"I declare that I had read this thesis and according to my opinion, this thesis is enough to fulfill the purpose for award of the Bachelor Degree in Mechanical Engineering from the aspects of scope and quality."

Signature : ....

Supervisor : Dr. Mohd. Yusof Bin Sulaiman

Date : ...20/5/06...........

A NUMERICALLY STUDY OF HEAT FLOW DISTRIBUTION IN A MULTI PURPOSE ENCLOSURE

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This thesis is submitted to the Faculty of Mechanical Engineering as a partial fulfillment of the award of Bachelor Degree in Mechanical Engineering

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MAY 2006

"I declare that this thesis entitled "A numerically study of heat flow distribution in multipurpose enclosure" is the result of the work of myself except for the reference which I had clarified sources."

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Date : ..19/05/2006...

This thesis is dedicated to my beloved father, Mr. Abdul Rahim bin Majidi, and also to my siblings, Mohd. Al-Gadhafee, Mohd. Faizal, Tuty Emily and not forgotten to my special one.

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ABSTRACT

This paper presents the numerical study of heat flow distribution in multi-purpose enclosure or particularly to develop a 3-D simulation of oven baking with Computational Fluid Dynamics (CFD) method which is using PHOENICS software packages. This is to analyze the simulation of temperature distribution in detail in the oven baking design. Besides, this report consists of the understanding concept of study which is prepared toward the actual research. The actual developments of this research start from the simple case study of a flow in a heated cavity. In the oven design, the suitable heat source is applied and the heat distribution is predicted by focusing on the effect of heat flow when differentiation of insulation material is applied. Furthermore the details in this paper also included the experimental process and the outcome for the comparison to the simulation result. Moreover, this final paper presents the result analysis and the analysis comparison of different cases based on different insulation material. As the final point, the recommendations for the further research on this study are stated.

ABSTRAK

Secara khususnya laporan ini menerangkan tentang kajian perangkaan pengagihan aliran haba di dalam tempat tertutup atau secara terperincinya untuk menghasilkan simulasi tiga dimensi oven menggunakan kaedah Computational Fluid Dynamics (CFD) dengan menggunakan perisian PHOENICS. Hal ini adalah untuk menganalisa simulasi pengagihan suhu atau haba di dalam oven secara terperinci apabila pemanasan berlaku. Laporan ini juga mengandungi pemahaman konsep tajuk kajian yang dijalankan. Penghasilan kajian yang sebenar bermula dari kes kajian yang ringkas iaitu aliran haba yang berlaku di dalam ruang berongga yang dipanaskan. Dalam rekaan oven, sumber haba atau pemanasan yang sesuai diaplikasikan dan pengagihan haba atau suhu diramalkan dengan memfokuskan kesan perbezaan beberapa bahan penebat terhadap aliran suhu di dalam oven. Selain dari itu, laporan ini juga menerangkan proses eksperimen yang dijalankan dan nilai data yang diperolehi sebagai perbandingan kepada keputusan simulasi yang diperolehi. Sebagai kesimpulan, cadangan dinyatakan untuk kajian yang lebih jauh untuk kes kajian yang telah dijalankan.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOL

SYMBOL	DEFINITION
k	Thermal Conductivity
q	Heat flow
h	Heat transfer coefficient
x	Thickness
l	Length
w	Width
t	Thickness
A	Area

GREEK

δ	Distance

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This research is to develop a numerical study of heat flow distribution or particularly the natural convection in enclosure by applying CFD simulation to analyze the flow of temperature distribution. Particularly this study is to develop a three-dimensional simulation of small baking oven. The convection oven concept has been chosen for this numerical study. The research is to develop the different geometry of the oven and predict the heat distribution inside the oven by applying heat source. Before starting the research it is important to understand the concept of the study itself.

This study starts with the understanding the concept of this research this study will be divided into two-part of study which is two-dimensional and three-dimensional numerical analysis of enclosures. Both cases of study are important to show the simulation of heat flow distribution or particularly the temperature profile inside an enclosure when the surfaces are heated with determined temperature. Besides, these cases is to achieve the research objectives it selves.

This study starts with developing a simple sketch or design of convection oven by considering the factor that effect the convection cooking. The factor to be considered in the design of convection oven will be reviewed in this report. Since the scope of the study is applying the heat source and predict heat distribution it is important to consider the heat source to perform best analysis. The final sketch or design will be created in CAD and subsequently to be constructed in CFD software followed by meshing and analysis.

By using CFD on this research, the design of internal components of oven could be redesign to achieve a more uniform heating. The expected analysis provides the information of temperature and velocity distribution in details which are useful for the oven design and process optimization.

1.1 Project Title:

A numerically study of heat flow distribution in multipurpose enclosure.

1.2 Objectives of Study

The objective of the study is to predict heat distribution in multi-purpose enclosure. In particular, the objective of presenting this study is to analyze the heat distribution under multiple temperature differences when heat sources are applied specifically in the temperature distribution in oven baking. In this numerical study a CFD simulation is suggested to gain the analysis. Furthermore, this study is to compare the result of analysis with experimental data.

