EXPERIMENTAL STUDY OF HEAT TRANSFER IN ASPHALT SOLAR COLLECTOR

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A thesis submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Mechanical)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JUNE 2015

To my beloved mother, father and my wife

ACKNOWLEDGEMENT

First of all, gratefulness of thanks to our creator, “ALLAH” for this continuous blessing, which make this work neither the first nor the last. Especially I would like to express my deepest gratitude to my project supervisor, Assoc. Prof. Dr. Nor Azwadi Bin Che Sidik, for all the guidances, advices and supports that given to me in the process of completing this thesis.

Last but not least, my appreciation goes to my wonderful parents and my wife and all family member specially my brother Hameed for their moral and financial supports that made me successful in my studies. I wish you long life and prosperity and the one above all of us, the omnipresent God, for giving me the strength and wisdom to finish my thesis, thank you so much.

ABSTRACT

This study investigates the heat transfer in asphalt collector. In this study, the first approach is based on increasing the heat gain which is captured by solar energy on asphalt pavement in order to decrease surface temperature. The second approach is related to decrease the time required to cooling the pavement surface. Experimental study used to determine the temperature distribution in the asphalt collector. The study was conducted with large scale of geometry; by using circulation water inside two separate layer copper coil in order to increase the contact area between the asphalt and fluid and compare the result with single layer different depth and combination between the upper and lower coil layer. The results of study show that the use combination of two layer coil have significantly on decreasing the surface temperature and enhance heat capture by bringing high amount of solar energy out which reduce the risk due to increase the temperature .

ABSTRAK

Kajian ini mengkaji pemindahan haba dalam pengumpul asfalt. Dalam kajian ini, pendekatan pertama adalah berdasarkan haba terkumpul yang ditangkap oleh tenaga solar di atas turapan asfalt untuk mengurangkan suhu permukaan. Pendekatan kedua adalah berkaitan dengan mengurangkan masa yang diperlukan untuk menyejukkan permukaan turapan. Eksperimen dilakukan untuk menentukan pengagihan haba dalam pengumpul asfalt. Kajian dijalankan dengan geometri berskala besar iaitu dengan menggunakan edaran air dalam dua lapis wayar kuprum yang berasingan untuk meningkatkan luas sentuhan antara asfalt dan bendalir dan membandingkan keputusan dengan kedalaman lapisan tunggal yang berbeza dan kombinasi antara lapisan wayar atas dan bawah. Keputusan kajian menunjukkan penggunaan kombinasi dua lapisan wayar telah mengurangkan suhu permukaan dengan signifikan, dan menangkap haba dengan mengeluarkan sejumlah tenaga solar yang tinggi, sekaligus mengurangkan risiko pertambahan suhu.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Global warming presents a serious threat all around the world. These become every country all around the world make reconsideration towards more sustainable economic model and mind set which requires more active involvements all country around the worlds. As a efforts towards that objective, many of the private sector come out with the news product that can leads to decrease the global warming. As energy price grows fast, concurrently with the awareness of the environmental issue also grow fast among all the public in nation

Use of renewable energy has become one of the most important measures to achieve sustainable development. As a result, many countries have released policies to encourage the utilization of renewable energy resources in various sectors [6-8]. As a renewable energy source, solar energy is virtually inexhaustible and its efficient utilization has played a crucial role in dealing with issues associated with use of traditional fossil fuel energy such as environmental pollution and depletion of natural resources[9-11]

At present, the main application modes of solar energy are photo thermal conversion and photovoltaic-electricity conversion [12]. Asphalt pavements are featured with a big heat absorbing area and strong heat absorption ability [13]. Especially in suburbs, the pavements are perennially exposed to air. Except for traveling vehicles, there is generally no sun shading. In summer, asphalt pavements

subject to solar radiation can reach high temperatures causing not only environmental problems such as the heat island effect on cities but also structural damage due to rutting or hardening as a result of thermal cycles[14]. In winter, there are significant safety risks associated with the snow and ice on pavements due to increased probability of traffic accidents. Most common methods to remove ice or snow on road pavement include manual, mechanical and chemical methods. However, there are limitations associated with these methods of deicing or snow-melting, such as safety risks, erosion of reinforcing steel in pavement, and high cost of maintenance[15]. The reduction of fossil fuel consumption and gas emission to the atmosphere motivates research and development of new energy generation methods: renewable, clean, and respectful of the environment. Asphalt pavement has gained more and more attention in recent years as an interesting new renewable energy source [16]. The sun provides a cheap and abundant source of clean and renewable energy.

