"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's Degree in Mechanical Engineering (Thermal-Fluids) from the aspects of scope and quality."

Signature : .....
Supervisor Name : KOTHMAL ABDUL RAHEEM
Date : 16-12-2005

Signature : .....
Supervisor Name : NAZRI BIN MD DAUD
Date : 12/12/05

EXPERIMENTAL STUDIES OF THERMAL CONTACT RESISTANCE

MOHAMMAD NAJIB BIN ISHAK

SUBMITTED TO FACULTY OF MECHANICAL ENGINEERING
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OCTOBER 2005

I declare that this thesis entitled "title *of the thesis* "is the result of my own research except as cited in the references.

Signature : .....

Name : MOHAMMAD NAJIB B. ISHAK

Date : 16. 12. 2005

Special dedication to my family

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ABSTRACT

The project activities include the heat transfer concept with conductance mode, making and installation apparatus, experiment procedure to definite thermal contact resistance between 2 surfaces with external factor as different surface roughness, pressure, immediate insertion material, and power supply.

The method will used in this experiment where the electric heater will take action as the heat source, copper that had high value heat conductance will heat conductance become to the solid tested material (Copper, steel, aluminum) and also as heat sink. And water that was channeled to heat sink will take action as the cooler medium. Insulator that tight was needed to ascertain the heat flow system was in one dimension. The temperature reading will be taken in the position that was determined along material was tested, and the temperature of the surface of the intermediate can be known with way the outside determination if stable condition was reached.

The analysis of the decision was made through by graph and estimating. If might, variable that was undertaken will be compared between the value result and the value of the theory or join this two value.

ABSTRAK

Aktiviti projek merangkumi konsep pemindahan haba terutamanya melalui mod kekonduksian ,pembikinan dan pemasangan radas, prosedur eksperimen dan yang penting sekali menguji kobolehubahan rintangan sentuhan terma antara dua permukaan dengan faktor-faktor luaran seperti kekasaran permukaan pada spesimen , tekanan luar dan bekalan kuasa.

Kaedah yang digunakan dalam eksperimen ini adalah dimana pemanas elektrik akan bertindak sebagai sumber bekalan haba, tembaga yang mempunyai nilai pengalir haba yang tinggi akan menjadi pengalir haba kepada bahan pepejal yang diuji (Tembaga, keluli, aluminium) dan juga sebagai penenggelam haba. Dan air yang dialirkan secara sesaran pada penenggelam haba akan bertindak sebagai bahantara penyejuk. Penebatan yang ketat juga diperlukan untuk memastikan sistem pengaliran haba adalah dalam satu dimensi. Bacaan suhu akan diambil pada kedudukan yang ditentukan sepanjang pepejal diuji, dan suhu permukaan perantaraan akan dapat diketahui secara penentuan luar apabila keaadaan mantap dicapai.

Analisis keputusan dibuat melalui graf dan pengiraan. Jika boleh pembolehubah yang dijalankan akan dibandingkan antara keputusan nilai eksperimen dan nilai teori atau mengabungkan kedua-dua nilai tersebut.

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NOMENCLATURE

SYMBOL	CLARIFICATION	UNIT
$A_{d.c}$	The actual contact area	m^2
A	Area surface	m^2
C	Constriction number	-
h	Between surface conduction	W/K
K	Conduction number's	-
k	Thermal conduction	W/mK
k_o	Gases conduction at pressure zero	-
P	load	Kg
p	Contact pressure	Kg mm^{-2}
Pr	Prandtl number's	-
Q	Thermal fluke	W m^{-2}
q	heat	W
R	Contact resistance	K/W
S	Size between surface number's	-
T	temperatures	K
U	Conduction number's	-
u	Contact conduction per area	$Wm^{-2}K^{-1}$
K_1,k_2	Conduction between two solid at T_1 and T_2	-

GREEK LETTER	CLARIFICATION	UNIT
σ	Stefan-Boltzmann constant	5.67^{-8} W/m^{2}K^4
γ	Specific heat ratio	-
μ	Dynamic viscocity	g/cm.s
ν	Dynamic viscocity	μ/ρ

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.0 General

From the aspect of thermodynamic education, we knew that the power might not in destroyed or was composed like whatever that was stated in the principle of the eternity of the power, but it might to transfer from one form to the other form. For example, if a body allow fell free from the high place will receive the kinetic power and in the same period potential energy will decrease.

In thermodynamic science that involved relations between heat as one form of the power that as a result by effect of vibration of atoms or the molecule in solid material and fluids and as random velocity magnitude for the body situation in the form of gas. And usually his emphasis's the number heat that was moved if the system changed the direction from a balance in the other balance, and that important the level of or the period magnitude was not considered as the important factor for the length of the process. Whenever from the engineering aspect, the level of heat flow joined in give branch birth the study of science, the heat transfer.

1.1 Heat Transfer

From the aspect of the heat transfer also that was introduced with the system that where did not be in the balance thermal situation, and this was a phenomenon of the unbalanced system. This showed that in the heat transfer study

was to not suffice to make the thermodynamic principle simple as the basic reference. Although thermodynamic laws will help to understanding of transfer heat science. The need of the principle of the process of the heat transfer exist the temperature gradient; the system was said in the thermal balance if not the heat transfer clean around two mediums and this implication the situation a temperature. Whenever the stable situation, system was more important in the study of the thermal transfer. The stable situation (in a thermal manner) was said was reached if not again the change in the temperature in whatever which position in the system; the system might be still having the heat transfer clean provided that rate this was continue to confirm not the change in the temperature in which position.