1.3 Scope of Study

In the numerical study of heat flow distribution in multi-purpose enclosure there are three scopes to be achieved which are;

1.3.1 Design different geometries of enclosure with suitable contents.

Towards the achievement of this study, we will design the different geometry of an insulated oven in the environment of Computational Fluid Dynamics method and vary the study by differentiating the design with different types of insulation material.

1.3.2 Apply heat source and predict heat distribution.

In this numerical research we will study the effect of differentiation of insulation material to the heat distribution in the oven environment when heat source is applied. From the simulation result we could predict the heat distribution in the oven by effect of differentiation of oven considerations.

1.3.3 Acquire experimental data and compare result.

To gain the analysis comparison of experimental value and simulation value, hence experimental process is required. From the comparison we could determine the obstacles of the research itself and we could discover or predict ways to improve the outcome of the study.

1.4 Importance of the study

Natural convection due to differential heating of the vertical walls in the rectangular enclosures has been well studied in part because of wide range of application relevant to this phenomenon. Moreover, natural convection flow analysis in enclosures has many thermal engineering applications, such as cooling of electronic devices, energy storage systems and compartment fires. Furthermore, the concept of convection also applied in the oven baking to produce an oven with a uniform heating.

CHAPTER 2

THEORY AND DESIGN

2.1 Heat Flow

Theoretically, the other process by which the internal energy can change is through so called heat flow. This concept is more subtle and covers a range of physical processes which we shall give examples of in the following. In summary heat flow is the exchange of internal energy between thermodynamic systems. We denote heat flow into our system in consideration by ***dQ***. Thus in a process involving only heat flow and no mechanical work we have

$$dU=dQ$$

Again we have chosen the sign convention for ***dQ*** so that it is mainly a positive quantity for thermodynamic processes by which heat is converted to work. The three most important physical processes by which internal energy is exchanged between thermodynamic systems are radiation, conduction, and convection.

In the simplest of terms, the discipline of heat transfer is concerned with only two things: temperature, and the flow of heat. Temperature represents the amount of thermal energy available, whereas heat flow represents the movement of thermal energy from place to place. On a microscopic scale, thermal energy is related to the kinetic energy of molecules.

The greater a material's temperature, the greater the thermal agitation of its constituent molecules (manifested both in linear motion and vibrational modes). It is natural for regions containing greater molecular kinetic energy to pass this energy to regions with less kinetic energy. Several material properties serve to modulate the heat transfered between two regions at differing temperatures. Examples include thermal conductivities, specific heats, material densities, fluid velocities, fluid viscosities, surface emissivities, and more. Taken together, these properties serve to make the solution of many heat transfer problems an involved process.

2.2 Convection

Heat energy transfers between a solid and a fluid when there is a temperature difference between the fluid and the solid. This is known as "convection heat transfer". Generally, convection heat transfer can not be ignored when there is a significant fluid motion around the solid.

The temperature of the solid due to an external field such as fluid buoyancy can induce a fluid motion. This is known as "natural convection" and it is a strong function of the temperature difference between the solid and the fluid. Blowing air over the solid by using external devices such as fans and pumps can also generate a fluid motion. This is known as "forced convection".

Fluid mechanics plays a major role in determining convection heat transfer. For each kind of convection heat transfer, the fluid flow can be either laminar or turbulent. Laminar flow generally occurs in relatively low velocities in a smooth laminar boundary layer over smooth small objects, while turbulent flow forms when the boundary layer is shedding or breaking due to higher velocities or rough geometries.

2.2.1 Force convection

For cases where the fluid is already in motion, heat conducted into the fluid will be transported away chiefly by fluid convection. These cases, known as forced convection, require a pressure gradient to drive the fluid motion, as opposed to a gravity gradient to induce motion through buoyancy.

2.2.2 Free convection

When heat conducts into a static fluid it leads to a local volumetric expansion. As a result of gravity-induced pressure gradients, the expanded fluid parcel becomes buoyant and displaces, thereby transporting heat by fluid motion in addition to conduction. Such heat-induced fluid motion in initially static fluids is known as free convection.

In heat transfer, a distinction is made between free and forced convection. In this chapter, we will be focusing on free convection since the concept is applied on the case study itself which to design convection oven analyze the heat distribution. The temperature distribution of an oven is analyzed using CFD method. Free convection is convection in which motion of the fluid arises solely due to the temperature differences existing within the fluid. Example: hot air rising off the surface of a radiator.

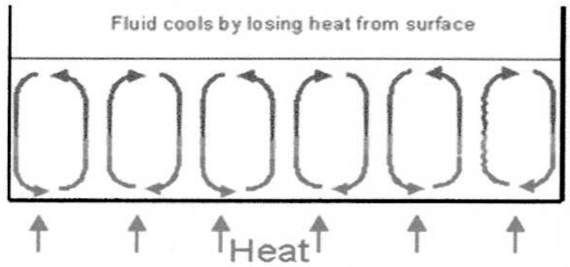

Figure 2.1 Concept of convection