The radiation from the Sun reaching the Earth generates heat on the ground. The solar radiation depends on the latitude and the angle of incidence From a Meteorological perspective, radiation variation in world for horizontal surfaces and as it seems the central and northern world. As shown in Figure 1.1. From meteorological perspective, radiation variation in world for horizontal surfaces and as it seems the central and northern world. As shown in Figure 1.1, this is measurements of the NASA Research Center.

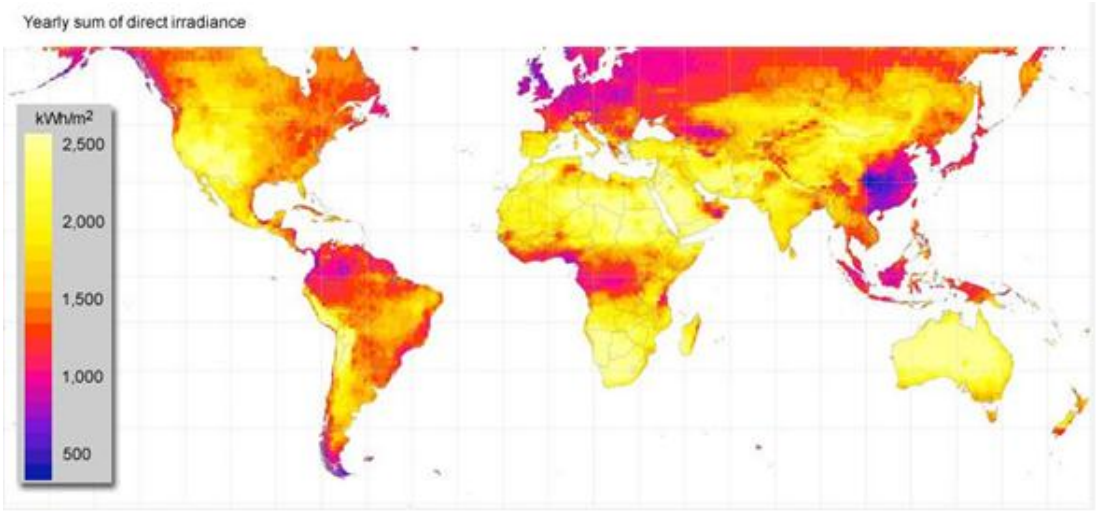

Figure 1.1 The average annual solar radiation variations in world

In asphalt solar collector (ASC), the fluid is circulated through a series of pipe circuits laid below pavement surface. The irradiation from the sun and the atmosphere is absorbed by the pavement and then the fluid through the pipes brings the solar energy out and stored in the ground over summer time. Hence, the energy is used for the heating of adjacent buildings as well as to keep the pavement, ice-free directly in winter [17]. Numerous studies have been conducted on the amount of energy that can be extracted, the amount of energy that is needed to keep an asphalt road free of ice, and the effect of energy transfer on temperature distribution along the depth of asphalt pavements [18]. ASC provides us a better alternative method for snow melting because of such system generally has higher energy efficiency than boilers or electrical heaters. Furthermore, by extracting heat in the summer and providing heat in the winter as shown in Figure 1.2.

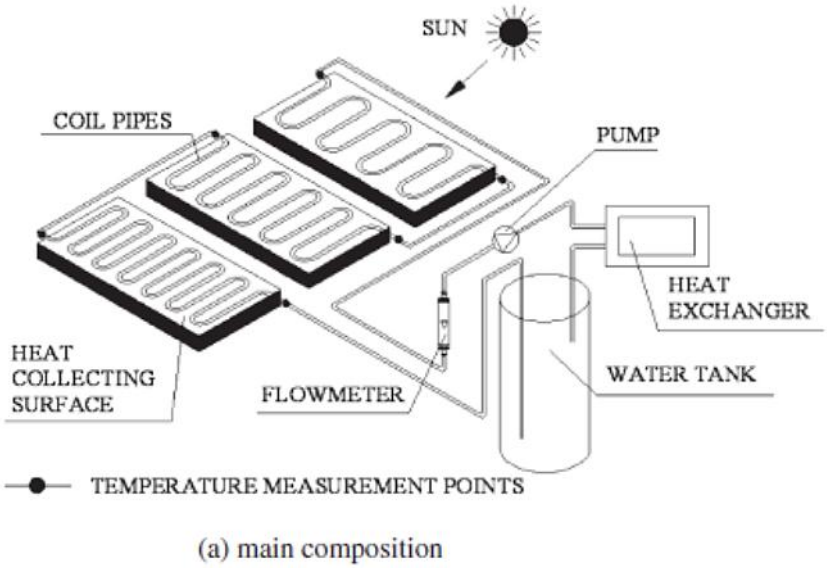

Figure 1.2 Schematic diagrams of the solar collecting [2]

Asphalt solar collector (ASC) provides us a better alternative method for snow melting. The higher fluid temperature is a positive way to improve the performance of snow melting system. Asphalt concrete is widely used in parking lots, tarmacs, airport runway, bridge deck, roadways, etc. Therefore, it is desirable that ice and snow be removed effectively to keep asphalt pavement free [19].

