"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)"

Signature : Juhari Ab Razak

Supervisor : Juhari Bin Ab. Razak

Date : 30 May 2006

JUHARI BIN AB RAZAK
Pensyarah
Fakulti Kejuruteraan Mekanikal
Kolej Universiti Teknikal Kebangsaan Malaysia
Karung Berkunci 1200
75450 Ayer Keroh, Melaka.

HEAT FLOW IN THE CONFINED SPACE BY USING DIFFERENT HEAT SOURCES

NURULAZILA BINTI ABD MAJID

This thesis is submitted to Faculty of Mechanical Engineering
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Faculty of Mechanical Engineering
Kolej Universiti Teknikal Kebangsaan Malaysia

May 2006

"I hereby declare that this thesis entitled "Heat Flow in the Confined Space by Using Different Heat Sources" is the result of my own research except as cited in the references"

Signature	: Nurulazila
Name	: Nurulazila Binti Abd Majid
Date	: 30 May 2006

Specially dedicated to my lovely family,

Mr. Abd Majid Bin Anjang Ahmad

Mrs. Tomini Binti Mohd Yunus

Mr. Shahrul Azman Abd Majid

Mr. Khairul Azhar Bin Abd Majid

Miss. Nurul Hafidah Binti Abd Majid

Miss. Nurul Ain Aqilah Binti Abd Majid

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Thanks for being my precious inspiration.....

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Faculty of Mechanical Engineering, KUTKM

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ABSTRACT

This report discusses the use of different heat source to show the heat flow pattern in confined space. It covers various studies on heat sources in investigation of free convection in a confined space. The heat sources were investigated for their energy, heat distribution and heat flow pattern. This study is to determine the most efficient heat sources based on time and cost. Two shapes of ovens with the same volume were fabricated as case studies. This research combines experimental and simulation of heat transfer analysis techniques to analyze the heat distribution pattern using different heat source in various shape of oven based on convectional baking application. From the results the best performance of heat source can be best determined based on the time taken to cook, cost and reliability. Heat source with higher temperature will reduce the cooking time. This innovation of convection oven can be applied in small and medium scale food industry.

ABSTRAK

Laporan tesis ini membincangkan tentang penggunaan sumber api yang berbeza bagi menunjukkan lakaran atau bentuk aliran haba dalam ruang yang tertutup. Ianya meliputi pelbagai kajian tentang sumber api yang berkaitan dengan pemanasan bebas dalam ruang yang tertutup. Sumber api ini akan dikaji dari segi tenaga, pembebasan haba serta bentuk aliran haba. Ini adalah untuk mengetahuikan bahan api yang paling efektif berdasarkan masa dan kos. Dua bentuk oven yang sama isipadunya telah direka bagi kajian kes ini. Kajian ini juga merangkumi pentafsiran data secara ujikaji dan simulasi berkaitan teknik analisis pemindahan haba bagi mendapatkan keputusan seterusnya menganalisa taburan haba bagi bahan api yang berlainan untuk bentuk-bentuk oven yang berbeza bergantung kepada aplikasi pemanasan ketuhar. Daripada keputusan yang diperolehi, bahan api yang paling baik prestasinya akan dikenalpasti berdasarkan masa yang diambil untuk memasak, kos dan kebaikannya. Bahan api yang mempunyai nilai suhu yang tinggi akan mengurangkan masa untuk memasak. Penciptaan ketuhar pemanasan ini boleh diaplikasikan pembuatan makanan oleh industri kecil dan sederhana.

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LIST OF SYMBOLS

SYMBOL	DEFINITION
Q	Heat Rate (Watts)
k	Thermal conductivity coefficient (W.K/m)
L	Length/thickness of the medium (m)
A	Cross sectional area, m^2
H	Convective film coefficient ($W/m^2{}^oC$)
T	Temperature in Kelvin, K or °C
q'	Local heat flux (dq/dA)
m	Mass

SUBSCRIPT	DEFINITION
T_h	Hotter temperature (C or K)
T_c	Colder temperature (C or K)
T_s	Surface temperature
T_∞	Ambient Q/ = Convection heat transfer (W)
T_a	Fluid temperature (°C)
T_t	Target temperature (°C)

GREEK	DEFINITION
Σ	Stefan- Boltzman constant, 5.67 x 10-8 Watts/m^2 K4
E	emissivity

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This research looks into one problem of food industry in Malaysia. One of the foods is "lemang". The process of cooking 'lemang' is very tedious. It requires great care of controlling open burning fire to cook this food. The cooking is usually done outdoor and open space as it is uses firewood as the burning material. This will caused problem during rainy and windy days as the fire is hard to control.

The times it takes to cook 'lemang' is quite lengthy, usually between three to four hours. A new innovation is proposed to cook 'lemang' indoor and to provide better control of heat. This new innovation uses convection oven as its main concept to provide consistent heat flow during the cooking process. In order to use the oven a new heat source is needed to provide a better control of heat distribution and if possible to reduce cooking time.

1.2 Statement of Study

A better heat source is required to replace firewood in convection oven. Firewood requires proper care in drying process to get optimized results if it to be used in the proposed oven. The research will look into feasible heat sources to be used in the convection oven prototype.

