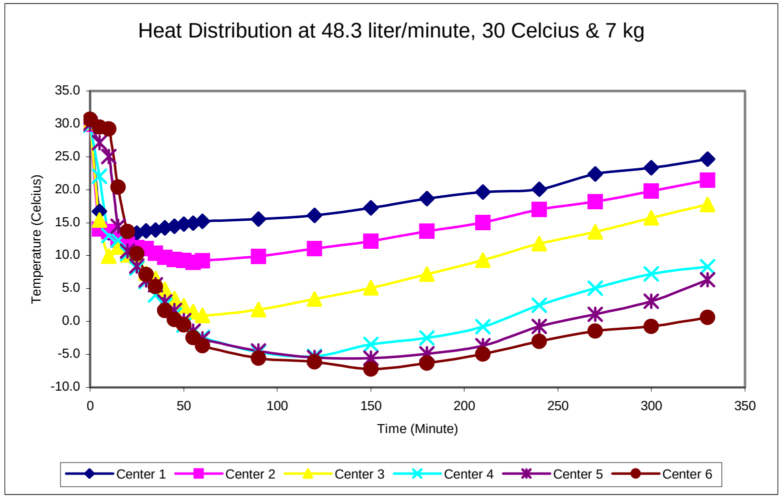
Table A21: Temperatures Data of Weight 3 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	24.3	20.7	19.4	16.5	17.4	28.7	25.3	21.1	20.1	18.2	18.1	29.1	28.2	27.2	26.1	25.2	23.5	22.0
10	23.9	19.9	17.8	14.1	13.9	18.5	24.3	20.5	18.2	15.6	14.3	19.4	27.8	24.5	21.9	19.7	18.6	21.3
15	23.7	18.6	16.2	13.0	12.2	15.5	24.1	19.2	16.8	13.3	12.8	15.9	26.5	23.0	20.5	18.7	16.9	18.0
20	23.1	17.5	15.9	11.5	8.2	10.2	23.7	18.3	16.3	11.8	8.7	10.9	26.0	22.4	19.6	17.0	14.4	16.8
25	22.9	17.3	14.3	10.5	4.3	4.9	23.5	18.1	15.1	10.9	4.8	5.3	25.7	21.1	19.0	17.8	13.2	14.1
30	22.2	17.0	13.0	8.1	1.8	1.2	23.1	17.8	13.5	8.6	2.3	1.6	25.3	21.7	19.2	18.1	12.4	13.7
35	21.9	16.8	12.3	7.2	0.4	-0.1	22.3	17.5	12.8	7.5	0.9	0.3	24.9	21.4	19.3	18.3	11.6	12.1
40	21.8	16.7	12.9	6.7	-0.7	-1.3	22.1	17.3	13.3	7.1	-0.1	-0.8	24.8	21.8	19.5	18.4	10.3	10.1
45	21.5	16.6	13.1	5.2	-1.7	-2.4	21.9	17.1	13.7	5.7	-1.1	-1.9	24.6	22.0	19.7	18.5	9.9	9.3
50	21.1	16.2	13.4	4.0	-2.6	-3.5	21.5	17.0	13.9	4.5	-2.1	-3.1	24.3	22.1	20.0	18.6	9.7	8.8
55	21.3	16.3	13.5	3.4	-2.6	-4.0	21.8	17.2	14.0	3.7	-2.3	-3.7	24.1	22.3	20.2	18.8	9.3	8.4
60	21.7	17.4	14.7	3.0	-2.9	-4.4	22.2	17.8	15.2	3.5	-2.4	-3.9	24.5	22.5	20.4	18.9	9.1	8.2
90	22.9	18.2	15.1	4.8	-4.3	-5.4	23.5	19.4	15.6	5.3	-3.9	-4.9	25.6	23.7	21.5	19.8	8.8	7.5
120	23.4	19.3	16.5	6.7	-4.7	-5.9	23.9	20.1	16.9	7.2	-4.1	-5.2	26.3	24.1	22.1	20.2	9.1	6.7
150	24.6	20.4	18.8	9.7	-5.9	-7.1	25.1	21.4	19.3	10.4	-5.3	-6.8	27.1	24.9	23.6	21.4	12.4	6.1
165	25.3	22.3	20.8	11.8	2.6	-1.1	25.8	23.1	21.4	12.2	3.5	-0.9	27.8	26.0	23.8	22.0	14.2	8.5

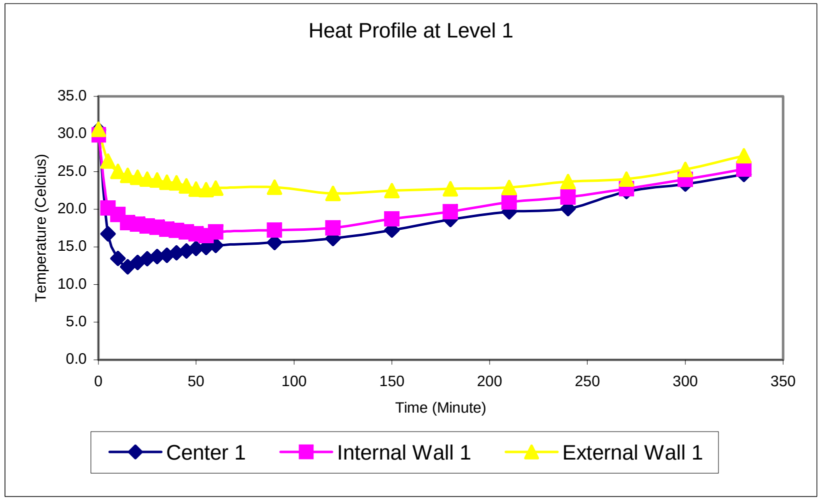
Table A22: Temperatures Data of Weight 2 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	26.6	23.0	20.0	16.5	15.9	18.7	27.1	23.4	20.5	17.1	16.4	19.1	29.5	27.6	27.6	26.8	25.6	27.7
10	25.1	22.2	18.6	15.8	12.7	8.2	25.4	22.6	19.1	16.3	13.3	8.6	28.1	25.1	22.2	20.2	18.1	17.1
15	24.2	21.8	17.6	11.7	9.7	5.3	24.6	22.1	18.0	12.3	10.2	5.8	27.0	24.8	20.2	18.4	17.8	23.8
20	23.5	19.8	16.4	9.7	6.6	1.5	23.9	20.1	16.9	10.2	7.1	1.9	26.6	23.3	19.7	16.5	16.3	22.6
25	23.0	19.3	15.5	6.6	4.1	-2.9	23.6	19.7	15.9	7.1	4.8	-2.5	25.3	23.7	19.5	15.7	15.3	20.3
30	22.9	19.0	14.5	5.7	3.4	-4.9	23.3	19.4	15.1	6.1	3.9	-4.3	25.1	23.5	19.3	15.1	14.7	18.6
35	22.7	18.8	14.2	5.1	2.9	-5.5	23.1	19.1	14.8	5.8	3.3	-5.1	25.0	23.3	19.1	15.0	14.5	14.0
40	23.1	18.6	13.3	3.7	2.7	-6.5	23.6	19.0	14.1	4.3	3.1	-6.1	25.2	23.9	19.7	15.4	14.1	13.5
45	23.7	18.0	13.2	3.2	2.6	-7.8	24.1	18.5	13.9	3.9	3.0	-6.6	25.4	24.1	20.1	16.2	13.8	12.4
50	24.9	17.7	13.0	4.1	2.9	-8.0	25.3	18.1	13.7	4.3	3.3	-7.7	26.5	24.3	20.5	17.9	13.7	10.4
55	25.8	18.4	13.8	6.2	3.6	-7.9	26.4	18.9	14.2	6.9	4.1	-7.2	27.6	24.5	21.1	18.7	13.2	9.2
60	27.0	19.6	15.0	6.5	4.1	-7.6	27.2	20.1	15.7	7.6	4.7	-6.9	28.7	24.8	21.9	19.1	13.7	7.7
90	28.1	20.6	16.7	10.2	8.9	-5.5	28.3	21.1	17.2	11.4	9.5	-5.1	29.2	25.4	24.4	19.1	16.3	12.7
115	29.1	23.4	20.6	13.8	10.8	5.1	29.3	23.9	21.1	14.6	11.1	5.4	29.6	26.4	25.8	21.4	18.8	16.7

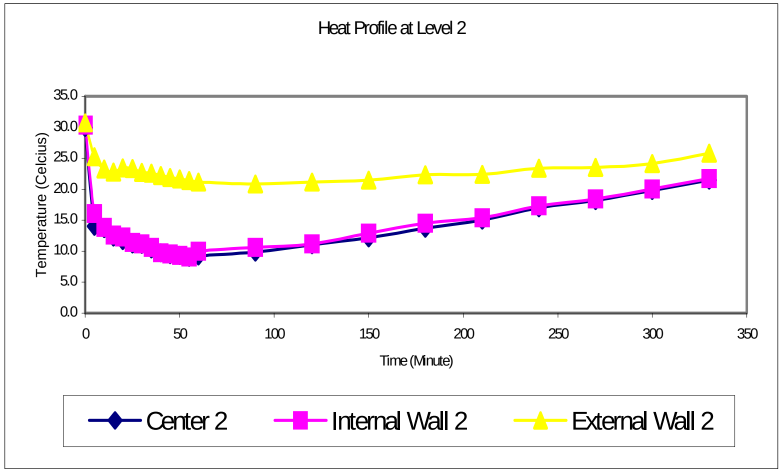
Weight 7 kg

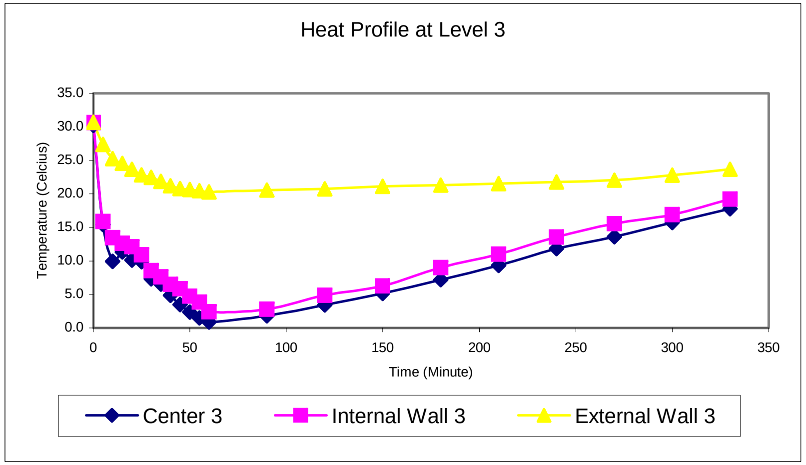


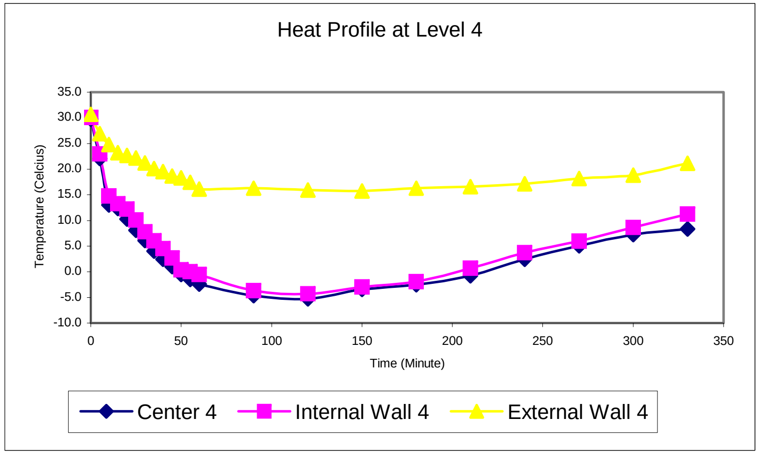
Heat Distribution at 48.3 liter/minute, 30 Celcius & 7 kg
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

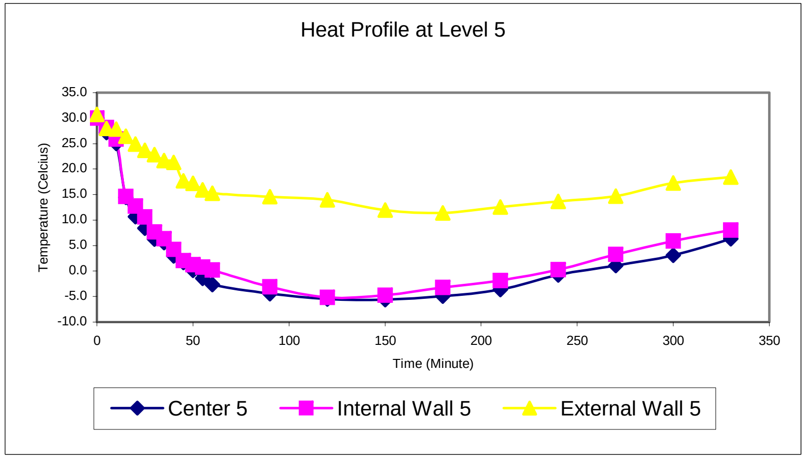


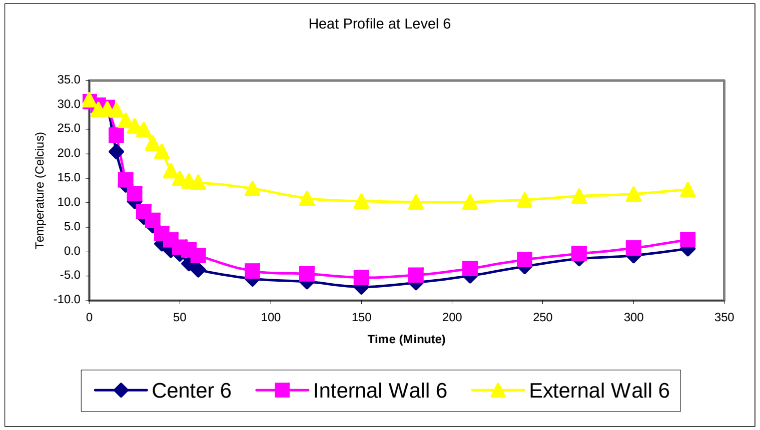
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1

