PRELIMINARY STUDY ON BRICKS DRYING PROCESS USING MICROWAVE TECHNOLOGY

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Mechanical - Advanced Manufacturing Technology)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JUNE 2015

*To my beloved parents **SALAH** and **NOUR** who have supported me all the time, to my waif **Um Muaad** for her unyielding support during my study period, as well as my brothers (Abdullaziz, Khalid, Mouhammed, and Ahmed) and my sisters. And all that help me in any way for the successful completion of this work.*

الى اغلى واحب الناس الى قلبي **امي وابي**, الى زوجتي الغالية **ام معاذ** . الى قرة عيني ابنائي . الى اخواني واخواتي . الى اصدقائي جميعا..

ACKNOWLEDGEMENT

All praises are due to **Allah** the cherished, who taught man with a pen, what he knew not. My thanks and gratitude go to **Allah** for bestowing me with wisdom, will, and good health throughout the period of my master study. I asked Allah Subhanahu wataallah to bestowed peace and blessings upon His Messenger, Muhammad S.A.W, and all his family and companions.

I would like to express my deepest gratitude towards my supervisor **Assoc. Prof. Dr. Izman Bin Sudin** for his guidance, encouragement and valuable comments during the research and writing of this project report. His attentions and technical expertise were key elements to my success. I am satisfied in gaining an in depth knowledge from him. My respectful also to my co-supervisor **Dr. Denni Kurniawan** and **Dr. Engku Nazim** for their advices, valuable comments and suggestions.

I wish also to express my sincere appreciation to my friends **Mr. Yahaya Bashir** and **Mr. Tijjani Abdullahi** for their cooperation, time and insight on related matters during this research.

Last but not the least, I am thankful to my friend **Mr. Thamer** and indebted to all those who helped me directly or indirectly in completion of this project report.

ABSTRACT

Clay brick is one of the essential materials in building construction. The demand for clay brick has been increased over the years as it goes along with the rise of world population and industrial building constructions. The current state of brick manufacturing process is still very traditional where drying of clay brick takes very long time and labour intensive. Adding to this problem, uneven heating during drying and firing affect a lot to bricks quality which often cause cracks. This research aims to evaluate the effectiveness of microwave energy source against the conventional methods for drying four different types of clay bricks. Green clay samples were pressed into a slab specimen at different compositions (%clay, %water, %lime, %fly ash). Later, the green samples were dried under four different mediums (natural, hot air, electric oven and microwave). The quality of dried bricks was compared in terms of water absorption, density, and porosity. It is found that microwave heating outperforms the three conventional heating methods by drying all types of brick samples without crack. Design of experiment (DOE) was utilized to evaluate significant factors (temperature (60-70-80oC), time (6-8-10 min) and percentage of charcoal (0-3-6%)) to dry red brick samples. Responses were crack density, brick density, water absorption and moisture contents. Analysis of variance indicates that all three factors are significant. Temperature is the most influential factors among the three affecting all responses. It is found that drying bricks at 70oC succeeding without any crack generation on the samples. It is also noted that a significant faster drying rate is seen when adding various percentages of charcoal contents in brick samples. From the results obtained, it is concluded that microwave technology has a great potential to be applied as a heating source in the production of bricks. The usage of this technology is foreseen able reduce the intensive labour dependent in brick manufacturing industry and this method is able to manufacture brick in a more sustainable environment.

ABSTRAK

Bata tanah liat bahan penting dalam industri dan ia telah digunakan untuk pelbagai jenis tujuan membina. Kaedah tradisional bata tanah liat pengeringan mengambil masa yang lama untuk kering. Dalam tempoh itu, banyak masalah berlaku disebabkan pemanasan tidak sekata ia akan menjejaskan kualiti batu bata itu. Tesis ini bertujuan untuk memberikan kaedah alternatif pengeringan dan mengesan kemungkinan menggunakan gelombang mikro sebagai teknologi baru untuk proses pengeringan yang berkesan. Microwave disebabkan cepat kering adalah dicadangkan untuk produk baru bata tanah liat atau bahan buangan kitar semula seperti abu terbang dengan menukar kepada produk bata. Satu sampel basah tanah liat ditekan ke dalam papak yang telah tertakluk dalam penyinaran gelombang mikro daripada 2.45 GHz. Kelakuan pengeringan telah dibandingkan antara empat mod: ketuhar gelombang mikro, ketuhar elektrik, udara panas, dan pangkalan udara semula jadi pada masa pengeringan, retak, penyerapan air, ketumpatan dan keliangan. Data dan keputusan yang diperolehi daripada ujian yang telah dianalisis dan dipersembahkan dalam format yang lebih sesuai, seperti graf, jadual, dan kenyataan. Pemanasan gelombang mikro dengan kuasa yang tinggi menyebabkan pecah spesimen apabila persediaan suhu yang dicapai pada 100^{o}C. Walau bagaimanapun, jika kuasa yang dikawal untuk mengekalkan suhu yang kurang daripada titik wap air pada 70oC atau kurang, pengeringan berjaya tanpa generasi retak sehingga selesai dengan berbanding dengan sumber-sumber pemanasan konvensional. Ia juga menyatakan menambah peratusan variasi arang (3-6%) Kadar pengeringan secara signifikan lebih cepat. Kesan tiga parameter input, yang suhu (60-70-80^{o}C), masa pengeringan (6-8-10 min), dan peratusan arang pada generasi retak, dan masa pengeringan telah dianalisis dengan menggunakan reka bentuk eksperimen (DOE) kaedah. Melalui analisis ANOVA, ia telah mendapati bahawa suhu adalah parameter yang paling penting yang memberi kesan untuk semua tindak balas. Penambahan adalah arang yang besar ke atas kadar pengeringan dan kepadatan. Daripada keputusan dari ujian yang diperolehi menunjukkan bahawa teknologi gelombang mikro boleh diperkenalkan kepada pengeluaran bata talian sebagai sumber pemanas. Ia akan menyumbang untuk membuat proses automatik industri bata, mengurangkan masa pengeluaran dan mengurangkan potensi kerosakan ke atas manusia dan alam sekitar.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	-	Analysis of Variance
DF	-	Degree of Freedom
BS	-	British Standard
CMC	-	Critical Moisture Content
DOE	-	Design of Experiment
MMC	-	Minimum Moisture Content
MS	-	Mean Square
MW	-	Microwave
RSM	-	Response Surface Methodology
SABS	-	South African Bureau of Standards
SBF	-	Simulated Body Fluid
SS	-	Sum of Square

