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INSULATION OF CONFINED SPACE FOR OPTIMIZATION OF HEAT FLOW.

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This thesis is submitted to Faculty of Mechanical Engineering
in partial fulfillment of the requirements for the award of the degree of
Bachelor Degree in Mechanical Engineering (Thermal-Fluids).

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May 2006

"I hereby declare that the thesis "Insulation of confined space for optimization of heat flow" is the result of the work of my own research except as cited in the references".

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" Sebalung budi dan ucapan terima kasih buat ayahanda.Mamat Bin Ismail. bonda. Sharah Binti Ibrahim serta keluarga Abdul Yazid Bin Mamat. Mohd. Riduan Bin Mamat. Badrul Hisyam Bin Mamat dan Mohd. Firdaus Bin Mamat yang sentiasa memberi sokongan dan nasihat sepanjang anakanda menyiapkan tesis ini. Restu dan berkat doa ayahanda bonda serta keluarga penguat semangat buat anakanda..."

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ABSTRACT

This report discussed the use of insulation in confined space for optimization of heat flow. The objective of this project is to compare the insulation materials of a confined space for the optimization of heat flow. The scope of this project is to study the effect of several insulation materials for confined space, i.e. oven, using several heat sources and to find the optimum material based on time and cost. Several materials are tested for oven insulation. Simulations of heat flow pattern as well as experimental data are discussed. Suitable insulator will be based on heat maintained; cost and time. The experimental data are derived from the insulation testing on two type prototype ovens such as square shape and hexagon shape. The insulators are also tested using several heat sources. The results show that the use of insulation in the prototype oven has help reduce the time for cooking several food products.

ABSTRAK.

Repot ini mengandungi perbincangan mengenai penggunaan penebat bagi kawasan yang tertutup untuk mengoptimumkan pengaliran haba. Objektif projek ini adalah untuk membandingkan antara jenis-jenis bahan penebat bagi kawasan tertutup untuk mengoptimumkan pengaliran haba. Skop projek ini adalah untuk mengkaji kesan beberapa jenis bahan penebat untuk kawasan tertutup contohnya, oven dengan menggunakan beberapa jenis sumber haba dan untuk menyelidik bahan yang terbaik berdasarkan masa dan kos. Beberapa bahan telah diuji untuk dijadikan penebat oven. Simulasi mengenai corak aliran haba dan data eksperimen turut dibincangkan. Penebat yang sesuai akan dipilih berdasarkan kestabilan haba, kos dan masa. Data eksperimen diperolehi daripada ujian penebatan pada dua jenis oven prototaip iaitu berbentuk empat segi dan heksagon. Penebat diuji menggunakan pelbagai sumber haba. Keputusan kajian menunjukkkan bahawa penggunaan penebat di dalam oven prototaip membantu mengurangkan masa untuk memasak pelbagai produk makanan.

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LIST OF SYMBOLS

SYMBOL	DEFINITION
$\dot{Q}$	Heat transfer
h	Convection heat transfer coefficient or film conductance
A	Area
x	Thickness
k	Thermal conductivity
L	Length

GREEK LETTER	DEFINITION
δ	Distance
σ	Stefan- Boltzman constant, 5.67×10^{-8} Watts/m^2 K^4
ε	Emissivity

SUBSCRIPT	DEFINITION
T_w	The wall temperature
T_∞	The fluid free-stream temperature
T_h	The hotter temperature
T_c	The colder temperature
T_s	The surface temperature
A_s	The area of surface

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The research looks into problem of outdoor food industry in Malaysia. Common problems are requirements by city council, open burning, smoke and weather condition. This industry requires some innovations to make it more competitive and environmental friendly.

One of the ideas is to make use of the convection oven for this outdoor food industry. A prototype of such an oven has been developed. In order to provide better heat flow and distribution, and to prevent heat loss, better insulation of the oven is required.

1.2 Statement of the Problem

"Lemang" is usually cooked outdoor because it uses firewood, which contributes to open burning and causing smoke. The use of prototype convection oven will minimize the problems and made it possible to cook it indoor using selected heat source. The use oven in indoor cooking of "lemang" can be further optimized by using proper insulation around the oven to prevent heat loss. Better

insulation will reduce cooking time and cost. A study on insulation materials best suited for this prototype convection is required.

1.3 Objective of Study.

The objective of this project is to compare the insulation materials of a confined space for the optimization of heat flow, properties inside of a free convection oven, and then to compare the results to theoretical heat transfer models by simulation using FEA software. In this research, heat flow pattern inside the confined space using the insulations will be studied.