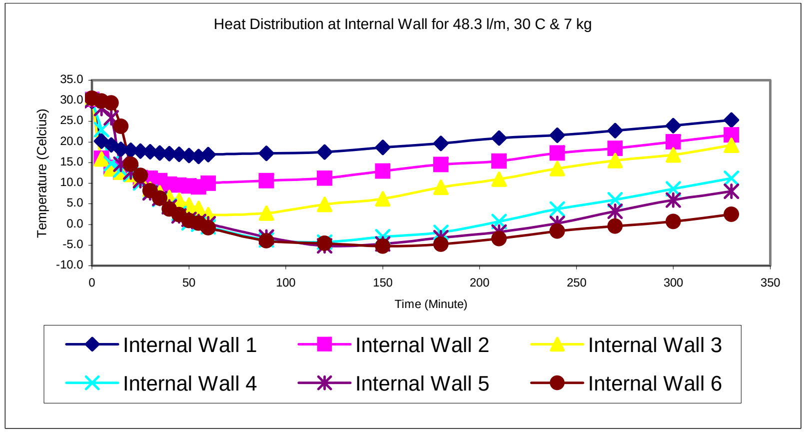

Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2

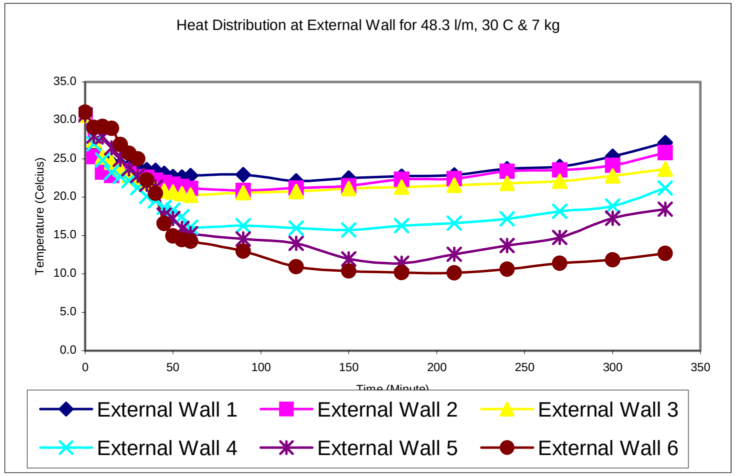

Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3


Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

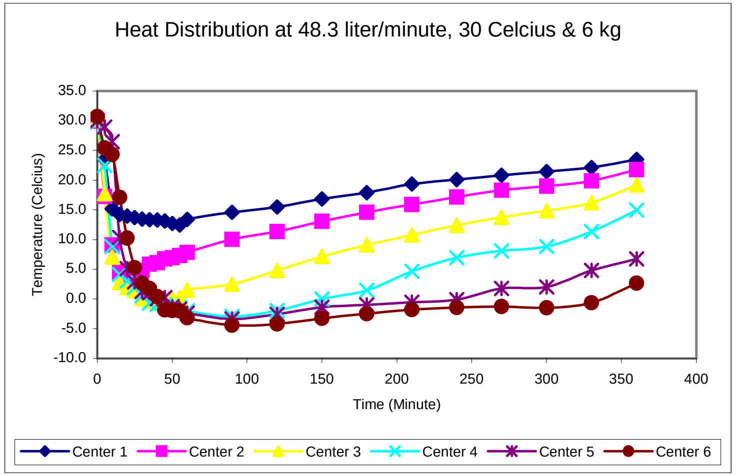

Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5


Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

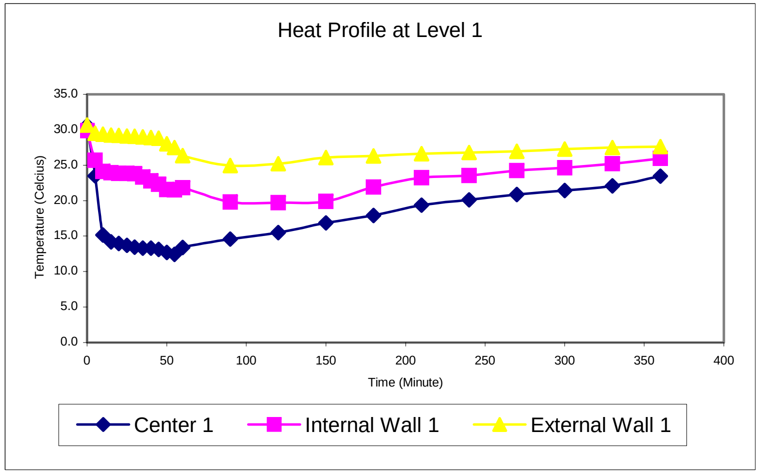

Heat Distribution at Internal Wall for 48.3 l/m, 30 C & 7 kg
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6


Heat Distribution at External Wall for 48.3 l/m, 30 C & 7 kg
Temperature (Celcius)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

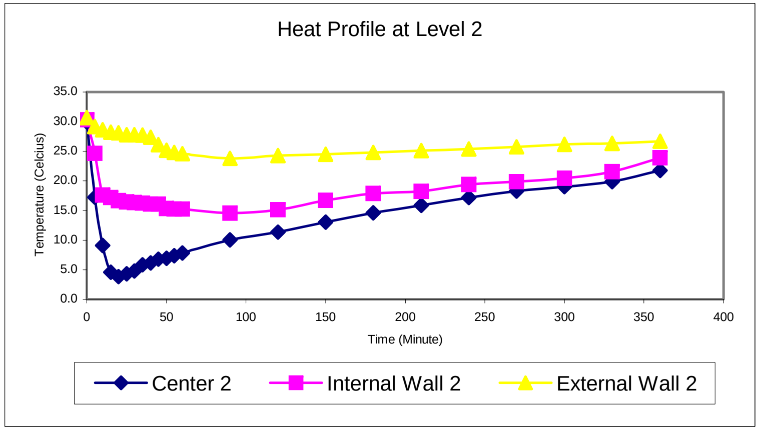
Weight 6 kg



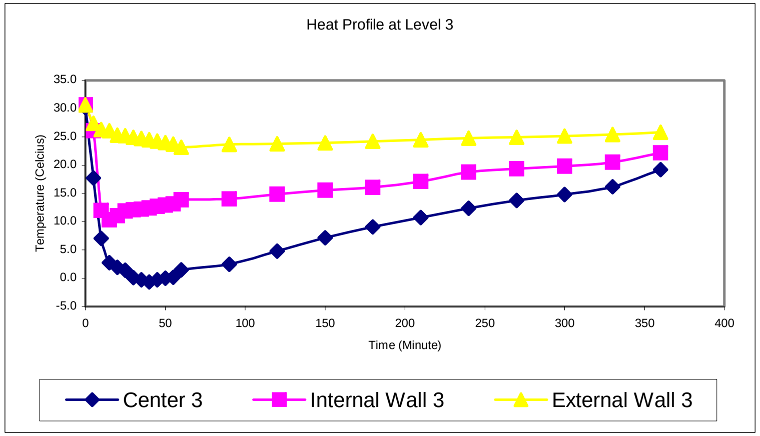
Heat Distribution at 48.3 liter/minute, 30 Celcius & 6 kg
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6



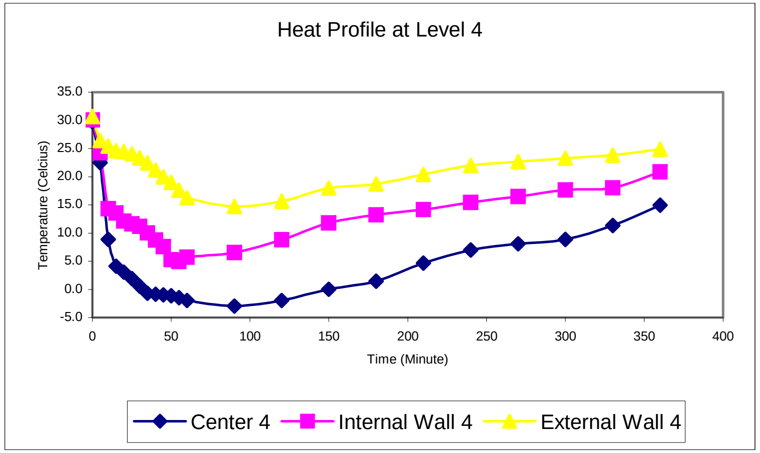
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1

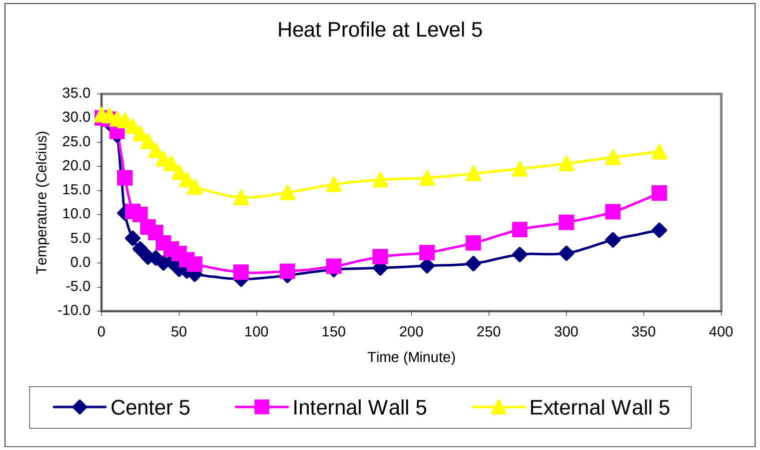


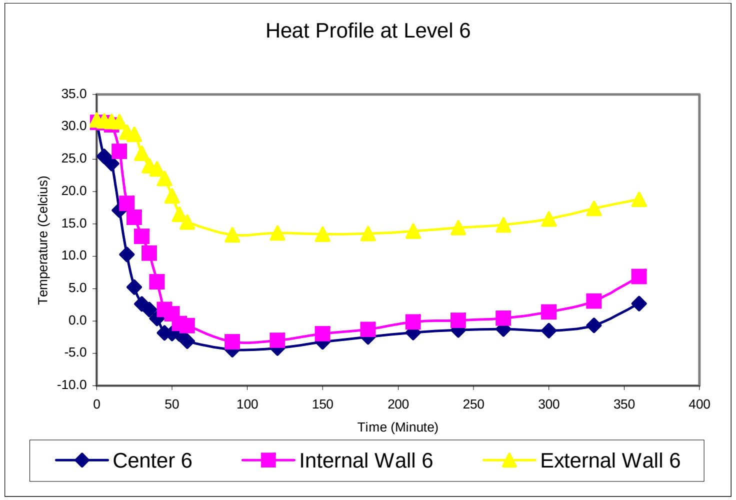
Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2

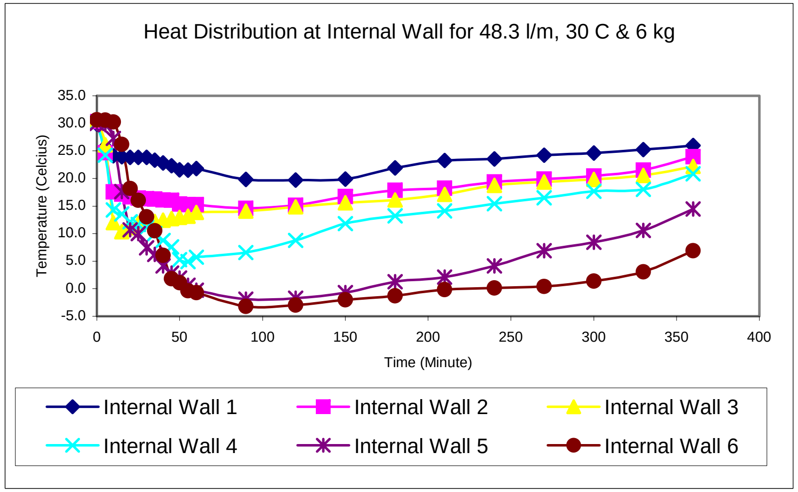


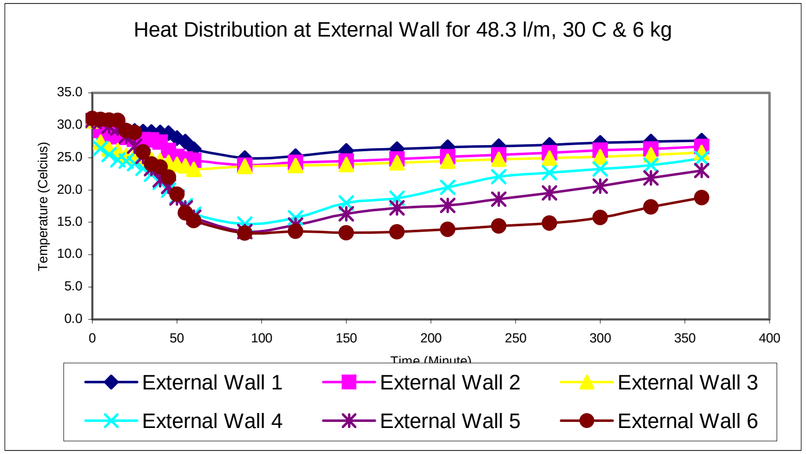
Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3