This temperature gradient took measures as the urging power for the process of the heat transfer was current and might in analog as voltage in the electric flow current and as different the pressure in the fluids flow.

1.2 Heat Transfer engineering

Heat Transfer equipment like boiler, heat exchanger, heater, refrigerator, radiator and solar collector was design with the principle of knowledge of the analysis of the heat transfer. And the problem that will be dealt with in the design can be categories in two main collections;

i. Rating problem
   To determine rate of heat transfer in system with different temperature was defined.
ii. Sizing problem
   To determine size or system capacity to heat transfer goal on definite rating in deferent temperature definite.

The heat transfer process or equipment might be studied in a manner the experimentally, the measurement and testing or in a manner the analytically with the analysis and calculation. The experiment situation had goodness where it was most

exposed to the physical system that gave the decision that was as true with the limitation of the experiment error that limited. Although, this method of being expensive to take a long time and usually not practical. Whenever in the analytically method that had the fast and cheap surplus, but the decision accuracy that was found being most exposed to the view and perfection that were made in analysis. In the study of the heat transfer was better if joining the two the method once.

1.3 Objective Project

This is an experimental project to setup the experiment apparatus to study or investigate thermal contact resistance,

$$R_c = \frac{\Delta T}{Q} \quad (K/w)\ (^0C/w) \qquad 1.1$$

And temperature decrease at 2 contact specimen with the different surface roughness, external pressure, and power supply.

1.4 Scope

The project activities is including heat transfer concept with conductance mode, making and installation apparatus and experiment procedure to definite thermal contact resistance between 2 surface. Result analysis make through by graph and calculation.

1.5 Problem Statement

This analysis to achieve the thermal contact resistance Rc, at to contact specimen.

Various theories and the experiment value were undertaken to determine the value of the thermal contact resistance. But, reform that spread must be carried out around the value and the experiment of the theory get was caused by the attached kind of joining the surface is difficult. Correlation method in a manner the theory to measure the thermal touch was important and depending to how the accuracy of the characteristics of the surface. Conduction depended to thermal conductivity, the surface finished, the pressure in the touch and size as well as the form of the touch not fixed. In decisive thermal conduction the first important case must be carried out measure of the surface roughness.

CHAPTER 2

PROBLEM ANALYSIS

2.0 General

Thermal contact resistance is interest in many fields including internal combustion engineering, bearing with lubrication, heat transfer across granular solids, micro electrics, superconductor, aerospace structure, and biomedical prosthetics. The heat transfer will be current if being received the temperature gradient in some system. And the thermal flow or the heat transfer to the surface of the mediation of two materials must be estimated and controlled or the temperature drop at the interface known, then the conductance data must be available either from experiment or prediction. If the fall of the temperature was to the surface of the mediation known, then the conduction data the touch could be forecasted with more accurate. The thermal conduction data also was needed for the grating thermal (k) for some material. Heat transfer through two contacting bodies is characterized by a temperature drop across the interface.

In the analysis of the heat conduction through multilayer solids, we assumed "perfect contact" at the interface of two layers, and thus no temperature drop at the interface. This would be the case when the surface are perfectly smooth and are in perfect contact at each point. In reality, however, even surfaces that appear smooth to the eye appear rather rough when examined under a microscope, with numerous peaks and valley.

When two such surfaces are pressed against each other, the peaks will form good material contact, but the valley will form voids filled with air. Thus, an interface will contain numerous air gaps of varying sizes, which act as insulation because of the low thermal conductivity of air. Thus, an interface offers some resistance to heat transfer, and this resistance is called the thermal contact resistance Rc. As expected, the contact resistance is observed to decrease with decreasing surface roughness and increasing interface pressure.

$$R_c = \frac{\Delta T}{Q} \quad (k/w)\ (^0C/w) \qquad 2.1$$

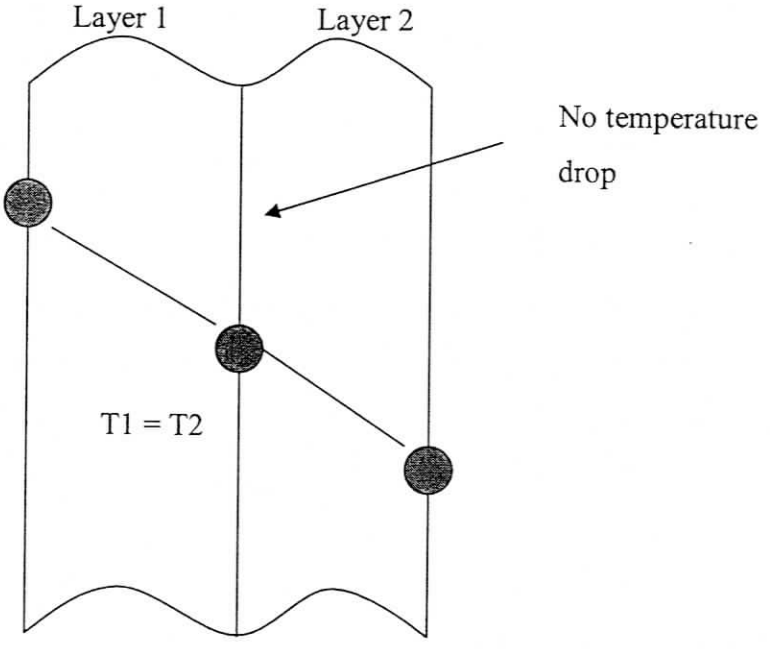

Figure 2.1: Perfect thermal contact