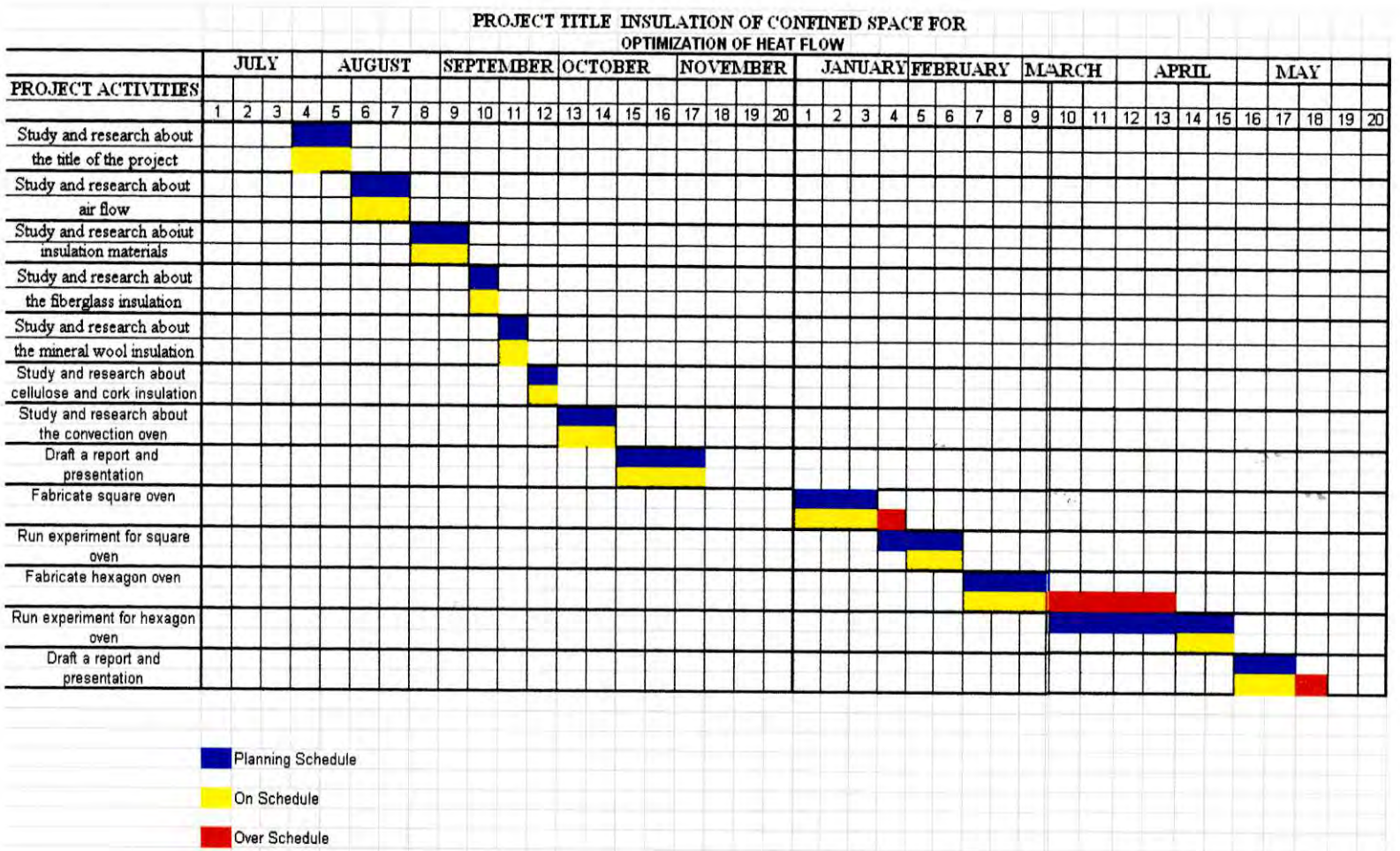
1.4 Scope of Study.

The scope of this project is to study the effect of several insulation materials inside confined space using several types of heat sources and to find the optimum material as based on time and cost. In this study, the confined space is defined as a prototype convection oven. Several shapes of oven will be tested as well as several insulation materials.

1.5 Importance of the Study.

i. To recognized the advantages and the disadvantages for each sample of insulator used.
ii. To find the most efficient insulator for the optimized flow of heat for free convection oven in enclose sure space.
iii. To evaluate the heat flow pattern in different shapes of oven using different insulation.

1.6 Gantt Chart



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A residential oven (the oven use at home) encompasses three basics modes of heat transfer which are conduction, convection and radiation. For simplicity the convectional baking process of standard residential oven will be considered, for which the lower resistive heating element is the sole source of heat generation within the oven cavity. For the residential oven it can divide into three basic components same as our ovens, which are the resistive heating element, the oven liner material and the air inside of the oven.

Insulation is the practice of providing a barrier surrounding, or within a confined space to slow the conductive flow of heat. A reflective barrier is often added to insulation to slow radiative heat flow. Insulation's main purpose is to stop the flow of heat. The trapped air is called dead air. The dead air is a barrier that helps stop the flow of heat. Stopping this flow can keep heat out or inside an oven.