Heat Profile at Level 4
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0
50
100
150
200
250
300
350
400
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

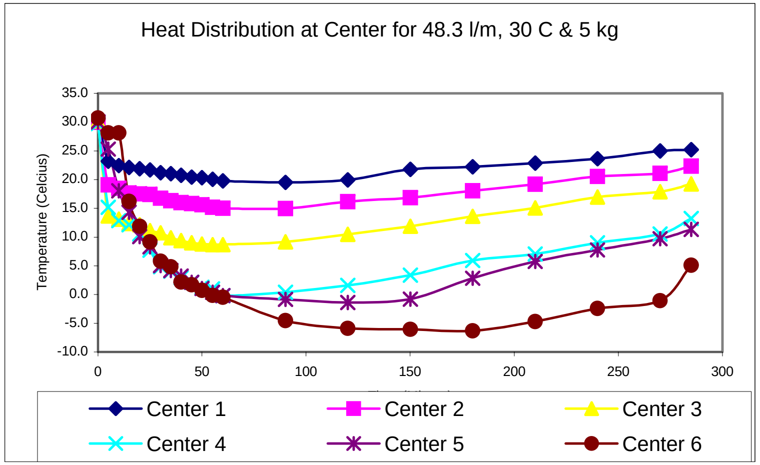

Heat Profile at Level 5
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
50
100
150
200
250
300
350
400
Time (Minute)
Center 5
Internal Wall 5
External Wall 5


Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

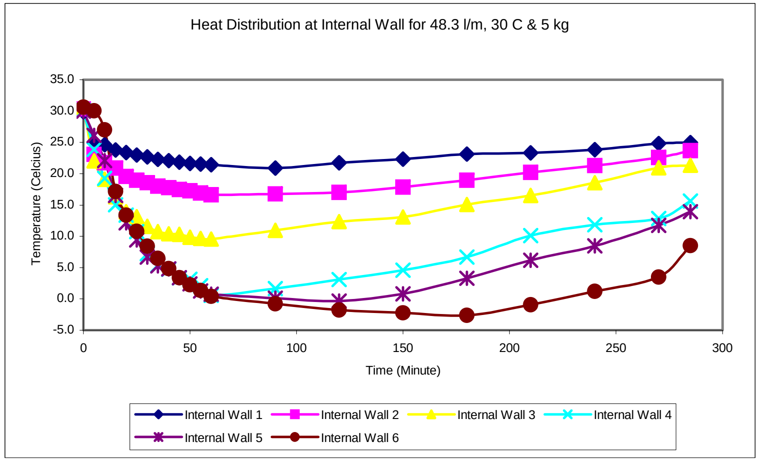

Heat Distribution at Internal Wall for 48.3 l/m, 30 C & 6 kg
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6


Heat Distribution at External Wall for 48.3 l/m, 30 C & 6 kg
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

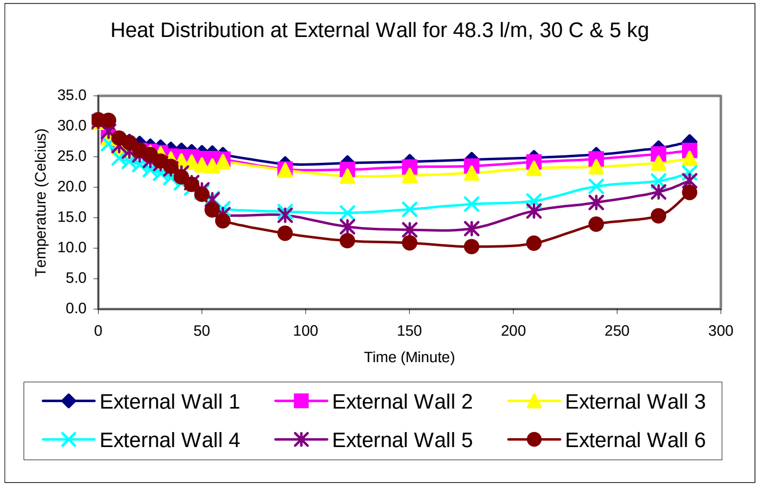
Weight 5 kg



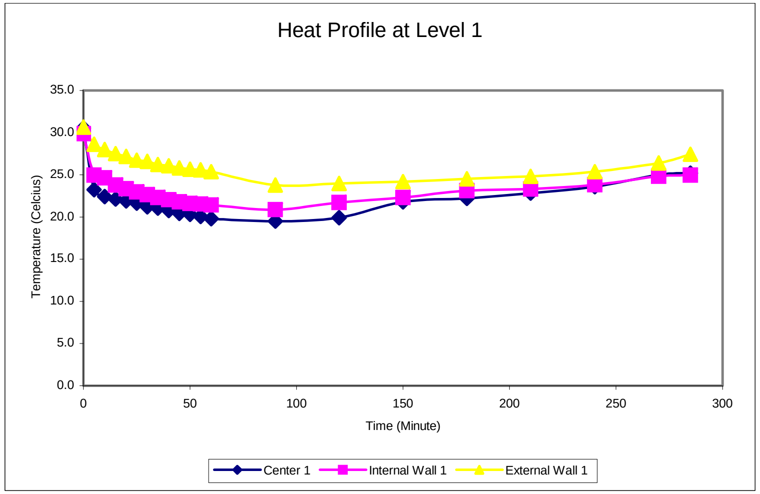
Heat Distribution at Center for 48.3 l/m, 30 C & 5 kg
Temperature (Celcius)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6



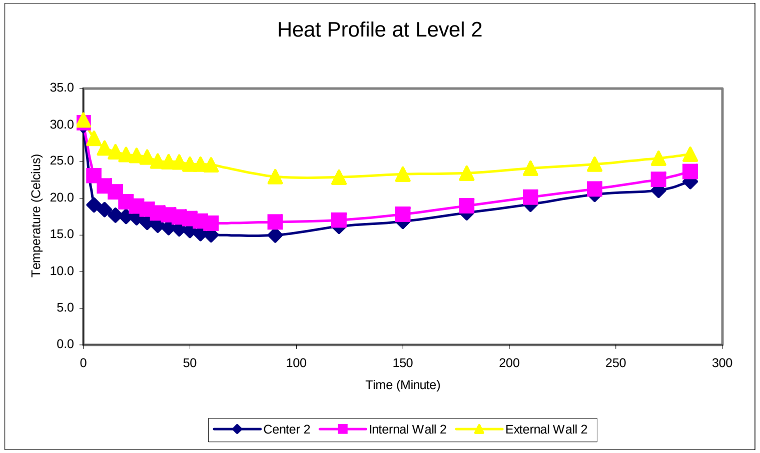
Heat Distribution at Internal Wall for 48.3 l/m, 30 C & 5 kg
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

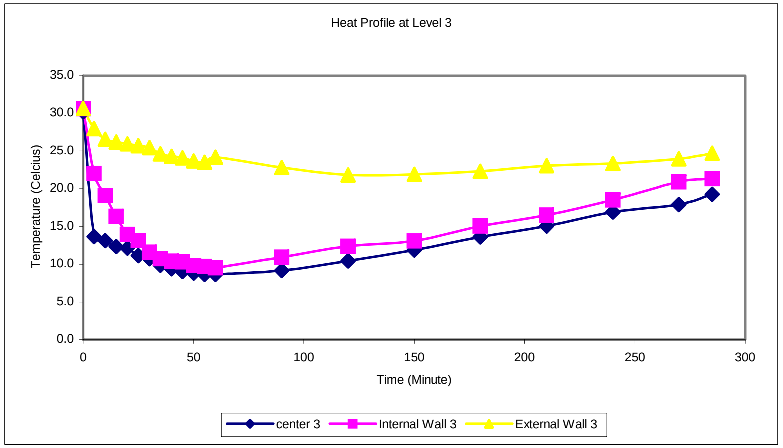


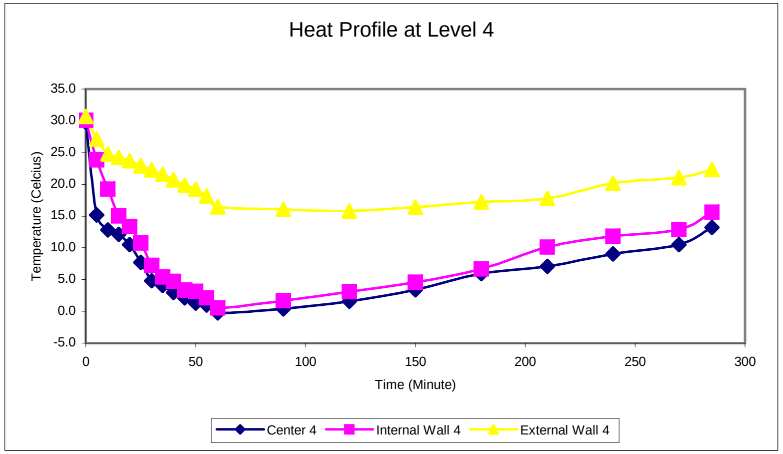
Heat Distribution at External Wall for 48.3 l/m, 30 C & 5 kg
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

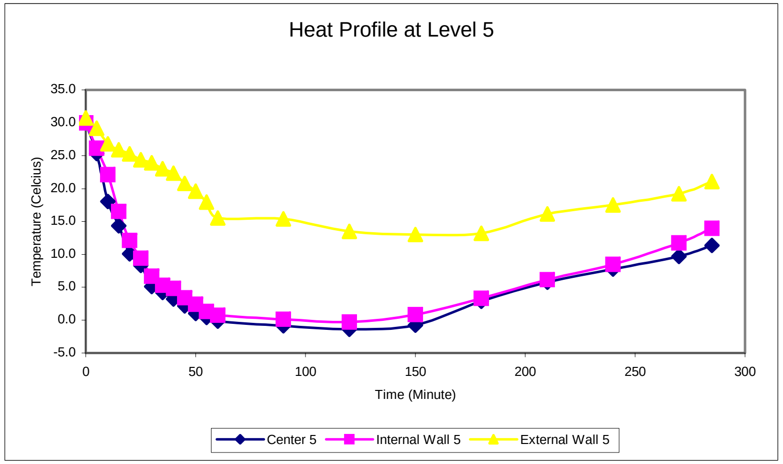


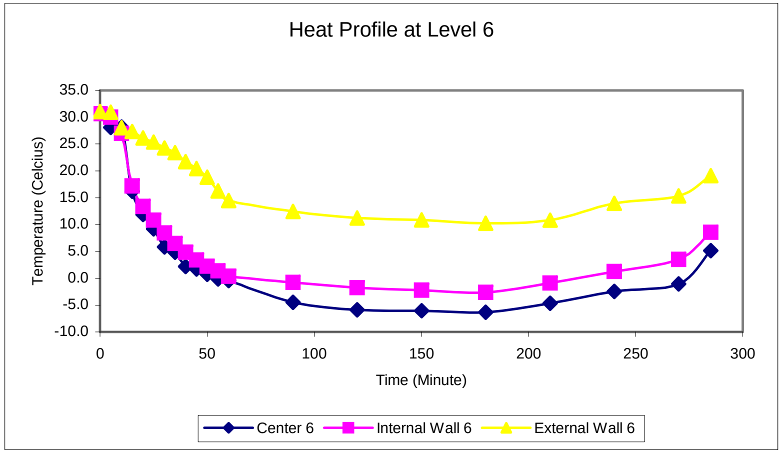
Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2


Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
center 3
Internal Wall 3
External Wall 3

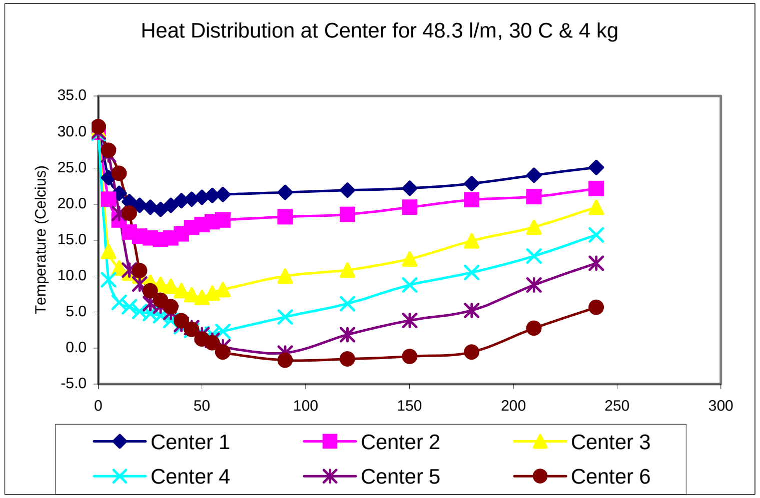

Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4


Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

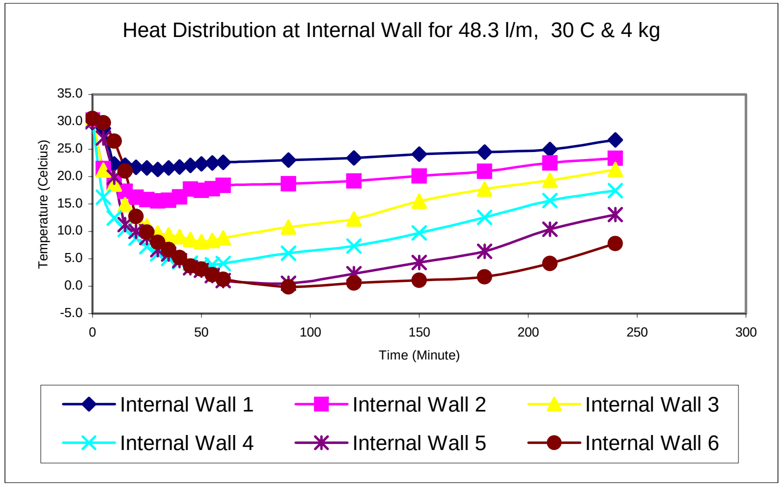


Heat Profile at Level 6
Temperature (Celcius)
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

