"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 Mechanical Engineering (Thermal-Fluid)"

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DEVELOPMENT OF MEASURING AMPLIFIER FOR THERMOCOUPLE MEASUREMENT

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

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I declare that this thesis entitled "Development of Measuring Amplifier for Thermocouple Measurement" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently in candidature of any other degree.

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ABSTRACT

During making this research, it is study about amplifier and heat transfer in more details. Heat transfer is divided into three categories which are conduction, convection and radiation. There also needs to know about hardware because for easily choose while doing experiment to get the suitable data. And also about thermocouple, the first thing need to know is the temperature of pipe or ducting need to measure. Then that can choose a suitable thermocouple with temperature. The table of thermocouple is used as a reference in measuring temperature. In order making interface, the main device needed is PIC16F877 and MAX232. In this research also, the measuring amplifier was developed. It is used to increase the potential voltage of thermocouple from mV level to the level between 0 and 5V. This is required to reduce the quantization error during the sampling process using internal analogue to digital converter installed in PIC16F877 before transfer the data to a local PC

ABSTRAK

Sepanjang kajian diajalankan, banyak membincangkan tentang *amplifier* dan pemindahan haba dengan lebih terperinci. Pemindahan haba dibahagikan kepada tiga bahagian iaitu konduksi, konveksi dan radiasi. Juga dikehendaki untuk menganalisa tentang perkakas kerana akan memudahkan pemilihan barang dengan betul apabila hendak melakukan eksperiment bagi mendapat data yang sesuai. Dan juga mengenai *thermocouple*, yang paling penting ialah mengetahui suhu pada paip dan salur yang hendak diukur. Dengan itu boleh memilih *thermocouple* yang sesuai dengan suhu. Jadual *thermocouple* digunakan sebagai rujukan dalam pengukuran suhu. Untuk menghasilkan pengantara, alat utama yang diperlukan ialah PIC16F877 dan MAX232. Dalam kajian ini juga, *amplifier* pengukuran telah dibina. Ia digunakan untuk menaikkan voltan potensi bagi thermocouple dari peringkat mV ke peringkat antara 0 dan 5V. Ini diperlukan untuk mengurangkan ralat sepanjang proses persampelan menggunakan *internal analogue to digital converter* yang telah dipasang pada PIC16F877 sebelum memindahkan data ke Komputer.

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SYMBOL	DEFINITION
V	Voltage
I	Current
R	Resistance
T	Temperature

GREEK	DEFINITION
∞	Infinity
Ω	Ohm

SUBSCRIPT	DEFINITION
in	Input
out	Output
M	Mean
L	Low
H	High

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CHAPTER 1

INTRODUCTION

1.1 Heat transfer

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 material's temperature, the greater thermal agitation of its constituent molecules (manifested both in linear motion and vibration 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 transferred 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.

Heat is defined as energy transfer due to temperature gradient or difference. Whereas heat is the exchange of energy between hot and cold objects and we understand the exchange to occur from the hot to the cold one. Heat transfer is predicts how fast the energy exchange as heat occurs. Transfer of heat are describing, when a hot object is placed in cold surroundings, it cools; the object loses internal energy, while the surroundings gain internal energy.

Heat transfer mechanisms can be grouped into 3 broad categories:

Conduction is regions with greater molecular kinetic energy will pass their thermal energy to regions with less molecular energy through direct molecular collisions, a process known as conduction. In metals, conduction-band electrons also carry a significant portion of the transported thermal energy.

Convection is, 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.

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.

For radiation terms all materials radiate thermal energy in amounts determined by their temperature, where the energy is carried by photons of light in the infrared and visible portions of the electromagnetic spectrum. When temperatures are uniform, the radiative flux between objects is in equilibrium and no net thermal energy is exchanged. The balance is upset when temperatures are not uniform, and thermal energy is transported from surfaces of higher to surfaces of lower temperature

The engineering discipline of heat transfer is concerned with methods of calculating rates of heat transfer. Engineers to design components and systems in which heat transfer occurs use these methods. Heat transfer considerations are important in almost all areas of technology. Traditionally however, the discipline that has been most concerned with heat transfer is mechanical engineering because of the importance of heat transfer in energy conversion systems, from coal-fired power plants to solar water heaters.

