# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## TEMPERATURE MONITORING OF WATER PUMP RELATIVE TO THE EFFECT OF FLOWRATE IN PIPELINE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Engineering Technology Faculty) (Hons.)

by

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# DECLARATION

I hereby, declared this report entitled "Temperature Monitoring of Water Pump Relative to The Effect of Flowrate in Pipeline" is the results of my own research except as cited in references.

| | | |
|---|---|---|
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# APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power)(Hons.). The member of the supervisory is as follow:

………………………………

AHMAD MUZAFFAR BIN ABDUL KADIR

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# ABSTRAK

Pemantauan suhu pam air relatif dengan kesan kadar aliran dalam keadaan yg lancar adalah projek untuk perlindungan motor dan proses kecekapan untuk kadar aliran dalam saluran paip. Pam air dan injap kawalan bertindak sebagai elemen kawalan untuk sistem ini. Apabila pam air beroperasi, air pam dari tangki air 1 ke tangki air 2. Dari tangki air 1, aliran air melalui penunjuk aliran yang digunakan untuk menentukan kadar aliran air. Seterusnya, aliran air untuk mengawal injap dan ia mengawal pembukaan injap. Injap kawalan memainkan peranan yang penting dalam sistem ini kerana ia mengurangkan tekanan terbina dalam saluran paip. Air mengalir dari tangki air 1 ke tangki air 2 menggunakan gravity bumi. Suhu meningkat pam air selepas ia beroperasi selama berjam-jam yang. Sensor thermocouple mengesan perubahan suhu dan menukarkannya kepada isyarat elektrik. Kemudian isyarat elektrik dihantar ke Myrio dan memaparkan suhu pada perisian LabVIEW versi 2015 dalam komputer.

# ASTRACT

The temperature monitoring of water pump relative to the effect of flowrate in pipeline is a project for motor protection and efficiency process for flowrate in pipeline. The water pump and control valve act as control element for this system. When the water pump operates, water is pump from water tank 1 to water tank 2. From water tank 1, the water flow through a flow indicator which is used to determine the flowrate of water. Next, the water flow to control valve and it control the opening of the valve. The control valve play an important role in this system because it reduce the build-up pressure in pipeline. The water flow back from water tank 1 to water tank 2 using earth gravity. The temperature of water pump increases after it operates for an hours. The thermocouple sensor detect the changes of temperature and convert it to electrical signal. Then the electrical signal is sent to myrio and display the temperature on LabVIEW software version 2015 in computer.

# DEDICATION

To my lovely and beloved parents,
Ilime bin Ibrahim and Qusniza binti Ibrahim
My siblings,
Amir bin Ilime
My Supervisor,
En. Ahmad Muzaffar bin Abdul Kadir and Pn. Rosnaini binti Ramli
Dedicated in thankful for the supporting, best wishes and encouragements.

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# CHAPTER 1

# INTRODUCTION

## 1.0 Introduction

In this era of 21st century, the demand for automatic control has prevailed almost all types of industries operating. Temperature is one of the most common such process parameter, controlling of which is supreme importance of many industries such as steel industry, power generating industry, food and beverages industries. A very small discrepancy in temperature can ruin the entire process and cause a huge loss. The system measures the temperature of the corresponding media where sensor is placed. The paper is aimed at development of temperature monitoring system. The system works by monitoring temperature taken from user and maintains the temperature below certain threshold value. The systems providing optimum temperature for water pump motor to avoid from overheating. This because when the temperature is increase, the water pump motor works less efficient and may damage the winding of motor. The hot temperature shorten the life span of water pump motor. The control element for this system would be temperature. Basically this section will explain the objective, scope and problem statement.

## 1.1 Background

Temperature monitoring of water pump relative to the effect of flowrate in pipeline is a system that monitor the temperature of water pump motor. Regularly checking the operating temperature of critical motors will pay huge dividends by preventing unexpected shutdowns and extending motor life. In industrial environment, ambient temperature is referred to as room temperature that surrounds the motor. The difference between the ambient temperature and that of a motor operating under load is called the temperature rise. The sum of the ambient temperature and the temperature rise equals the overall hot temperature of the motor or a component.