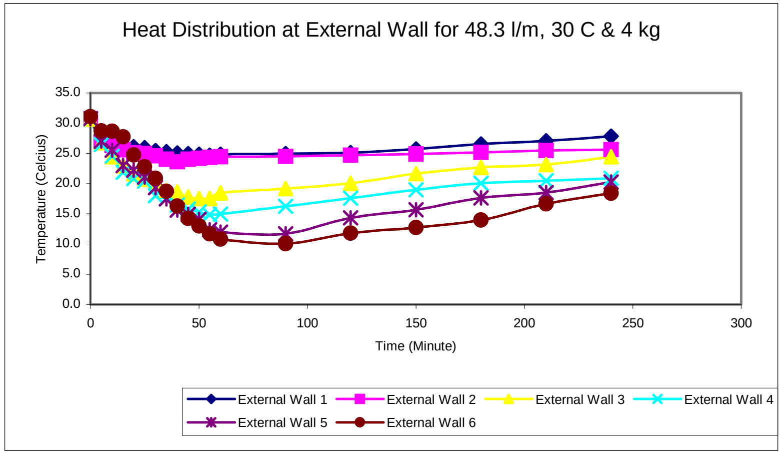
Weight 4 kg

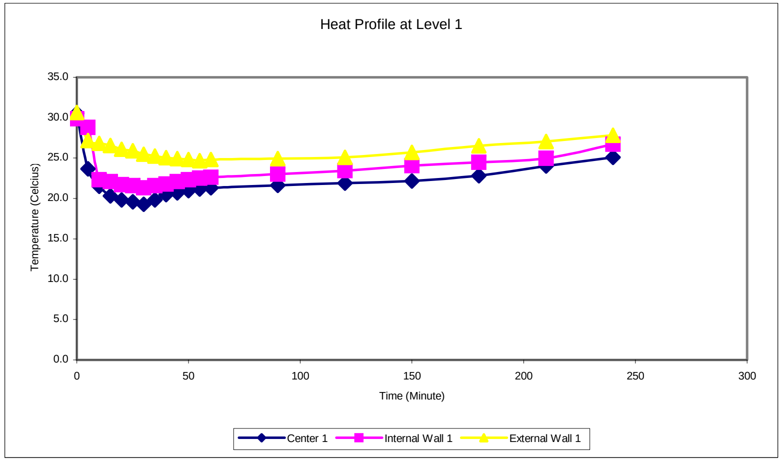


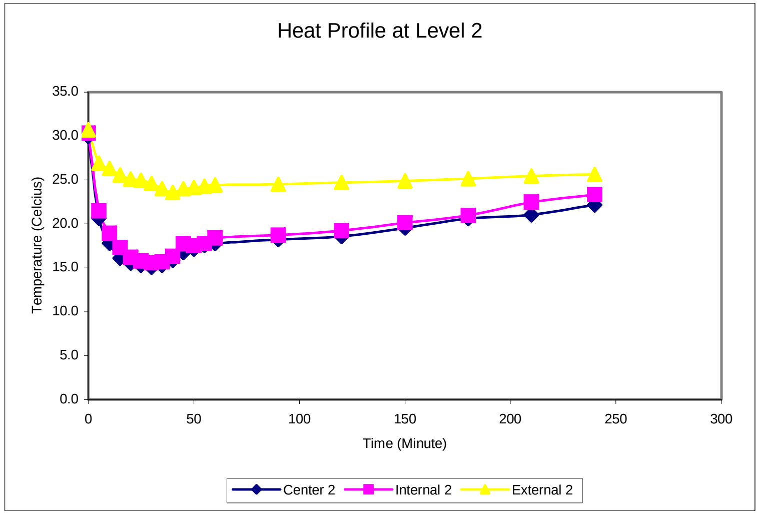
Heat Distribution at Center for 48.3 l/m, 30 C & 4 kg
Temperature (Celcius)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

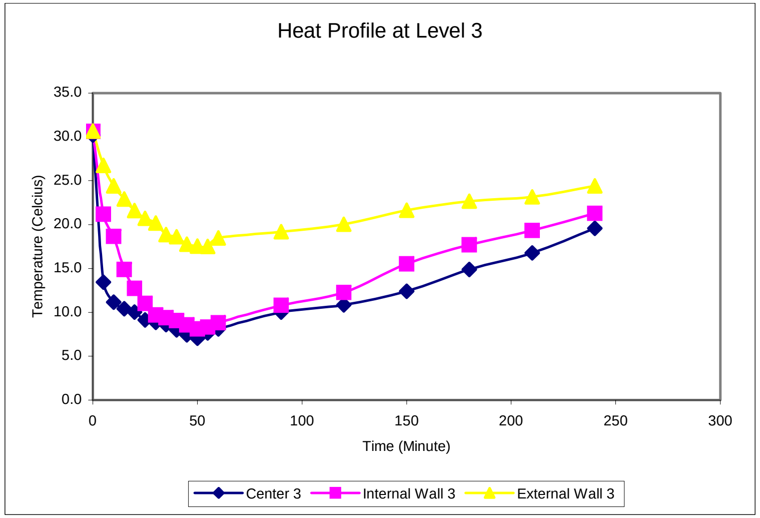


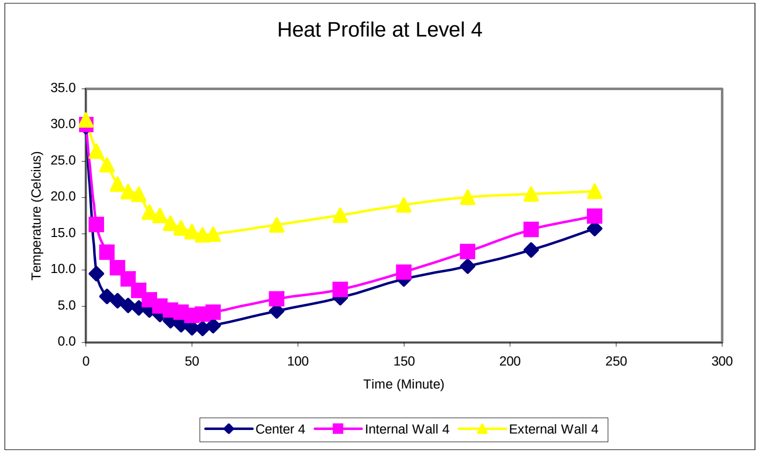
Heat Distribution at Internal Wall for 48.3 l/m, 30 C & 4 kg
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6


Heat Distribution at External Wall for 48.3 l/m, 30 C & 4 kg
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

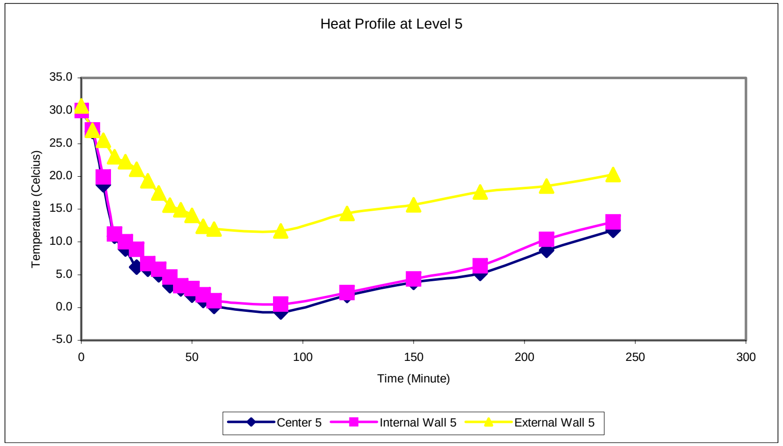

Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal 2
External 2

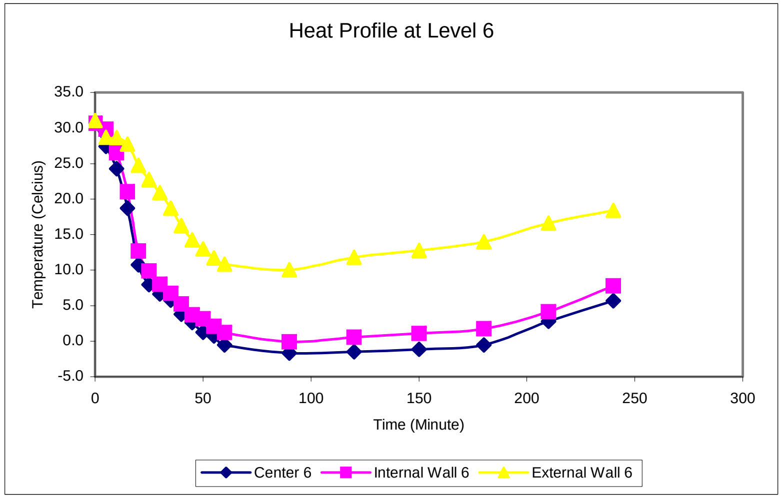

Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3



Heat Profile at Level 4
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
250
300
Time (Minute)
Center 4
Internal Wall 4
External Wall 4

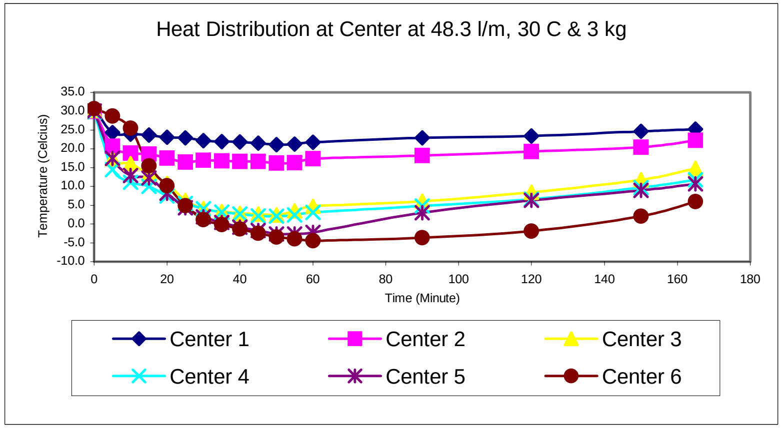


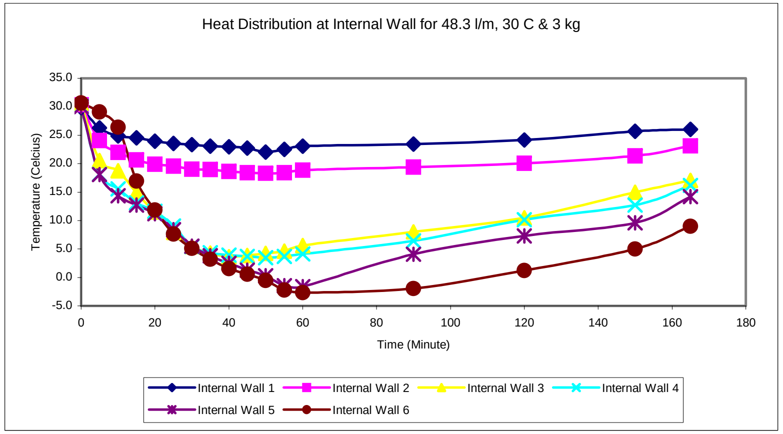
Heat Profile at Level 5
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0
50
100
150
200
250
300
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

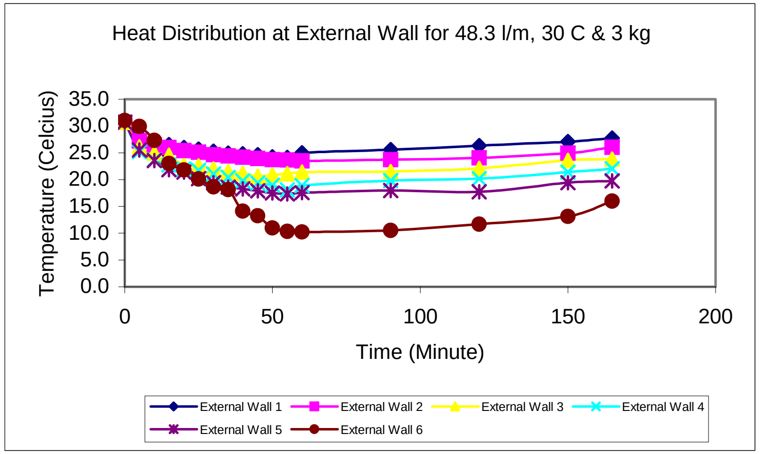


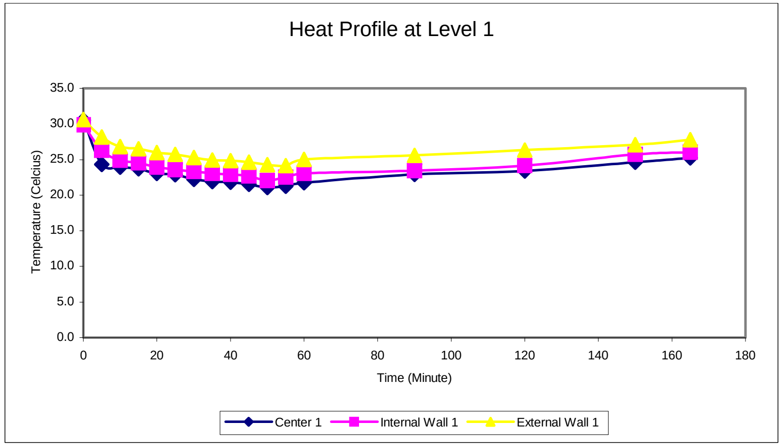
Heat Profile at Level 6
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0
50
100
150
200
250
300
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