1.2 Heat in pipe

A device which makes use of changes of phase heat transfer in a novel way is the heat pipe. A circular pipe has a layer of wicking material covering the inside surface with a hollow core in the center. A condensable fluid is also contained in the pipe, and the liquid permeates the wicking material by capillary action. When heat is added to one end of the pipe (the evaporator) liquid is vaporized in the wick and the vapor moves to the central core. At the other end of the pipe, heat is removed (the condenser) and the vapor condenses back into the wick. Liquid is replenished in the evaporator section by capillary action.

Although the basic concept will work in the absence of gravity, the heat pipe may be tilted so that the condenser is at a higher elevation than the evaporator. In this case, the action of gravity serves to speed the flow of liquid down through the wicking material. This is called a favorable tilt. In contrast, when the condenser is placed at a lower elevation than the evaporator the action of gravity will impede the flow of liquid in the wick and the heat pipe is said to have an adverse tilt.

A reservoir containing a noncondensable gas is connected to the heat removal end of the heat pipe. This gas may then form an interface with the vapor and "choke off" part of the condensation to the wick. With increased heat addition, more vapors are generated with an increased in vapor pressure, and the noncondensable gas is forced back into the reservoir, thereby opening up additional condenser area to remove the additional heat.

For a reduction in heat addition, just the reverse operation is observed. If the heat source temperature drops below a certain minimum value, depending on the specific fluid and gas combinations in the heat pipe, a complete shutoff can occur. So the control feature can be particularly useful for fast warm-up applications in addition to its value as a temperature leveler for variable load conditions.

Heat pipes are particularly useful in energy conservation equipment where it is desired to recovered heat from hot gases for air-preheat or supplemental heating applications. In some cases the heat pipe can take the place of more costly combinations of pump, piping, and dual heat exchanger configurations.

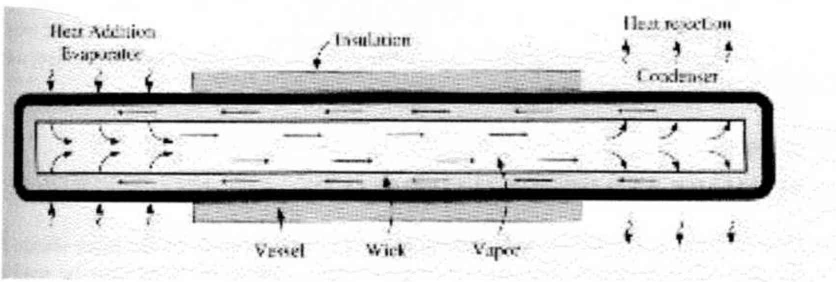

Figure 1.1: Heat pipe configuration in horizontal position

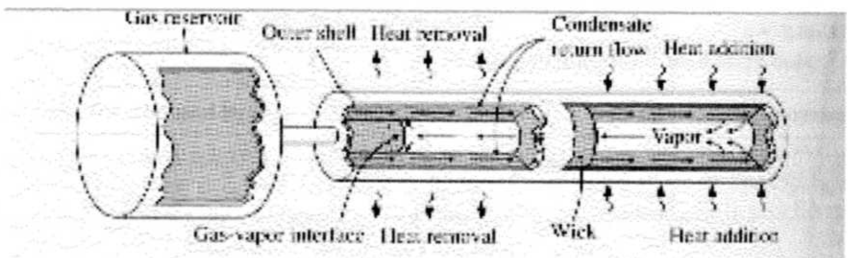

Figure 1.2: Variable conductance heat pipe configuration

1.3 Problem statements

How to take data to record to computer is the most important thing need to be considered. Most real world data are not in a form that can be directly recorded by a computer. These quantities typically include temperature, pressure, distance, velocity, mass and energy output (such as optical, acoustic, and electrical energy). Very often these quantities are measured versus time or position.

A physical quantity must first be converted to an electrical quantity (voltage, current or resistance) using a sensor or transducer. This enables it to be conditioned by electronic instrumentation, which operates on analog signals or waveforms (a signal or waveform is an electrical parameter, most often a voltage, which varies with time). This analog signal is continuous and monotonic, that is, its values can vary over a specified range (for example, somewhere between –5.0 volts and +3.2 volts) and they can change an arbitrarily small amount within an arbitrarily small time interval.

To be recorded by a computer, data must be in a digital form. Digital waveforms have discrete values (only certain values are allowed) and have a specified (usually constant) time interval between values. This gives them a stepped (noncontinuous) appearance. When this time interval become small enough the digital waveform becomes a good approximation to the analog waveform. If the transfer function of the transducer and the analog instrumentation is known, the digital waveform can be an accurate representation of the time-varying quantity to be measured.