2.2 Convection ovens

An oven is an enclosed compartment for heating, baking or drying. It is most commonly used in cooking and pottery. Two common kinds of ovens are gas ovens and electric ovens. Ovens used in pottery are also known as kilns. Convection ovens use heated air that is forced into the oven by fans located in the back of the oven, generally for cooking food. By moving heated air past the food, convection ovens operate at a lower temperature than a standard conventional oven and they can cook food more quickly. They are mostly used in industrial and commercial applications, but can be purchased for the home as well. With a convection oven there will be about a 25 to 30% decrease in cooking temperature and a 20% decrease in cooking time as compared to a conventional oven. Convection ovens reduce food shrinkage, so you can probably squeeze out an extra serving.

Also the oven cavity of the convection oven will cook more food per cubic inch than a regular oven. Since this heat-circulating fan is not inside the oven cavity, the oven can be filled from top to bottom as long as an inch of space is left for the air to circulate between the food and the oven walls. Frequently smaller in size, the convection oven has less air in the oven to heat, making convection an efficient choice of ovens.

Figure 2.1: Image of a convection oven.
[Courtesy of http://www.geocities.com/yummyphysics/imgconvection/]

`In a regular oven, air is warmest close to the heat source. Placement of food is critical for best results since food cools the air immediately around it and the area near the elements may be too hot. When the air is still, heat rises from the source at the bottom and collects at the top of the oven. In the regular electric oven, food must be place in the centre of the oven for even baking and roasting results. The convection oven moves cool air away from the food. As hot air flows around the food, the cool air is recirculated past the source of heat.

Convection ovens provide more uniform heat than regular ovens by moving the oven air away from both the heat source and the top of the oven cavity. Circulating hot air seals in natural juices from the start of cooking. With a convection oven, food cooks faster or at a lower temperature than it does in a regular oven.

Figure 2.2: Heat flow in the convection oven.
[Courtesy of http://www.geocities.com/yummyphysics/imgconvection/]

To use a convection oven most efficiently, the oven door must be kept closed as much as possible. Airflow must be maintained. The air in the oven must circulate freely. Shape of food affects convection cooking. A long thin meat cooks faster than a bulky one of the same weight because more surfaces are exposed to moving hot air. Size of pan also must be considered. The same quantity of food cooks faster in two small pans than it does in one large pan since air can circulate more freely.

2.2.1 Oven

An oven is an enclosed compartment for heating, baking or drying. It is most commonly used in cooking and pottery.

2.2.2 Types of Ovens:

i. Conventional Thermal Oven: It uses upper and lower elements or gas heat so it can lower the cost and fewer features.

ii. Thermal-Convectional Oven: Higher quality, better cooking performance, more even cooking throughout the oven cavity. Another feature to look for is the "hidden bake element". This enables to use the lower 30% of the oven without concerns of burning the bottom of cakes, pies and casseroles. There are ovens claiming to be convection, but they really just have a fan moving air. Look for convection ovens with an additional heating element in the back of the oven with the fan and it known as pure convection or European convection.)

iii. Micro/Convection Oven: There are a few manufacturers that make Convection ovens with microwave features that mix convection and microwave to speed cooking time and maintain food quality. These ovens provide excellent usage of space by allowing one appliance to do the job of two.

2.2.3 Advantages of convection oven:

Thermal insulation in high-density, very low thermal conductivity fiberglass, contained behind aluminum panels. The insulating material fits the outer surfaces of the baking compartment perfectly, thus making it possible to reduce to a minimum any heat dispersion and consequently, saving energy. The nutrients are preserved and

the actual taste of the food also remains same. A minimum quantity of oil is required for cooking any type of dishes. This is good for health.

Unlike standard ovens, in which heat moves slowly from the heat source to the food, convection ovens use a fan to move hot air around the oven cavity. Because of this continuous circulation of heat, baked goods release their steam faster, resulting in flakier croissants and pastries, while meats and poultry render their fat more quickly, creating nicely browned skin and juicy meat. And because the heat is more intense, foods in a convection oven generally cook up to 25 percent faster. Since circulating air heats faster than does still air of the same temperature, food is heated more efficiently than with still air, resulting in cooking times 1/3 faster than regular ovens

Another advantage of convection cooking is the ability to cook many things at once. Because of the fan, you can fill up your oven racks with multiple items and not have to worry about uneven heat. Not only will your food cook faster, but your gas and electric bill will be much friendlier. The amount of time saved varies with the type of food cooked. With some foods, the convection oven cooks at a lower temperature than a regular oven, for about the same time.

2.2.4 The differences between convection ovens and regular ovens

In a regular oven, with a heat source located at the bottom, the hot air floats up to heat the food right above the heat source. Thus, the bottom of the food you're cooking is heated more efficiently than the top, so it's easy to burn the bottom. Also, the air flow is unpredictable, especially if the oven is overfilled, which may lead to the food not being cooked properly. A convection oven uses a built-in fan to distribute the hot air more evenly. Furthermore, the food cooked in a convection oven rarely burns (unless you keep it in for *too* long) and comes out nice, crispy and evenly cooked. Convection ovens cook up to 20% faster than regular ovens. Also,