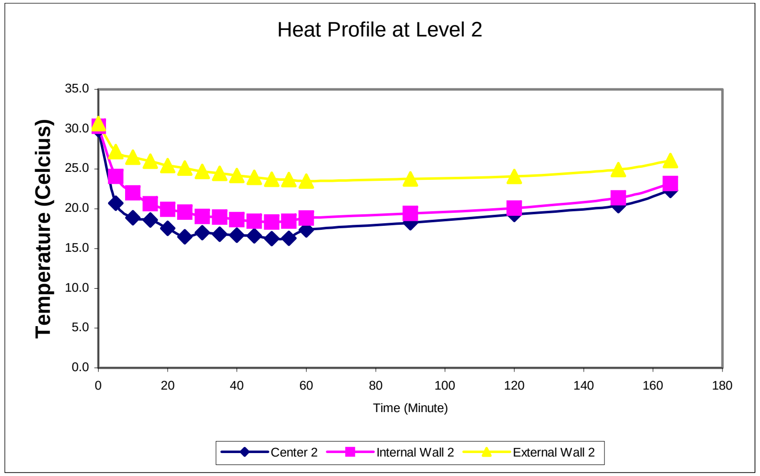
Weight 3 kg

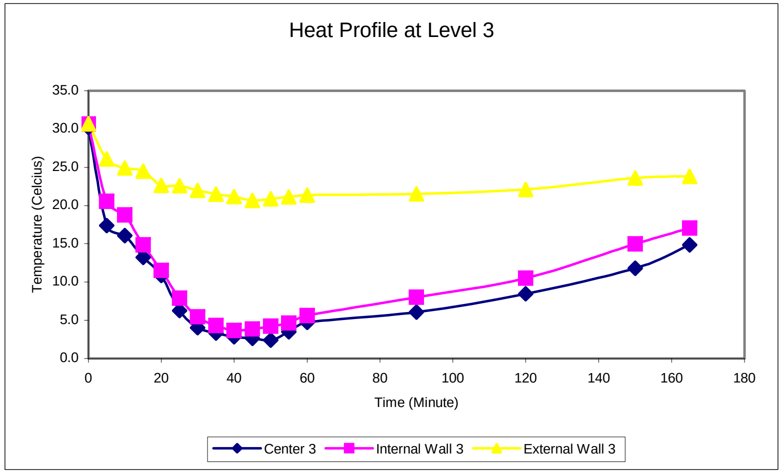

Heat Distribution at Center at 48.3 l/m, 30 C & 3 kg
Temperature (Celcius)
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

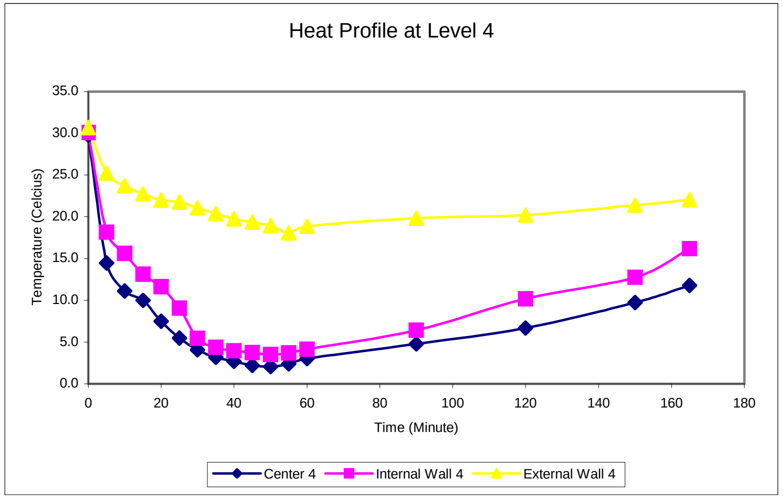

Heat Distribution at Internal Wall for 48.3 l/m, 30 C & 3 kg
Temperature (Celcius)
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

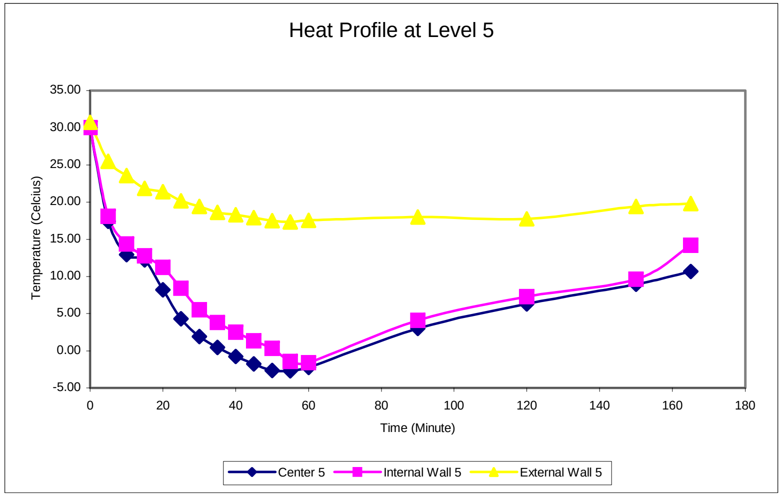

Heat Distribution at External Wall for 48.3 l/m, 30 C & 3 kg
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6

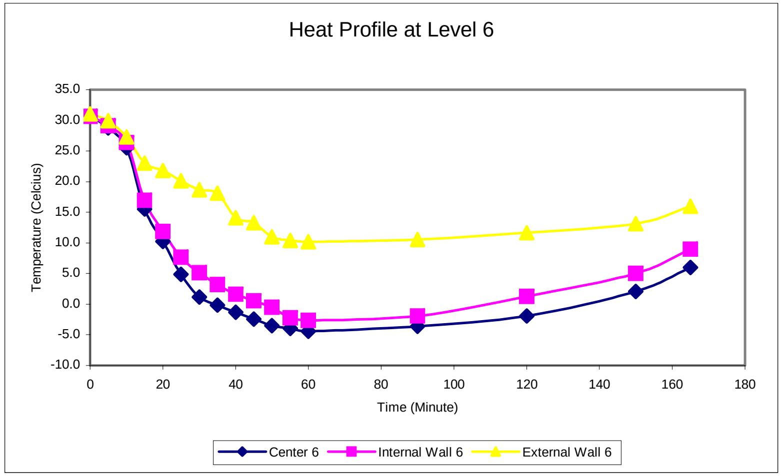

Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2


Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3

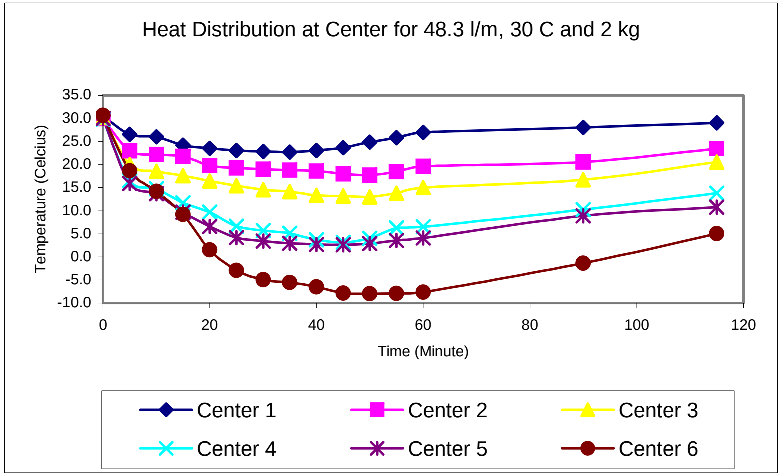

Heat Profile at Level 4
Temperature (Celcius)
Time (Minute)
Center 4
Internal Wall 4
External Wall 4


Heat Profile at Level 5
Temperature (Celcius)
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

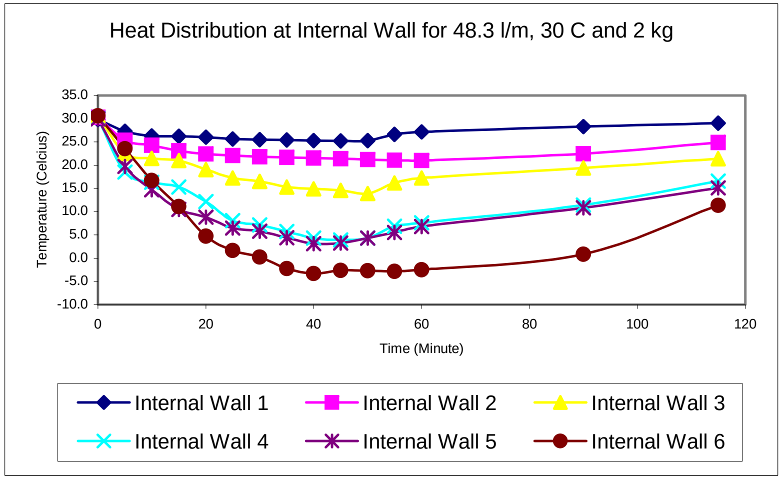


Heat Profile at Level 6
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
20
40
60
80
100
120
140
160
180
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

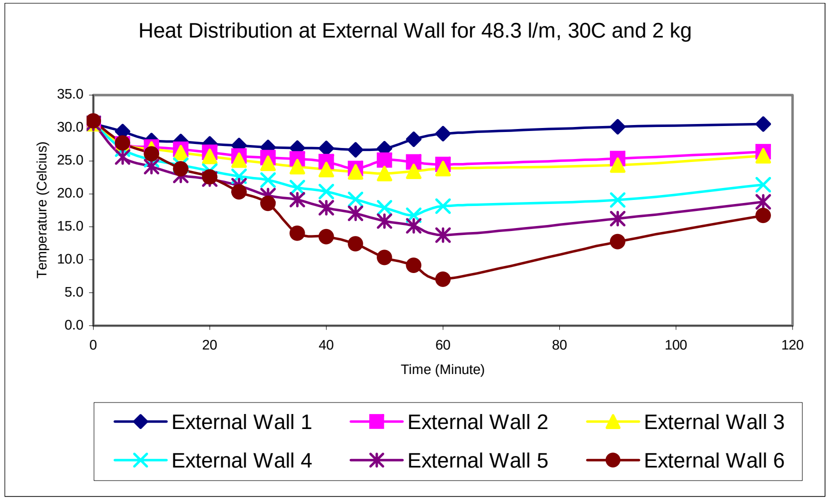
Weight 2 kg

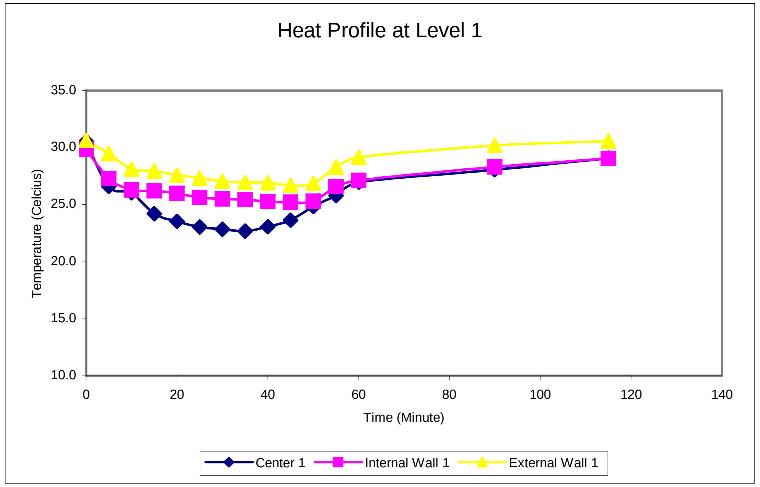


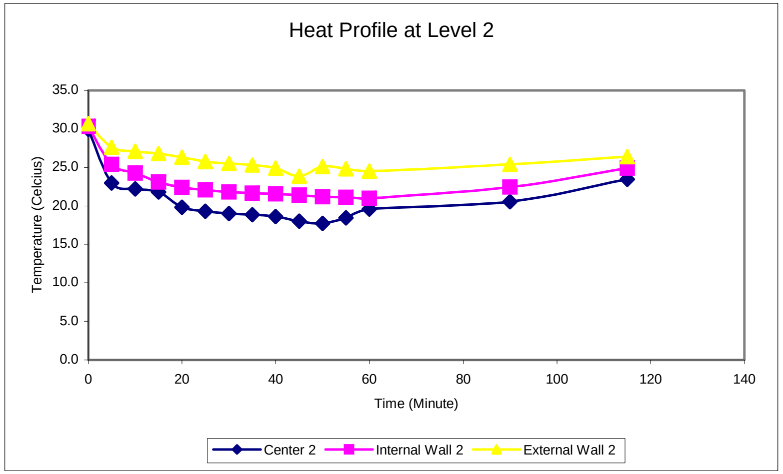
Heat Distribution at Center for 48.3 l/m, 30 C and 2 kg
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
20
40
60
80
100
120
Time (Minute)
Center 1
Center 2
Center 3
Center 4
Center 5
Center 6