Asphalt solar collectors consist of pipes embedded in the pavement with a circulating fluid inside as shown in Figure 1.2 Solar radiation causes an increase in pavement temperature. Due to the temperature gradient between the fluid circulating through the pipes and the pavement, a heat transfer process occurs from pavement to a fluid which leads to a drop in pavement temperature and an increase in fluid temperature. This drop in asphalt temperature contributes to mitigate the heat island effect and reduce the risk of permanent deformations. However, what makes asphalt solar collectors really interesting is their ability to use the temperature rise undergone by the circulating fluid to harness energy. Asphalt solar collectors are usually coupled with low temperature geothermal heat pumps, obtaining reasonable efficiency and operating costs. The energy obtained from asphalt solar collectors is generally used for snow-melting systems or to maintain thermal comfort of adjacent buildings. There are also concrete solar collectors, but because of the black color, the asphalt solar absorption coefficient is higher than concrete [20].

Therefore, there is a strong pressure to obtain the necessary energy from a source of renewable. Because like this buildings frequently have large adjacent paved areas (roads and vehicle-parking lots), there is a great potential for collecting and/or storing solar energy using these adjacent surfaces which are already required and funded for operational purposes (e.g. from a transportation or parking budget) [3] reported a full-scale trial of such a ‘pavement energy system’ (PES), installing pipes close to a pavement surface, thereby optimizing the pavement to collect solar energy in a pavement heat collection (PHC) configuration. Pavements, by installing loops at greater depths, might also be used as a heat source during winter and as a heat sink during summer.

1.2 Problem Statement

The Asphalt pavement surface temperature can reach up to 70 ℃ in summer inducing a rise in temperature of the air above, which is generally known as the heat island effect. It causes an increase in power consumption due to the use of air

conditioning and a decrease in air quality in cities. Moreover, pavements under such high temperatures are prone to suffer from rutting. In particular, the thermal oxidation rate doubles with each 10 K increment in temperature [21]. To design asphalt Solar collector for which depend on the Solar radiation The asphalt pavement surface temperature can reach up to 70 ℃ in summer inducing a rise in temperature of the air above, which is generally known as the heat island effect. It causes an increase in power consumption due to the use of air conditioning and a decrease in air quality in cities [21]. The study will concentrate on design asphalt pavement as solar collector in Malaysia to reduce the effect of big surface of road on environment.

The using of circulating water inside the pipe reduce the surface temperature of asphalt pavement but that's not enough to prevent the asphalt pavement from radiation to the surrounding that cause island heat especially after the temperature of asphalt became higher than surrounding. All researchers using one layer of pipe. This study will concentrate on heat transfer enhancement by using tow layer of copper pipe to absorb a lot of heat from ASC to reduce the time required to decrease the surface temperature.

1.2 Scope of the Study

- Experimental study in asphalt solar collector in Malaysia.
- Large scale asphalt solar collector.
- Using tow layer of copper coil embedded in asphalt solar collector.
- Using water as working fluid

1.4 Objectives of the Study

The objectives of in this project as following:

- To measuring surface temperature of asphalt solar collector
- To measuring temperature distribution in asphalt solar collector
- Demonstrate Efficiency of the Asphalt Solar Collector
- To Analysis the Heat Transfer and Enhancement

1.5 Outline of the Thesis

This thesis dividing into five chapters as following:

Chapter 1 represents the problem statement and scope of this study. Applications of the study and the objectives of the project are reported.

Chapter 2 contains the literature review which is related to the temperature distribution and enhances heat transfer in asphalt collector geometries involving experimental and numerical studies for three-dimensional geometries. The parameters that related to the thermal conductivity, pipe length, pipe spacing and inlet temperature fluid, while the last section is related to experimental work.

Chapter 3 details on the research methodology to be exercised focuses on design asphalt solar collector and the procedure for experimental work and experimental setup in asphalt collector. This chapter shows the experimental procedures for solving the present problem in details as well as the assumptions and limitations.

Chapter 4 This chapter introduces the results of the present experimental work to investigate the effects of with and without circulating water different flow.

Chapter 5 the summary and the conclusions obtained from the experimental work with related suggestions for future work.

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