


Saya akui bahawa saya telah membaca karya ini dan pada penerangan saya karya ini adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Struktur dan Bahan)

Tandatangan : 
Nama Penyelia : En. Nor Salim bin Muhammad
Tarikh : MEI 2007

NOR SALIM BIN MOHAMAD
Pensyarah
Fakulti Kejuruteraan Mekanikal
Kolej Teknikal Kebangsaan Malaysia
Karung Berkunci 1200, Ayer Keroh,
75450 Melaka.

TEMPERATURE MEASURING APPARATUS

MD MUZZAMMIL BIN MD JAIS

Laporan ini diserahkan kepada Fakulti Kejuruteraan Mekanikal sebagai memenuhi sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Mekanikal (Struktur & Bahan)

Fakulti Kejuruteraan Mekanikal
Universiti Teknikal Malaysia Melaka

MEI 2007

Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang
tiap – tiap satunya saya jelaskan sumbernya

Tandatangan :



Nama Penulis : MD MUZZAMMIL BIN MD JAIS

Tarikh : MEI 2007

ACKNOWLEDGEMENT

Firstly, I would like to express my gratitude to Allah S.W.T for giving opportunities and lighten me to complete this thesis. I also would like to thanks to.

1. Mr. Nor Salim bin Muhammad, advisor of my PSM, lecturer (FKM) *Universiti Teknikal Malaysia Melaka (UTeM)*.
2. Mr. Muzaini, senior technician of FKM, *Universiti Teknikal Malaysia Melaka (UTeM)*
3. Mr. Khairul, technician of Control and Instrumentations laboratory, *Universiti Teknikal Malaysia Melaka (UTeM)*.
4. Mr. Mazlan, technician of CNC machining (FKM), *Universiti Teknikal Malaysia Melaka (UTeM)*.

Thank you also to everyone who help and support me to complete this project especially my parents who are always support me to done with this project especially in financial support.

ABSTRACT

The aim of this project is to develop an apparatus to measure temperature using thermocouple and RTD sensors. Instead of measure temperature, this project includes observation of temperature and characteristics of the temperature measuring equipment. This project is based on a dry-well concept that is a stable heat source which is widely used in laboratory environments for calibration of temperature sensors. There are several experiment conducted in this study such as a study of the characteristic of a soldering iron using thermocouple as a sensor (with digital multimeter and temperature meter) and temperature calibration from the apparatus that has been built to compare the result of thermocouple and RTD (PT100) sensor. The apparatus for this purpose was developed using CNC lathe, milling, bending and welding.

TABLE OF CONTENTS

CHAPTER	SUBJECT	PAGES
1	INTRODUCTION	
	1.1 Project title	2
	1.2 Project Objective	2
	1.3 Project Scope	2
	1.4 Application of temperature measurement	3
	1.4.1 Furnace	3
2	LITERATURE REVIEW	9
	2.1 Introduction of temperature measurement	10
	2.2 Background study of thermocouple	15
	2.2.1 Introduction to Thermocouples	15
	2.2.2 Thermocouple theory	15
	2.2.3 Fundamental of thermocouple law	16
	2.2.4 The practical considerations of thermocouples	17
	2.2.5 The advantages and disadvantages of	19

thermocouples	
2.2.6 Types of thermocouple	20
2.2.7 Accuracy of thermocouple	23
2.2.8 Thermocouple wire grades	24
2.2.9 Thermocouple mounting	24
2.2.10 Thermocouple compensation and linearization	26
2.3 Background study of resistance thermometer	27
2.3.1 General description	27
2.3.2 How do resistance thermometers work?	28
2.3.3 Advantages and limitations	29
2.3.4 Resistance thermometer elements	30
2.4 Background study of thermistor	33
2.5 Background study of Dry-Well	34
2.5.1 Introduction of Dry-Well	35
2.5.2 Uncertainties associated with the use of	35

Metrology Well and its

built-in reference thermometer input

2.5.3 Axial uniformity	35
2.5.4 Radial uniformity	36
2.5.5 Loading effect	36
2.5.6 Stability	36
2.5.7 Stem conduction error	37
2.5.8 Reference probe, thermometer readout, and UUT considerations	37
2.5.9 Uncertainties associated with the use of a Metrology Well and its calibrated control sensor	37
2.5.10 Axial uniformity	37
2.5.11 Radial uniformity	38
2.5.12 Loading effect	38
2.5.13 Short-term and long-term drift	38
2.5.14 Hysteresis	38