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides an insight the research conducted on bricks drying process using various methods including microwave technology. A brief overview on microwave technology and related issues are also discussed. It is followed by the problem statement, objectives, scopes and significance of the research work.

1.1 Background of Problem

Microwaves were fundamentally used for communication. In the middle of the last century 1950, it was discovered that microwave energy can heat materials. Now microwave ovens have become more common for cooking and heating food products. Researchers have been looking for ways to utilize the advantages of microwave for industrial applications. Microwave is primarily used for heating, but non-thermal applications have also been studied. The most striking feature of microwave heating is volumetric heating, which is rather different from conventional heating where the heat must diffuse in from the surface of the fabric. Volumetric heating means that materials can absorb microwave energy internally and convert it to heat. It is this characteristic that leads to advantages using microwaves to process materials (Wu, 2002).

In the past, microwave heating had been successfully applied in the next fields: tempering meat, preheating rubber slugs, vulcanizing rubber, precooking bacon, drying pasta, drying crushed oranges, and so on (Kamble and Patil, 2015).

Clay brick is an important materials used in the building industries. Its applications range from building houses, factories, waterways, tunnels, bridges, etc. Its properties vary according to the purpose for which they are intended, but it have provided the basic material of construction for centuries. Clay brick have been used for construction for thousands of years, and some advances have been achieved to make the process easier and faster. The essential technique for making bricks from clay has remained unchanged. Green clay products can be dried "naturally" or artificially" (Gillott, 2012).

Common Issues in conventional drying of clay brick; drying process consists of many stages. Therefore that take a lot of time from 2-5 days. For natural drying which are using natural sources such as Sun, wind, and open-air drying, the complete drying need a long time (3days-week) depend weather condition. And required to use a large of space (220 x 106 m^2) for 1000 pieces. Cracking is one of the major issues in brick manufacturers and the losses can be up to 20% because these conventional heating often creates uneven heating in the clay brick which cause cracking. Artificial drying process using chamber dryers, tunnel dryers, and kiln that need equipments such as fans, channels, valves, controlling systems, heating source, and power. Additionally, the energy and labour intensive, long time production, large area, and high fuel consumption (5MJ kg-1) that will be make production process costly. Other more important problem the conventional heating using fuel is extremely harmful to the environment (Dlamini, 2014).

1.2 Problem Statement

Clay bricks are usually fired using fuel, gas or even natural wood. These conventional heating often creates uneven heating in the clay brick which cause cracking. Cracking is one of the major issues facing by brick manufacturers and the losses can be up to 20% of monthly production (Musielak and Śliwa, 2015). Brick production can be categorised as energy and labour intensive industry (Pirasteh *et al.*, 2014). Since a lot of energy used for drying process as well as involving many manual operations. Microwave technology has been seen a more sustainable method to the current heating techniques for brick industry. Despite many studies using microwave technology in drying processes, however, there is not much research reported that applies this technology for brick drying and firing process.

1.3 Objectives of Study

The objectives of this project were as follows:

1. To determine the feasible range of microwave parameters for effective drying different clay bricks
2. To evaluate the properties of clay bricks after dried using microwave energy source with and without adding charcoal contents
3. To determine significant microwave parameters that affect dried brick properties.

1.4 Scopes of Study

1. Modified domestic microwave oven (Elba Operating at 2.45GHz and output power of 700W) was used to dry brick specimens. Operating

temperature and time were varied: 60-70-80^{o}C and 6-8-10 minutes respectively.

2. Charcoal was varied from 3 – 6% in the clay and served as a microwave susceptor during heating.
3. Three types of bricks were prepared, namely; Kaolin, Red and Fly ash
4. Properties of dried bricks were compared in terms of moisture contents, water absorption, density, porosity and cracking nature.

1.5 Significance of Study

It is well known that microwave technology has a great potential for reducing energy consumption as compared to high power furnace and kiln that powered by fuel/gas for drying process of brick. The successful application of microwave energy in brick drying would also potential in reducing processing time from days to hours and able to reduce percentage of cracks due to uniform heating. This process is simple and possible to be automated for mass production. It uses very low current, clean production and utilize non-toxic raw material which makes the whole process a more environmental friendly.

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