Another factor is the build-up and back pressure in pipeline will cause the temperature rise to increase. The water pump need to works harder to flow water through the system. Therefore, a system need to be introduced to the industry to overcome the problem. The systems are providing the water pump motor to works in optimum temperature. It also helps the water pump not to overheat and extend the life span of motor. The sensor used for the system is thermocouple sensor, which able to withstand high temperature. A thermocouple is an electrical device consisting of two different conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature. Thermocouples are a widely used type of temperature sensor

Other than that, the flowrate need to be control by control valve because build-up pressure and back pressure that cause the motor to overheat. The system help user to monitor the temperature of water pump and optimize the temperature of motor. The systems are using water pump, pipeline, control valve, flow indicator and water tanks.

## 1.2 Problem Statement

In fact, operating a single phase induction water pump motor at just 10 C above its rated temperature can shorten its life by half .There are two factor that cause the motor to overheat which is ambient temperature and temperature rise in the motor. Ambient temperature is referred to room temperature, when the room temperature increase, the water pump heat up easily. Next, temperature rise is motor that operate under a load. In this case, when there is build up and back pressure in pipeline the motor works harder to make sure the water flow through the system. This situation make the temperature increase drastically. The sum of this two factor is called hot temperature. This main reason the temperature monitoring system are developed to overcome the problem.

## 1.3 Objective

There are several objectives need to achieve in this project:

1. Monitor the temperature of water pump at minimum and maximum range of working condition
2. Monitor the effect of ambient temperature to water pump heating.
3. Obtain the optimum flowrate of water pump in providing efficient pipeline flowrate with the effect of pressure build up

## 1.4 Scope

The scope of the project is to build hardware and design a system for the temperature monitoring which monitor the temperature of motor. The system consist of motor water pump, pipeline, water tank, gauge and thermocouple sensor. The systems are using thermocouple sensor. It consists of two dissimilar metals joined together. By applying heat to the junction of two metals produces a voltage between the two wires. The thermocouple alloys are commonly available as wire. This sensor is the suitable for this project because it has wide temperature range which can be used to monitor the temperature.

The systems are using water pump motor. This project use gravity pump to pump water against the gravity through the system. Gravity pumps pump the water is lifted by gravitational force. So the motor required enough power to pump the water. At the same time, the gauge need to control the flowrate to avoid build-up and back pressure that increase the temperature of motor.

Pipeline is used to transport liquid from one area to another area. This project required to transport the water from one tank to another tank. The minimum acceptable service line diameter is 25mm. when an existing water pipeline has pressure problem, design calculations will required to demonstrate the acceptabililty of the purposed works regardless of pipeline size.

The water pump motor is use to pump liquid to water tank through a pipeline. Thermocouple sensor is attach to the motor to monitor the temperature of water pump motor. The gauge is use to control the flowrate of liquid in the system.

# CHAPTER 2

# LITERATURE REVIEW

In this literature section, it comprises from the journal on the internet, paper proceeding and research, book and lectures. The literature review includes the case investigation of the project that may arise to overcome the problem and also gives a powerful knowledge on the fundamental of the project.

## 2.1 Temperature

Temperature is one of the basic physical quantities of thermodynamics. It's a numerical representation of how cold or hot something is. Each type of water pump has different capabilities to withstand the temperature. Thermocouple sensor is used to measure the temperature of water pump.

It's demonstrate that when the water pump is in operating condition, the temperature increases and the temperature is measure to show how hot the water pump. The increasing temperature in water pump will damage the component inside the water pump especially the winding because it is the hottest part in water pump. When the water pump stop operate, the thermal changes. So, the temperature of water pump is equal to the temperature of surrounding. It's called thermal equilibrium.

Next, the ambient temperature of surrounding is measure using a calibrated infrared thermometer. The ambient temperature is important factor the will affect the temperature of water pump. The maximum ambient temperature of water pump is 40 degree Celsius. Temperature exceed from 40 degree Celsius will short the life span of water pump.

## 2.2 Unit of temperature

### 2.2.1 Celsius (°C)

Celsius is defined by the freezing point of water. Zero on the Celsius scale (0 °C) is now defined as the equivalent to 273.15 K. The temperature difference of 1 degree Celsius equivalent to a difference of 1 Kelvin, meaning the unit size in each scale is the same. This means that 100 °C, previously defined as the boiling point of water, is now defined as the equivalent to 373.15 K. The Celsius scale is an interval system but not a ratio system, meaning it follows a relative scale but not an absolute scale. This can be seen because the temperature interval between 20 °C and 30 °C is the same as between 30 °C and 40 °C, but 40 °C does not have twice the air heat energy of 20 °C.