2.5.15	Control sensor calibration	39
2.5.16	Other considerations	39
2.5.17	Improving Dry-Well Calibrations	39
2.5.18	Selecting a Dry-Well Temperature Calibrator	41
2.5.19	Temperature Range	42
2.5.20	Accuracy and Stability	42
2.5.21	Well Flexibility	43
2.5.22	Portability	44
2.5.23	Sensor immersion	45
2.5.24	Throughput	46
3	METHODOLOGY	48
3.1	Experiment result for characteristic of soldering iron. (temperature meter)	49
3.2	Experiment result for characteristic of soldering iron. (digital multimeter)	51
4	APPARATUS DESIGN	53
4.1	Design	54

4.2	Machining process	56
4.3	Wiring process	62
4.4	Specification of circuit insulation configuration	62
5	EXPERIMENTS AND ANALYSIS	66
5.1	RTD (PT100) experiment result	67
5.2	Thermocouple experiment result	69
5.3	Sample calculation for interpolation	70
5.4	Discussion for each experiment	71
	CONCLUSION	72
	REFERENCES	74
	APPENDIXES	76

LIST OF FIGURE AND DIAGRAM

NUMBER	TITLE	PAGE
1.1	Industrial furnace	3
1.2	Stack Damper	7
2.1	Thermometer	10
2.2	Liquid bulb thermometer	11
2.3	Bimetal indicator	11
2.4	Example of Voltage type temperature measurement	12
2.5	Voltage VS Temperature	12
2.6	Thermocouple Wire	13
2.7	PRT	13
2.8	Thermistor	13
2.9	PRT diagram	14
2.10	Thermistor diagram	14
2.11	Infrared thermometer	14
2.12	Thermocouple concept	15

2.13	Traditional Thermocouple Measurement	18
2.14	Modern Thermocouple Measurement	18
2.15	Thermocouple types	22
2.16	Voltage output from thermocouples at different temperatures	23
2.17	Thermocouple Sheath Options	25
2.18	Hardware Reference Junction Compensation	26
2.19	Software Reference Junction Compensation	27
2.20	Resistance thermometer construction	30
2.21	Two wire configuration	31
2.22	Three wire configuration	32
2.23	Four wire resistance thermometer configuration	32
2.24	Four wire configuration (with full cancellation of spurious effects)	33
2.25	NTC thermistor, bead type, insulated wires	34
2.26	Thermistor symbol	34
2.27	Basic concept of Dry-Well	40
2.28	Dry Well with external reference thermometer	41
2.29	A removable insert can be customized with two drilled holes	44

	for best accuracy	
2.30	Handheld block calibrators have made industrial calibration more portable	45
2.31	Short – stem sensor should be calibrated by comparison at the same depth when using a block calibrator	46
3.1	Result for characteristic of soldering iron (using temperature meter)	49
3.2	Circuit to get the characteristic of soldering iron (Using temperature meter)	49
3.3	Voltage Amplifier	50
3.4	Graph result for characteristic of soldering iron (temperature meter)	50
3.5	Result for characteristic of soldering iron (using digital multimeter)	51
3.6	Circuit to get the characteristic of soldering iron (using digital multimeter)	52
3.7	Graph result for characteristic of soldering iron (digital multimeter)	52
4.1	Solid aluminium is used to build heat sink	54
4.2	Solid aluminium rod is use to build insert	55

4.3	Steel plate is used to build housing	55
4.4	Complete machining and fabricating process	56
4.5	Dimension for machining process for heat sink	57
4.6	Dimension for machining process insert	58
4.7	Dimension for fabricating process for housing (body)	59
4.8	Dimension for fabricating process for housing (door)	60
4.9	CNC lathe machining process	61
4.10	Milling machine used for drilling process with custom drilling set	61
4.11	Circuit insulation configuration for controller	62
4.12	Controller used as signal condition and temperature controller	63
4.13	Sensor probe used for reference probe (input) and calibrator	63
4.14	Heater used as output	64
4.15	Multimeter as reading set	64
4.16	Apparatus after complete wiring	65

5.1	RTD (PT100) experiment result table	67
5.2	RTD (PT100) experiment result graph	68
5.3	Thermocouple experiment result table	69
5.4	Thermocouple experiment result graph	70

CHAPTER 1 INTRODUCTION

1.1 Project title:

Temperature measuring apparatus

1.2 Project objective:

1. To develop an apparatus which are able to measure temperature.
2. Observation of temperature.
3. Study the characteristics of the temperature measuring equipment.