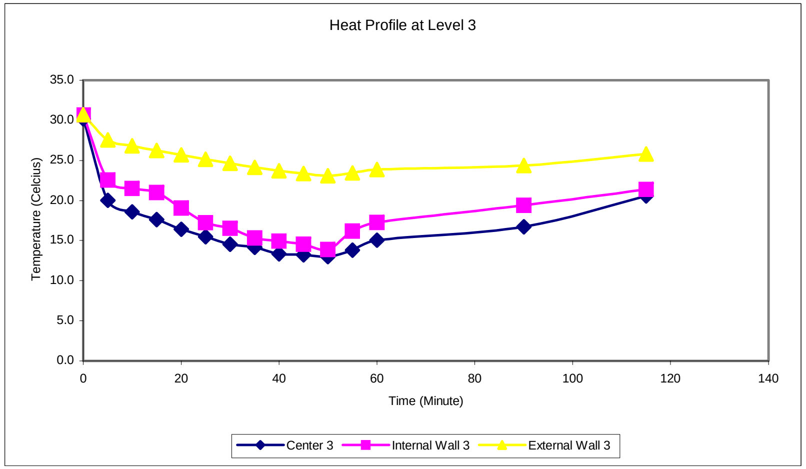


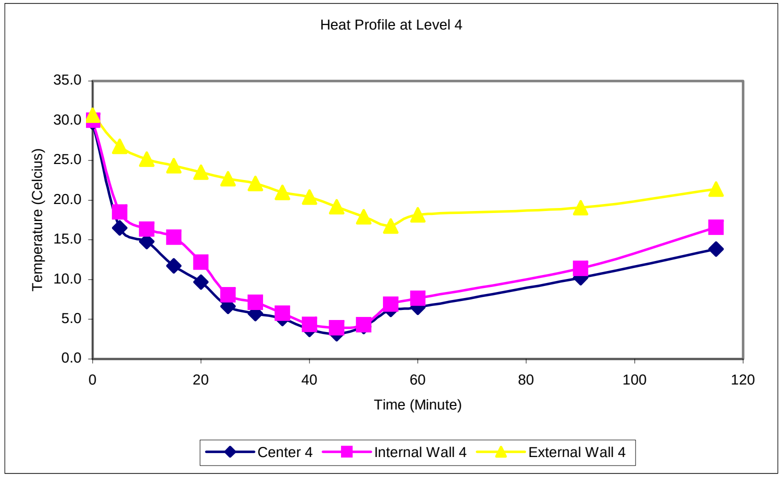
Heat Distribution at Internal Wall for 48.3 l/m, 30 C and 2 kg
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
20
40
60
80
100
120
Time (Minute)
Internal Wall 1
Internal Wall 2
Internal Wall 3
Internal Wall 4
Internal Wall 5
Internal Wall 6

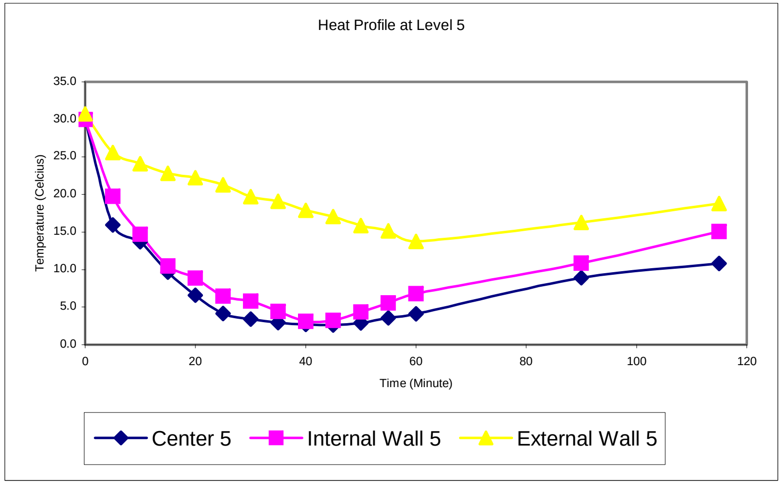

Heat Distribution at External Wall for 48.3 l/m, 30C and 2 kg
Temperature (Celcius)
Time (Minute)
External Wall 1
External Wall 2
External Wall 3
External Wall 4
External Wall 5
External Wall 6


Heat Profile at Level 1
Temperature (Celcius)
Time (Minute)
Center 1
Internal Wall 1
External Wall 1


Heat Profile at Level 2
Temperature (Celcius)
Time (Minute)
Center 2
Internal Wall 2
External Wall 2


Heat Profile at Level 3
Temperature (Celcius)
Time (Minute)
Center 3
Internal Wall 3
External Wall 3


Heat Profile at Level 4
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
20
40
60
80
100
120
Time (Minute)
Center 4
Internal Wall 4
External Wall 4


Heat Profile at Level 5
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
20
40
60
80
100
120
Time (Minute)
Center 5
Internal Wall 5
External Wall 5

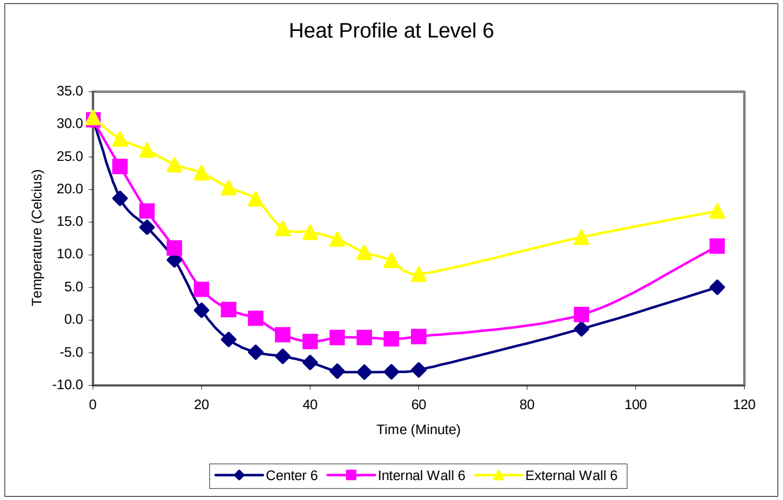

Heat Profile at Level 6
Temperature (Celcius)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0
20
40
60
80
100
120
Time (Minute)
Center 6
Internal Wall 6
External Wall 6

Table A17: Temperatures Data of Weight 7 kg for Surrounding Temperature of 30°C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	26.7	24.0	18.4	20.1	27.2	29.5	27.2	25.5	20.9	23.0	28.1	29.9	26.4	23.3	20.4	22.9	28.8	29.1
10	18.5	13.7	8.1	10.3	23.4	29.3	22.9	18.9	12.5	14.8	27.9	29.5	23.3	20.3	14.2	15.8	28.4	29.2
15	17.4	12.3	7.8	12.3	16.4	20.4	20.2	15.6	12.6	13.3	14.6	23.8	24.5	19.7	13.5	15.2	26.4	29.0
20	16.9	11.7	7.6	10.3	12.7	13.7	18.0	14.1	12.1	12.2	12.8	14.6	24.3	19.5	12.7	15.0	24.9	26.8
25	16.4	11.2	6.9	7.1	8.4	10.3	17.5	13.6	10.9	10.1	10.6	11.9	24.0	19.3	11.9	14.8	23.7	25.7
30	16.1	11.1	6.3	6.1	7.3	8.1	17.3	12.2	8.6	7.8	7.7	8.2	23.9	18.7	12.5	14.6	22.8	25.0
35	15.9	10.3	6.0	5.0	6.6	7.3	17.1	11.8	7.9	6.1	6.3	6.4	23.6	18.4	12.9	14.5	21.7	22.2
40	15.5	9.7	5.9	5.5	5.0	5.6	15.7	10.6	7.5	5.5	4.3	3.7	23.5	18.0	13.2	14.2	21.3	21.5
45	15.3	9.4	5.5	5.0	3.7	3.3	15.5	8.1	6.8	4.7	2.1	2.4	23.1	18.2	13.8	14.0	17.7	18.6
50	14.8	9.3	5.3	4.6	2.8	2.5	15.3	7.9	6.3	3.4	1.2	1.0	22.7	18.3	14.2	13.9	17.2	18.0
55	14.6	9.0	5.2	4.0	1.8	1.4	15.2	7.7	5.9	2.7	0.7	0.3	21.6	18.5	14.5	13.7	16.9	17.4
60	14.4	8.3	4.9	3.4	0.6	-0.7	15.0	7.5	5.4	3.5	1.2	0.8	20.8	18.7	14.8	13.8	16.2	16.2
90	13.6	6.9	4.8	2.6	-1.5	-2.6	14.2	7.3	5.2	2.9	-1.0	-2.1	21.4	19.9	15.9	13.4	15.8	15.3
120	14.5	6.1	3.4	0.9	-2.5	-3.1	15.1	6.7	3.9	1.6	-2.0	-2.6	22.1	21.2	16.7	13.1	12.9	12.3
150	16.2	5.2	2.7	-0.6	-3.6	-4.2	16.7	5.8	3.3	-0.1	-3.0	-3.8	22.5	21.5	17.1	14.1	12.1	11.4
180	17.7	4.7	2.2	-2.5	-4.1	-4.8	18.1	5.2	2.7	-2.1	-3.7	-4.3	23.7	22.1	18.3	15.3	11.4	10.2
210	18.7	5.5	1.3	-3.8	-4.7	-5.3	19.2	5.9	1.9	-2.7	-4.2	-4.8	23.9	23.2	19.9	15.8	10.6	9.6
240	19.6	6.7	1.8	-4.5	-5.2	-5.9	20.1	7.2	2.3	-3.9	-4.8	-5.3	25.8	25.5	23.1	18.2	9.7	8.6
270	20.4	8.2	2.6	-3.6	-6.1	-6.4	20.8	8.8	3.1	-3.2	-5.7	-6.1	27.3	26.1	24.8	20.8	9.2	8.1
300	23.4	10.8	4.1	-1.3	-4.1	-5.8	23.9	11.3	4.7	-0.8	-3.6	-5.3	27.8	26.8	25.1	21.2	8.4	7.6
330	24.6	12.4	5.8	2.4	-2.4	-4.6	25.1	12.8	6.2	2.9	-2.0	-4.1	28.1	26.1	25.7	22.2	11.4	9.7
360	25.4	22.3	16.1	9.7	5.9	0.3	25.9	23.9	17.6	10.4	6.6	1.5	28.5	27.4	26.5	23.5	19.4	14.1
385	26.9	24.7	19.7	17.5	14.9	7.9	27.1	25.9	24.1	19.9	15.3	9.7	29.3	28.2	27.0	25.2	21.7	18.4

Table A18: Temperatures Data of Weight 6 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	30.7
5	28.5	27.2	20.7	24.5	26.9	29.4	28.7	27.7	21.8	25.2	27.8	29.6	29.5	28.2	23.4	26.4	28.6	29.8
10	19.5	15.1	12.7	14.9	24.5	26.3	23.1	18.6	13.2	15.8	25.3	28.9	23.9	19.7	14.3	16.4	26.8	29.2
15	18.2	14.6	11.2	12.5	18.4	21.1	22.9	23.2	12.3	13.5	19.6	22.2	23.7	24.2	13.1	14.6	20.5	26.8
20	17.9	14.0	9.9	10.4	15.1	16.3	22.3	22.7	10.5	11.1	16.7	17.2	23.5	28.1	11.3	13.4	18.3	23.2
25	17.7	13.8	9.4	9.1	8.9	9.3	21.5	21.4	10.0	10.6	9.8	11.0	23.3	22.2	11.0	12.9	15.8	21.9
30	17.4	13.3	9.1	9.0	6.3	7.6	21.0	20.3	9.7	10.2	7.4	8.1	23.1	21.1	10.7	11.6	13.2	18.9
35	17.3	13.0	8.8	8.7	5.1	5.8	20.8	18.2	9.2	9.0	6.3	6.5	23.0	19.3	10.3	11.2	12.8	16.0
40	17.0	12.8	8.3	6.9	3.0	3.4	20.3	17.1	8.9	7.7	4.1	4.1	22.9	18.2	9.8	10.6	11.4	13.5
45	16.8	12.6	8.0	5.0	2.3	1.8	19.3	16.1	8.7	5.6	2.8	2.2	22.7	17.1	9.6	10.2	10.0	11.0
50	16.7	12.4	7.8	4.1	1.3	0.9	18.6	15.3	8.3	5.3	1.9	1.1	22.5	16.4	9.2	10.0	9.6	10.3
55	16.4	12.0	7.7	3.5	0.6	-0.7	18.5	14.3	8.0	3.9	0.7	-0.4	22.2	15.1	9.0	9.6	9.2	9.5
60	16.3	11.8	7.5	2.0	-0.3	-1.1	18.0	13.2	7.9	2.7	0.5	-0.9	22.0	14.4	8.8	9.3	8.8	8.3
90	15.5	12.6	8.9	1.3	-2.3	-3.4	16.8	13.7	9.4	1.6	-1.9	-2.9	25.6	14.9	10.1	8.7	8.5	8.2
120	16.5	13.4	9.8	0.3	-2.8	-3.8	17.5	14.5	10.6	0.8	-2.1	-3.2	26.2	15.3	10.9	9.7	8.1	7.6
150	17.9	14.1	10.7	-1.4	-3.8	-4.8	20.9	14.7	11.6	-1.1	-3.3	-4.1	26.5	15.9	12.2	11.0	9.3	7.4
180	18.9	15.6	11.1	0.1	-4.9	-5.4	21.9	16.9	12.1	0.6	-4.1	-4.9	27.3	17.7	12.9	11.7	10.2	8.0
210	21.1	16.2	12.4	3.2	-4.2	-5.8	22.2	17.8	13.5	3.9	-3.8	-5.2	27.6	18.5	14.3	13.4	11.6	8.9
240	22.8	18.2	15.4	7.1	-3.7	-6.4	23.5	18.7	16.8	7.7	-3.1	-6.0	27.8	19.4	17.7	16.1	12.6	10.4
270	23.4	19.9	17.8	9.8	-2.1	-5.5	24.2	20.5	18.4	10.5	-1.7	-4.9	27.9	21.2	19.9	18.7	14.5	11.9
300	24.1	20.2	18.2	11.4	-0.2	-2.7	24.6	20.8	19.8	11.7	0.4	-2.1	28.0	21.8	20.8	20.3	17.6	15.8
330	24.1	22.2	19.2	13.4	7.8	2.1	25.2	22.9	20.6	14.0	8.6	3.1	28.2	23.4	21.5	20.9	19.9	17.4
360	25.5	23.4	20.8	14.8	8.9	5.7	26.0	23.9	21.2	15.8	12.4	9.5	28.6	24.7	23.1	21.9	20.0	18.8