### 2.2.2 Fahrenheit (°F)

Fahrenheit is a thermodynamic temperature scale, where the freezing point of water is 32 degrees Fahrenheit (°F) and the boiling point 212°F (at standard atmospheric pressure). This puts the boiling and freezing points of water exactly 180 degrees apart. A degree on the Fahrenheit scale is 1/180 of the interval between the freezing point and the boiling point of water. Absolute zero is defined as -459.67°F.

### 2.2.3 Kelvin (K)

The kelvin is a unit of measure for temperature based upon an absolute scale. It is one of the seven base units in the International System of Units (SI) and is assigned the unit symbol K. The Kelvin scale is an absolute, thermodynamic temperature scale using as its null point absolute zero, the temperature at which all thermal motion ceases in the classical description of thermodynamics. The kelvin is defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water (exactly 0.01 °C or 32.018 °F). It also defined such that the triple point of water is exactly 273.16 K.

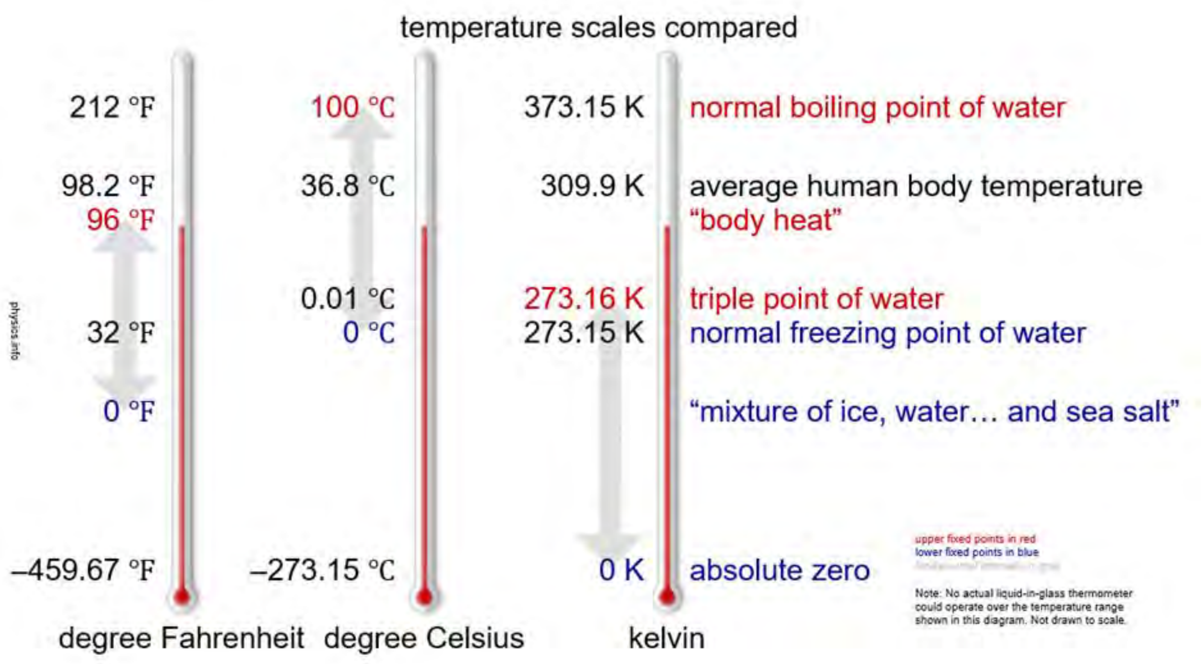


Figure 2.1 : Temperature scale compared between Fahrenheit, Celsius and kelvin

| Temperature Conversion Formulas | | |
|---|---|---|
| **TO CONVERT FROM** | **TO** | **SUBSTITUTE IN FORMULA** |
| Degrees Celsius | Degrees Fahrenheit | (°C x 9/5) + 32 |
| Degrees Celsius | Kelvin | (°C + 273.16) |
| Degrees Fahrenheit | Degrees Celsius | (°F - 32) x 5/9 |
| Degrees Fahrenheit | Degrees Rankin | (°F + 459.69) |

Figure 2.2 : Temperature Conversion Formula

## 2.3 Types of Temperature Sensor

### 2.3.1 Thermocouple

Figure 2.3 : Thermocouple sensor [1]

A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wires legs are welded together at one end, creating a junction. There are 2 junction which is hot and cold junction. This is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created. The voltage can then be interpreted using thermocouple reference tables to calculate the temperature.