The process of converting an analog signal to a digital one is called analog-to-digital conversion, and the device that does this is an analog-to-digital converter (ADC). The resulting digital signal is usually an array of digital values of known range (scale factor) separated by a fixed time interval (or sampling interval). If the values are sampled at irregular time intervals, the acquired data will contain both value and time information.

1.4 The importance of study

Most of the studies of measuring amplifier had been carried for thermocouple measurement at pipe or ducting.

In this research the measuring amplifier was developed. It is used to increase the potential voltage of thermocouple from mV level to the level between 0 and 5V. This is required to reduce the quantization error during the sampling process using internal analogue to digital converter installed in PIC16F877 before transfer the data to a local PC.

Besides, thermocouple is also important that we need to know the details about it. Such as the type of thermocouple that can be measure the temperature.

1.5 Purpose of study

This research is carried out to investigate the temperature at pipe or ducting using data logging with following objectives:

i. Develop measuring amplifier for thermocouple measurement
ii. Study how to convert voltage to temperature value depends on type of thermocouple.
iii. Use different method while doing an experiment for comparison.

1.6 Scope of the study

This research is focused on the field of study for data logging and temperature measurement. The scope of the projects consists of:

i. Study the heat transfer in the pipe or ducting
ii. Study the development of measuring amplifier.
iii. Develop the amplifier using suitable thermocouple.
iv. Apply the experiment for measuring amplifier for external cold joint of the measuring.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Data Logging

Data in a general term used to describes numbers, letters and symbols present with a computer system. A data logger is an electronic device that is used to record measurements over time.

Data logging is the process whereby physical data e.g., temperature, humidity, motion, pressure or light is collected using electronic sensors, which are usually built in to a device known as a data logger. The data is then downloaded from the data logger and stored to a computer or other hardware such as a laptop, personal digital assistant (PDA) or graphics calculator. Specialized software programs enable this data to be displayed on a computer (or other hardware) in the form of charts, graphs and tables

Data logging is essentially no control (by a computer) of the instrument, process or system that provides the data. The information is simply continuously sent to the data logger (computer) and stored or displayed.

Data logging involves the use of electronic devices to sense, measure and record physical parameters in an experiment. A wide variety of sensors are available: motion, force, current, voltage, temperature, pressure, photo gates, etc. Data logging measurements are made in real time and displayed simultaneously using either a graphic calculator or a computer. Alternatively data may be collected remotely using a data-logger and subsequently downloaded into a graphic calculator or computer.

With hand-held technology it is possible to collect, store, display and analyze data both at and away from the laboratory bench. Data collected can be displayed in tables and graphs and the software available allows for sophisticated analysis. Data logging technology allows the student to collect and store data in a short period of time and to focus on its analysis. It also has the advantage that the experiment may be repeated easily if necessary

Digital data loggers have been refined into valuable energy-auditing tools. They make it easy to collect detailed information over a long span of time with a high degree of accuracy. But many auditors and contractors are still hesitant to use these expensive, high-tech devices. They still depend on instincts, senses, and instruments that give one bit of data for one moment in time

In contrast, real time data acquisition and control implies that a computer, not only acquires data and stores them in memory, but also mathematically 'processes' such data and then transmits control signals back to the instrument process or system.

2.2 Advantages of Data Logging

Using computers to record data has a number of advantages over recording data manually:

- Measurements are always taken at the right time. Unlike a human the computer will not forget to take a reading or take a reading a little bit too late.
- Mistakes are not made in reading the results. Humans can make errors when e.g. they read the temperature off a thermometer.
- Data logging devices can be sent to places that humans can not easily go to. e.g. to the planet Mars, into the bottom of a volcano, or onto a roof to get to a weather station.
- Graphs and tables of results can be produced automatically by the data logging software
- Record data accurately and instantaneously
- Store data in the memory of the data logger with a view to connecting it at a later time to a computer (or other hardware) for presentation, analysis and manipulation
- Produce a "real time" graphical representation of an investigation or experiment on a computer monitor
- Pause an experiment in order to add text to a graph to mark actual events within the experiment
- Focus on the development of students' scientific enquiry and higher order thinking skills such as data analysis, interpretation of graphs, result prediction and reflecting on the control of variables
- Collect data at different intervals, for a specified time or at a time of a particular event, such as a threshold of sound, temperature or light
- Promote collaborative learning