Table A19: Temperatures Data of Weight 5 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.2	19.1	13.6	15.2	25.3	28.1	25.0	23.1	22.0	23.9	26.1	30.0	28.6	28.2	28.0	27.1	29.2	31.0
10	21.1	16.5	10.1	11.8	18.3	24.1	23.6	19.7	17.1	15.2	22.1	27.0	25.5	21.9	18.6	16.8	26.1	28.1
15	20.1	17.7	12.3	12.1	14.3	16.2	23.8	19.5	16.3	15.0	16.5	17.2	25.0	21.6	17.2	16.2	20.9	23.3
20	19.9	17.5	12.1	10.5	10.1	11.9	23.3	19.1	13.9	13.4	12.1	13.4	24.8	21.3	17.0	15.7	18.3	21.1
25	19.7	17.4	11.1	7.7	8.3	9.2	23.0	18.7	13.1	10.7	9.4	10.8	24.7	20.9	16.7	14.5	17.4	19.4
30	19.5	16.7	10.7	4.8	5.1	5.8	22.7	18.5	11.6	7.2	6.7	8.4	24.6	20.3	16.5	13.9	15.9	16.3
35	19.3	16.3	9.9	4.1	4.2	4.9	22.3	18.0	10.7	5.4	5.3	6.5	24.2	19.9	16.6	13.3	14.0	15.4
40	19.1	16.0	9.4	2.9	3.2	2.2	22.1	17.8	10.4	4.7	4.8	4.8	24.1	19.5	16.8	13.0	13.3	14.9
45	19.0	15.8	9.0	2.1	2.1	1.7	21.8	17.5	10.3	3.4	3.4	3.4	23.8	19.2	17.1	14.2	13.0	14.5
50	20.3	15.6	8.8	1.3	1.0	0.7	21.6	17.3	9.8	3.2	2.4	2.3	23.7	20.0	17.7	14.8	12.9	14.1
55	20.1	15.2	8.7	1.0	0.4	-0.2	21.5	16.9	9.7	2.1	1.3	1.4	23.0	20.3	17.9	15.0	12.7	13.8
60	18.8	13.5	8.7	0.2	-1.2	-2.5	21.4	15.6	9.5	0.5	-0.8	-1.9	23.4	20.6	18.2	15.5	12.5	13.5
90	17.5	11.5	7.8	0.8	-2.9	-3.7	20.9	16.8	8.2	1.3	-2.2	-3.2	23.9	21.8	18.7	15.9	13.7	12.4
120	18.9	10.2	6.4	-0.6	-3.4	-4.2	21.7	17.0	7.5	-1.3	-3.7	-4.1	24.0	22.9	21.9	15.8	13.5	10.7
150	20.8	12.7	7.9	-2.0	-4.2	-5.3	22.3	17.9	8.8	-1.7	-3.6	-4.8	24.2	23.3	21.9	16.4	13.0	10.9
180	21.2	15.1	9.6	-3.9	-5.4	-6.3	23.1	19.0	10.7	-2.7	-4.7	-5.7	24.5	23.5	22.3	17.2	13.2	10.2
210	22.8	19.2	13.0	-1.1	-3.8	-6.2	23.3	20.2	13.5	-0.8	-3.1	-5.5	24.8	24.1	23.1	17.8	16.1	10.8
240	23.6	20.6	16.9	3.0	-1.8	-4.4	23.8	21.3	17.6	3.8	-0.9	-3.8	25.4	24.7	23.4	20.2	17.5	13.9
270	25.0	21.1	17.9	8.5	2.7	-1.1	24.8	22.6	18.9	9.9	3.5	-0.7	26.4	25.5	24.0	21.0	19.2	15.3
285	25.2	22.3	19.3	13.2	7.3	3.1	25.0	23.7	20.3	14.6	8.0	3.8	27.4	26.0	24.7	22.4	21.1	19.1

Table A20: Temperatures Data of Weight 4 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time (min)	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	29.9	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	23.7	20.7	18.4	15.5	26.8	27.4	28.8	21.5	21.2	16.3	27.1	29.8	27.2	26.9	26.8	24.4	27.0	28.7
10	22.5	18.8	15.2	12.4	15.7	20.3	24.3	20.9	15.6	12.8	16.9	21.5	25.8	22.9	20.4	19.5	22.5	26.7
15	21.3	16.1	10.4	9.8	10.8	18.7	22.1	17.3	14.9	10.3	11.2	21.0	24.5	21.6	19.9	19.1	20.0	27.7
20	20.8	15.5	10.0	8.1	8.9	10.8	21.7	16.2	12.7	8.8	10.0	12.7	24.1	21.1	18.6	17.8	19.2	24.7
25	20.6	15.3	9.1	6.8	6.2	8.0	21.6	15.8	11.0	7.2	7.9	9.9	23.9	20.5	17.7	17.4	18.1	22.8
30	20.3	15.1	8.9	5.5	5.8	6.7	21.3	15.6	9.7	5.9	6.7	7.8	23.5	20.1	17.2	16.8	17.3	20.9
35	19.8	14.9	8.6	4.9	4.0	5.7	21.6	15.7	9.4	5.0	5.3	6.2	23.2	19.8	16.9	16.5	16.5	18.7
40	19.5	14.7	8.0	3.0	2.3	2.8	21.8	16.3	9.0	4.5	3.7	3.3	23.1	19.4	16.6	16.4	14.6	16.3
45	19.2	14.9	7.4	2.5	1.9	-0.6	22.1	17.7	8.5	4.2	2.3	0.2	22.9	19.0	17.1	16.0	12.9	14.2
50	19.5	15.5	7.0	2.0	0.9	-1.2	22.3	17.5	8.1	3.7	1.9	-0.8	23.2	19.7	17.5	15.7	11.1	13.0
55	20.0	16.2	7.6	1.9	-1.1	-2.7	22.5	17.8	8.3	2.5	-0.6	-2.1	23.5	20.8	18.0	15.7	10.4	11.7
60	20.3	16.8	9.1	-0.3	-2.1	-3.5	22.6	18.4	11.8	0.7	-1.1	-2.8	23.8	21.6	18.5	15.9	9.2	9.1
90	21.6	17.2	9.8	-0.9	-3.5	-4.2	23.0	18.7	10.8	-0.1	-2.8	-3.7	24.4	22.3	19.2	16.8	8.6	8.1
120	21.9	18.6	10.8	-0.6	-3.4	-5.5	23.4	19.2	12.3	0.3	-2.7	-4.9	25.1	23.7	20.0	17.6	8.8	7.8
150	22.2	19.6	12.4	1.8	-4.8	-6.2	24.1	20.1	14.5	2.7	-3.7	-5.3	25.7	23.9	21.6	18.0	9.7	7.4
180	22.8	20.6	14.9	4.5	-4.2	-6.6	24.5	21.0	16.7	5.6	-3.1	-5.5	26.5	24.1	22.7	19.0	10.5	6.8
210	24.0	21.0	16.8	7.8	-2.8	-5.8	25.0	22.5	18.3	8.6	-2.0	-4.9	27.1	24.5	23.2	20.5	13.3	8.4
240	25.1	22.1	19.6	9.7	-1.8	-3.7	26.7	23.3	21.3	11.5	-0.9	-3.1	27.8	25.6	24.4	21.9	15.8	9.4

Table A21: Temperatures Data of Weight 3 kg for Surrounding Temperature of 30^{o}C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	24.3	20.7	19.4	16.5	17.4	28.7	25.3	21.1	20.1	18.2	18.1	29.1	28.2	27.2	26.1	25.2	23.5	22.0
10	23.9	19.9	17.8	14.1	13.9	18.5	24.3	20.5	18.2	15.6	14.3	19.4	27.8	24.5	21.9	19.7	18.6	21.3
15	23.7	18.6	16.2	13.0	12.2	15.5	24.1	19.2	16.8	13.3	12.8	15.9	26.5	23.0	20.5	18.7	16.9	18.0
20	23.1	17.5	15.9	11.5	8.2	10.2	23.7	18.3	16.3	11.8	8.7	10.9	26.0	22.4	19.6	17.0	14.4	16.8
25	22.9	17.3	14.3	10.5	4.3	4.9	23.5	18.1	15.1	10.9	4.8	5.3	25.7	21.1	19.0	17.8	13.2	14.1
30	22.2	17.0	13.0	8.1	1.8	1.2	23.1	17.8	13.5	8.6	2.3	1.6	25.3	21.7	19.2	18.1	12.4	13.7
35	21.9	16.8	12.3	7.2	0.4	-0.1	22.3	17.5	12.8	7.5	0.9	0.3	24.9	21.4	19.3	18.3	11.6	12.1
40	21.8	16.7	12.9	6.7	-0.7	-1.3	22.1	17.3	13.3	7.1	-0.1	-0.8	24.8	21.8	19.5	18.4	10.3	10.1
45	21.5	16.6	13.1	5.2	-1.7	-2.4	21.9	17.1	13.7	5.7	-1.1	-1.9	24.6	22.0	19.7	18.5	9.9	9.3
50	21.1	16.2	13.4	4.0	-2.6	-3.5	21.5	17.0	13.9	4.5	-2.1	-3.1	24.3	22.1	20.0	18.6	9.7	8.8
55	21.3	16.3	13.5	3.4	-2.6	-4.0	21.8	17.2	14.0	3.7	-2.3	-3.7	24.1	22.3	20.2	18.8	9.3	8.4
60	21.7	17.4	14.7	3.0	-2.9	-4.4	22.2	17.8	15.2	3.5	-2.4	-3.9	24.5	22.5	20.4	18.9	9.1	8.2
90	22.9	18.2	15.1	4.8	-4.3	-5.4	23.5	19.4	15.6	5.3	-3.9	-4.9	25.6	23.7	21.5	19.8	8.8	7.5
120	23.4	19.3	16.5	6.7	-4.7	-5.9	23.9	20.1	16.9	7.2	-4.1	-5.2	26.3	24.1	22.1	20.2	9.1	6.7
150	24.6	20.4	18.8	9.7	-5.9	-7.1	25.1	21.4	19.3	10.4	-5.3	-6.8	27.1	24.9	23.6	21.4	12.4	6.1
165	25.3	22.3	20.8	11.8	2.6	-1.1	25.8	23.1	21.4	12.2	3.5	-0.9	27.8	26.0	23.8	22.0	14.2	8.5

Table A22: Temperatures Data of Weight 2 kg for Surrounding Temperature of 30°C, Composition of 4060 and Flowrate of 48 Liter per Minute