There are many types of thermocouples, each with its own unique characteristics in terms of temperature range, durability, vibration resistance, chemical resistance, and application compatibility. Type J, K, T, & E are “Base Metal” thermocouples, the most common types of thermocouples. Type R, S, and B thermocouples are “Noble Metal” thermocouples, which are used in high temperature applications.

Commercial thermocouples are inexpensive, interchangeable and supplied with standard connectors. In contrast to most other methods of temperature measurement, thermocouples are self-powered and require no external form of excitation. The main limitation with thermocouples is accuracy, system errors of less than one degree Celsius (°C) can be difficult to achieve.

The principle of operation is when the voltage generated at a single junction of two different types of wire is what is of interest as this can be used to measure temperature at very high and low temperatures. The magnitude of the voltage depends on the types of wire used. Generally, the voltage is in the microvolt range and care must be taken to obtain a usable measurement. Although current flows very little, power can be generated by a single thermocouple junction.

### 2.3.2 Resistance Temperature Detector (RTD)

Figure 2.4 : RTD (resistance temperature detector) Sensor [2]

An RTD (resistance temperature detector) is a temperature sensor that operates on the measurement principle that a material's electrical resistance changes with temperature. The relationship between an RTD's resistance and the surrounding temperature is highly predictable. It's allowing for accurate and consistent temperature measurement. By supplying an RTD with a constant current and measuring the resulting voltage drop across the resistor, the RTD's resistance can be calculated, and the temperature can be determined.

The principle of operation is when an RTD takes a measurement when a small DC current is supplied to the sensor. The current experiences the impedance of the resistor, and a voltage drop is experienced over the resistor. Depending on the nominal resistance of the RTD, different supply currents can be used. The sensor reduce self-heating by supply low current. The low current is around 1mA or less of current is used.

The RTD is connected by two wires to a Wheatstone bridge circuit and the output voltage is measured. The disadvantage of this circuit is that the two connecting lead wire resistances add directly two the RTD's resistance and an error is incurred.

RTDs (resistance temperature detector) use the fact that some metals increase their electrical resistance as they get hotter. To measure the temperature change, the sensor output is fed into a Wheatstone bridge with a reference voltage.

### 2.3.3 Thermistors

Figure 2.5 : Thermistor Sensor [3]

Thermistors are special solid temperature sensors that behave like temperature-sensitive electrical resistors. No surprise then that their name is a contraction of "thermal" and "resistor". There are basically two broad types, NTC-Negative Temperature Coefficient, used mostly in temperature sensing and PTC-Positive Temperature Coefficient used mostly in electric current control.

They are mostly very small bits of special material that exhibit more than just temperature sensitivity. Thermistors, since they can be very small, are used inside many other devices as temperature sensing and correction devices as well as in specialty temperature sensing probes for commerce, science and industry.

Thermistors typically work over a relatively small temperature range, compared to other temperature sensors, and can be very accurate and precise within that range, although not all are. The principle of operation is when the resistance of thermistor is depends on temperature. When temperature changes, the resistance of the thermistor changes in a predictable way. The benefits of using a thermistor is accuracy and stability.

## 2.4 Comparison between Resistance Temperature Detector (RTD) VS Thermocouple VS Thermistor

| | RTD | Thermocouple | Thermistor |
|---|---|---|---|
| Temp. range | -260 to 850°C (-436 to 1562°F) | -270 to 1800°C (-454 to 3272°F) | -80 to 150°C (-112 to 302°F) (typical) |
| Sensor cost | Moderate | Low | Low |
| System cost | Moderate | High | Moderate |
| Stability | Best | Low | Moderate |
| Sensitivity | Moderate | Low | Best |
| Linearity | Best | Moderate | Poor |
| Specify for: | • General purpose sensing<br>• Highest accuracy<br>• Temperature averaging | • Highest temperatures | • Best sensitivity<br>• Narrow ranges (e.g. medical)<br>• Point sensing |

Figure 2.6:.Comparison RTD vs Thermocouple vs Thermistor

For this project, thermocouples are used because it is inexpensive, rugged and have a fast response time. Thermocouples read only relative temperature difference between the tip and the leads while RTD's and thermistors read absolute temperature. It’s is suitable for temperature monitoring for water pump. RTD is the not the best choice because have a slow response time and require a current source. It’s has a low amount of self-heating. Thermistors are fragile and have a limited range. It’s also require a current source and do experience more self-heating than an RTD.