1.2.3 Objectives

The objectives of the research are:

1. To compare the heat flow patterns of different heat source within a confined space.
2. To optimize the heating based on time, energy and cost

1.2.1 Scope of Study

The scopes of this research are:

1. To compare the heat flow patterns of different heat source within a confined space (convection oven)
2. To measure the heat transfer properties inside of a free convection oven
3. To compare the experimental result and simulation for Computational Fluid Dynamic software.
4. To investigate and optimize the profitable heating material that can be use in this research so that it can reduced time, energy and cost.
5. Chart the heating patterns of gas burner, charcoal and electric heater within a cuboid.
6. Test the cooking time for several food products.

GANT CHART FOR PSM

Activities	January				February				March				April			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Topic Discussion, Information Searching, Literature Review																
Conceptual Design																
Fabricate square oven																
Run the experiments for square oven																
Fabricate hexagon oven																
Run the experiment for hexagon oven																
Draft writing for final report																
Final Presentation																

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews topics on heat transfer, its utilizations in several types of oven and application in food industries. It also reviews some researches devoted to defining various baking application. However all of these studies involved specific in manufacturing of baked goods. The literature review report is the method evaluations to provide valuable insight into the way to get the result of the good performance of heat sources.

2.2 Introduction to Heat Sources

From website (www.fpl.fs.fed.us/documnts/usda/agib666/aib66603.pdf), Charcoal, a form of amorphous carbon, is produced when wood, peat, bones, cellulose, or other carbonaceous substances are heated with little or no air present. A highly porous residue of microcrystalline graphite remains. Charcoal is a fuel and was used in blast furnaces until the advent of coke. Today most charcoal is used for recreational, restaurant, and home cooking in the form of charcoal briquettes. A small amount of charcoal is used in

certain metallurgical processes and as a filter to remove organic compounds such as chlorine, gasoline, pesticides, and other toxic chemicals from water and air.

In 1961, the Forest Service counted nearly 2,000 charcoal-producing units in the United States, including brick kilns, concrete and masonry block kilns, sheet steel kilns, and retorts and ovens. Ninety-four percent of these were in the eastern United States and accounted for 98 percent of the Nation's charcoal production (Baker, 1985). Much of the lump charcoal produced today is produced in Missouri, where many manufacturers operate small kilns or retorts.

2.3 Introduction to Heat Transfer

Heat transferred from oven to food by:

1. Irradiation from oven walls.
2. Convection from circulating air.
3. Conduction through the tray on which the food is placed.

2.3.1 Conduction

Conduction is the most straight forward means of heat transfer. It is simply the movement of heat from one item to another through direct contact. For example, when the flame of a gas burner touches the bottom of a sauté pan, heat is conducted to the pan. The metal of the pan then conducts heat to the surface of the food lying in that pan.

Generally, metals are good conductors. Copper and aluminum are the best conductors, while liquids and gases are poor conductors. Conduction is important in all cooking methods because it is responsible for the movement of heat from the surface of a food to its interior. As the molecules near the foods exterior gather energy, they move

more and more rapidly. As they move, they conduct heat to the molecules nearby, thus transferring heat through the food (from the exterior of the item to the interior).

In conventional heating methods (non microwave), the heat source causes food molecules to react largely from the surface inward so that layers of molecules heat in succession. This produces a range of temperatures within the food, which means that the outside can brown and form a crust long before the interior is noticeably warmer. That is why a steak can be fully cooked on the outside but still rare on the inside.

$$Q = \frac{k\ A\ (T_h - T_c)}{L}$$

Where,

Q = heat rate (Watts)

k = thermal conductivity coefficient (W.K/m)

A = surface area of the medium (m2)

L = length/thickness of the medium (m)

T_h = hotter temperature (C or K)

T_c = colder temperature (C or K)

2.3.2 Radiation

Unlike conduction and convection, radiation does not require physical contact between the heat source and the food being cooked. Instead, energy is transferred by waves of heat or light striking the food. Two kinds of radiant heat are used in the kitchen which is infrared and microwave.

Infrared cooking uses an electric or ceramic element heated to such a high temperature that it gives off waves of radiant heat that cooks the food. Radiant heat waves travel at the speed of light in all direction unlike convection heat, which only rises until they are absorbed by a food. Induction cooking uses a special induction coil placed

below the stovetop's surface in combination with specially designed cookware made of cast iron or magnetic stainless steel.

The coil generates a magnetic current so that the cookware is heated rapidly with magnetic friction. Heat energy is then transferred from the cookware to the food by conduction. The cooking surface, which is made of a solid ceramic material, remains cool. Only the cookware and its contents get hot.

The actual formula for heat transfer by radiation is given by the Stefan-Boltzman equation:

$$\frac{\Delta Q}{\Delta t} = e \sigma A T4$$

Where,

σ = Stefan- Boltzman constant, 5.67 x 10-8 Watts/m^2 K4

e = emissivity

A = cross sectional area, m^2

T = temperature in Kelvin, K

For dark objects have an emissivity close to 1, while shiny or white objects have an e closer to 0.

2.3.3 Convection

Convection refers to the transfer of heat through a fluid, which may be liquid or gas. Convection is actually a combination of conduction and a mixing in which molecules in a fluid (whether air, water or fat) move from a warmer area to a cooler one.

There are two types of convection, natural and mechanical. Natural convection occurs because of the tendency of warm liquids and gases to rise while cooler ones fall. This causes a constant natural circulation of heat. For example, when a pot of stock is