Time	Internal Probe (Celsius)						Inside Wall Probe (Celsius)						Outside Wall Probe (Celsius)					
(min)	T1	T2	T3	T4	T5	T6	TD1	TD2	TD3	TD4	TD5	TD6	L1	L2	L3	L4	L5	L6
0	30.5	29.9	30.2	29.8	30.0	30.7	30.5	30.3	30.6	30.1	30.0	30.7	30.6	30.7	30.7	30.7	30.7	31.1
5	26.6	23.0	20.0	16.5	15.9	18.7	27.1	23.4	20.5	17.1	16.4	19.1	29.5	27.6	27.6	26.8	25.6	27.7
10	25.1	22.2	18.6	15.8	12.7	8.2	25.4	22.6	19.1	16.3	13.3	8.6	28.1	25.1	22.2	20.2	18.1	17.1
15	24.2	21.8	17.6	11.7	9.7	5.3	24.6	22.1	18.0	12.3	10.2	5.8	27.0	24.8	20.2	18.4	17.8	23.8
20	23.5	19.8	16.4	9.7	6.6	1.5	23.9	20.1	16.9	10.2	7.1	1.9	26.6	23.3	19.7	16.5	16.3	22.6
25	23.0	19.3	15.5	6.6	4.1	-2.9	23.6	19.7	15.9	7.1	4.8	-2.5	25.3	23.7	19.5	15.7	15.3	20.3
30	22.9	19.0	14.5	5.7	3.4	-4.9	23.3	19.4	15.1	6.1	3.9	-4.3	25.1	23.5	19.3	15.1	14.7	18.6
35	22.7	18.8	14.2	5.1	2.9	-5.5	23.1	19.1	14.8	5.8	3.3	-5.1	25.0	23.3	19.1	15.0	14.5	14.0
40	23.1	18.6	13.3	3.7	2.7	-6.5	23.6	19.0	14.1	4.3	3.1	-6.1	25.2	23.9	19.7	15.4	14.1	13.5
45	23.7	18.0	13.2	3.2	2.6	-7.8	24.1	18.5	13.9	3.9	3.0	-6.6	25.4	24.1	20.1	16.2	13.8	12.4
50	24.9	17.7	13.0	4.1	2.9	-8.0	25.3	18.1	13.7	4.3	3.3	-7.7	26.5	24.3	20.5	17.9	13.7	10.4
55	25.8	18.4	13.8	6.2	3.6	-7.9	26.4	18.9	14.2	6.9	4.1	-7.2	27.6	24.5	21.1	18.7	13.2	9.2
60	27.0	19.6	15.0	6.5	4.1	-7.6	27.2	20.1	15.7	7.6	4.7	-6.9	28.7	24.8	21.9	19.1	13.7	7.7
90	28.1	20.6	16.7	10.2	8.9	-5.5	28.3	21.1	17.2	11.4	9.5	-5.1	29.2	25.4	24.4	19.1	16.3	12.7
115	29.1	23.4	20.6	13.8	10.8	5.1	29.3	23.9	21.1	14.6	11.1	5.4	29.6	26.4	25.8	21.4	18.8	16.7

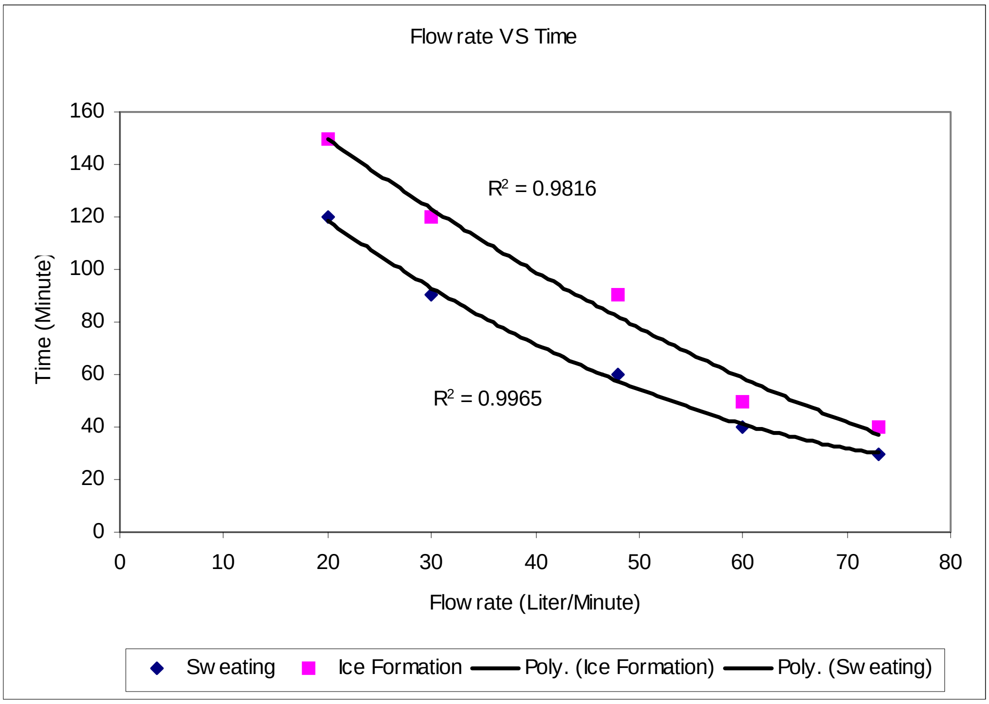
Table B23: Sweeting and Icing Data

Composition (Propane)	Sweeting (Minute)	Ice Formation (Minute)	Temperature (Celsius)	Flowrate (Liter/Minute)	Weight (kg)
100	45	55	30	48	6
80	50	60			
60	55	70			
40	60	90			
0	60	90			

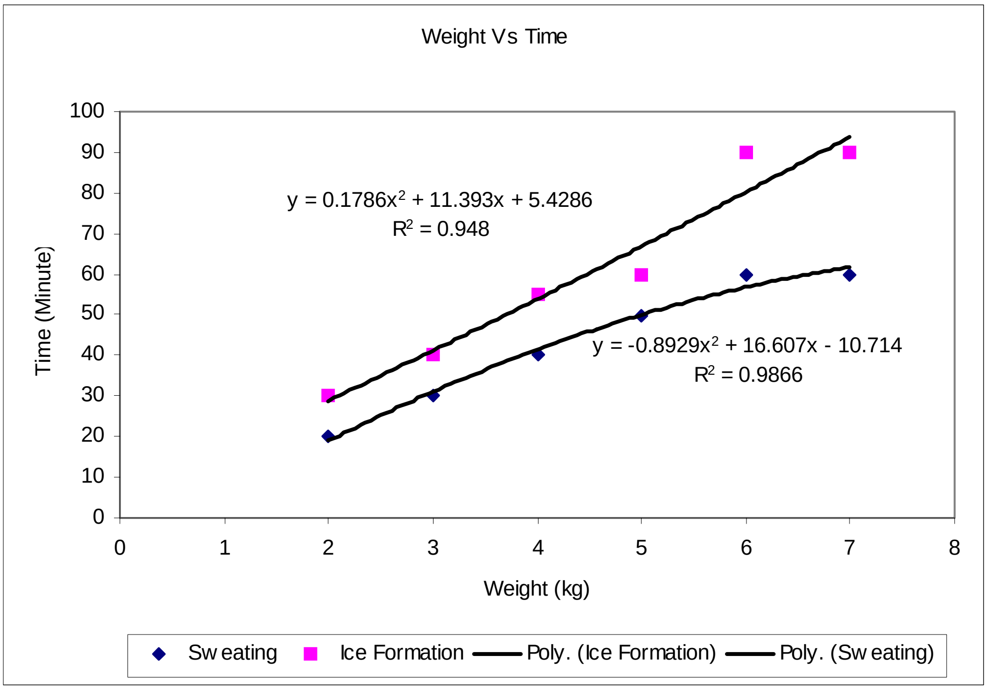
Temperature (Celsius)	Sweeting (Minute)	Ice Formation (Minute)	Composition (Propane/Butane)	Flowrate (Liter/Minute)	Weight (kg)
35	60	90	4060	48	6
30	60	90			
25	55	70			
20	40	60			
15	30	50			
10	25	45			

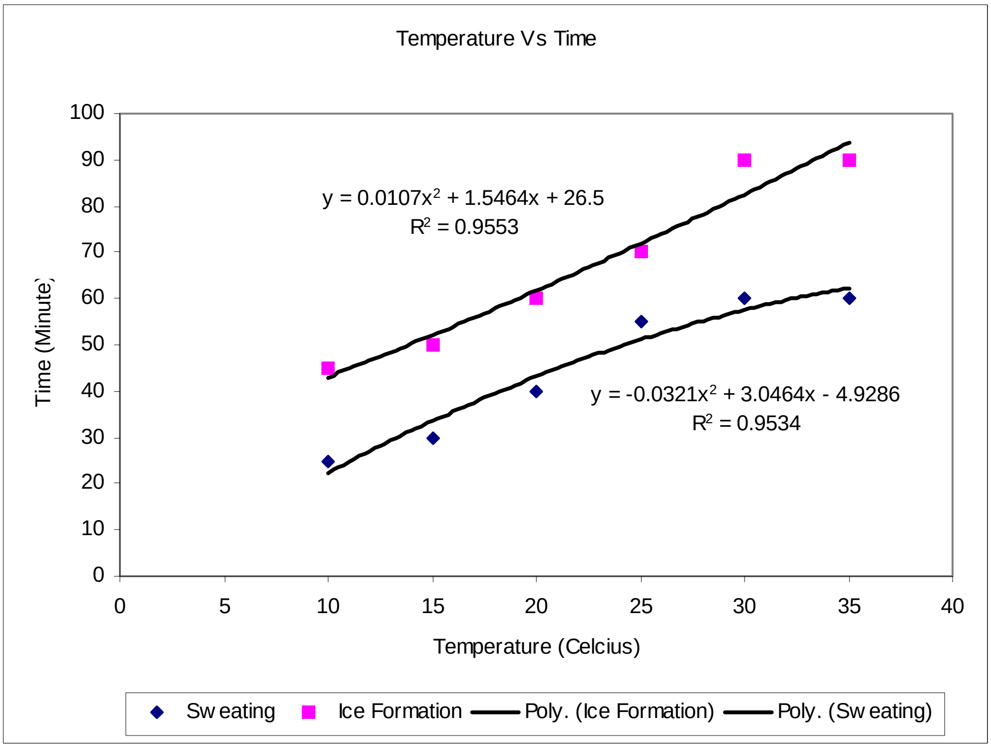
Flowrate (Liter/Minute)	Sweeting (Minute)	Ice Formation (Minute)	Composition (Propane/Butane)	Flowrate (Liter/Minute)	Weight (kg)
73	30	40	4060	48	6
60	40	50			
48	60	90			
30	90	120			
20	120	150			

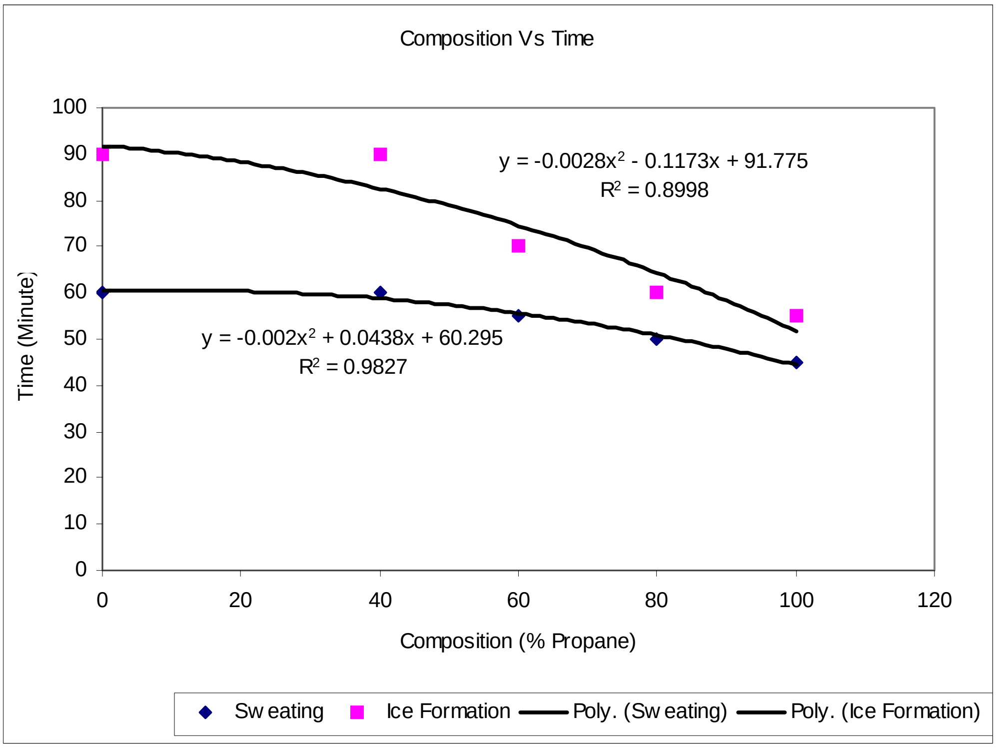
Weight (kg)	Sweeting (Minute)	Ice Formation (Minute)	Composition (Propane/Butane)	Temperature (Celsius)	Flowrate (Liter/Minute)
7	60	90	4060	30	48
6	60	90			
5	50	60			
4	40	55			
3	30	40			
2	20	30			



Flow rate VS Time
Time (Minute)
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Flow rate (Liter/Minute)
R^2 = 0.9816
R^2 = 0.9965
Sweating
Ice Formation
Poly. (Ice Formation)
Poly. (Sweating)


Weight Vs Time
y = 0.1786x² + 11.393x + 5.4286
R² = 0.948
y = -0.8929x² + 16.607x - 10.714
R² = 0.9866
Time (Minute)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
Weight (kg)
Sw eating
Ice Formation
Poly. (Ice Formation)
Poly. (Sw eating)


Temperature Vs Time
y = 0.0107x² + 1.5464x + 26.5
R² = 0.9553
y = -0.0321x² + 3.0464x - 4.9286
R² = 0.9534
Time (Minute)
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
Temperature (Celcius)
Sw eating
Ice Formation
Poly. (Ice Formation)
Poly. (Sw eating)



Composition Vs Time
100
90
80
70
60
50
40
30
20
10
0
Time (Minute)
y = -0.0028x2 - 0.1173x + 91.775
R2 = 0.8998
y = -0.002x2 + 0.0438x + 60.295
R2 = 0.9827
0
20
40
60
80
100
120
Composition (% Propane)
Sweating
Ice Formation
Poly. (Sweating)
Poly. (Ice Formation)