1.3 Project scope:

1. Study the characteristics of sensors in temperature measurement including structure, working principles, and output of the sensors.
2. Identifying the difference of the sensors that in temperature measurement.
3. Design a heat source in temperature measurement which able to calibrate temperature probes.
4. Study the required signal condition in temperature measurement.
5. Develop a simple signal condition for voltage type sensors and resistance type sensors in temperature measurement.
6. Measure the characteristic of the developed signal condition.

1.4 Application of temperature measurement:

1.4.1 Furnace

A furnace is a device used for heating. There are many types of furnaces provided.

One of the furnace that was applied in industries are described below:

Industrial furnaces

Furnace

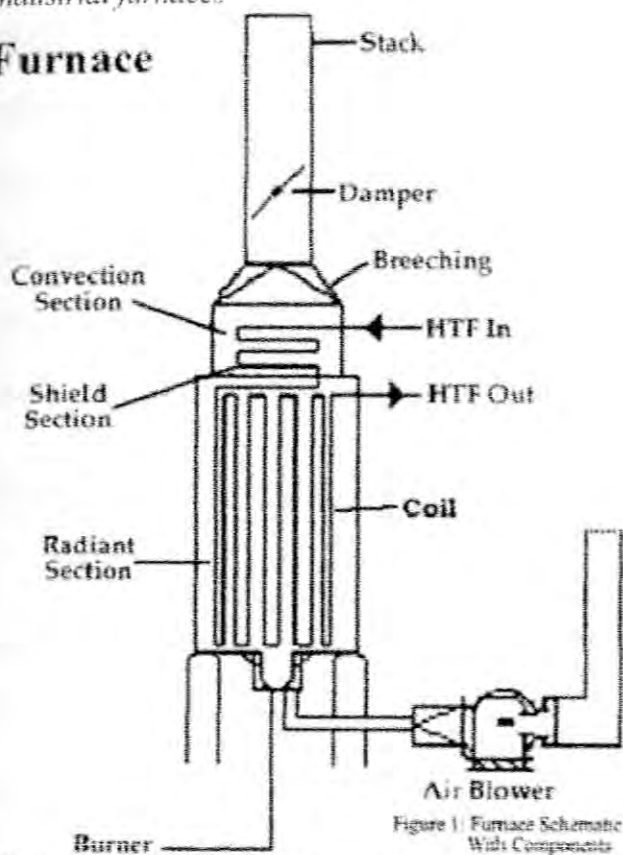


Figure 1: Furnace Schematic With Components

Figure 1.1 : Industrial furnace

A furnace or direct fired heater, is an equipment used to provide heat for a process or can serve as reactor which provides heats of reaction. Furnace designs vary as to its function, heating duty, type of fuel and method of introducing combustion air. However, all furnaces have some common features.

Fuel flows into the burner and is burnt with air provided from an air blower. There can be more than one burner in a particular furnace which can be arranged in cells which heat a particular set of tubes. Burners can also be floor mounted as in the picture, wall mounted or roof mounted depending on design. The flames heat up the tubes, which in turn heat the fluid inside in the first part of the furnace known as the radiant section. In the chamber where combustion takes place, known as the firebox, the heat is transferred mainly by radiation to tubes around the fire in the chamber. The heating fluid passes through the tubes and is thus heated to the desired temperature. The gases from the combustion are known as flue gas. After the flue gas leaves the firebox, most furnace designs include a convection section where more heat is recovered before venting to the atmosphere through the flue gas stack.

Radiant section

The radiant section is where the tubes receive almost all its heat by radiation from the flame. In a vertical, cylindrical furnace, the tubes are vertical. Tubes can be vertical or horizontal, placed along the refractory wall, in the middle, etc., or arranged in cells. Studs are used to hold the insulation together and on the wall of the furnace. They are placed about 1 ft (300 mm) apart in this picture of the inside of a furnace. The tubes, which are reddish brown from corrosion, are carbon steel tubes and run the height of the radiant section. The tubes are a distance away from the insulation so radiation can be reflected to the back of the tubes to maintain a rather uniform tube wall temperature. Tube guides at the top, middle and bottom hold the tubes in place.

Convection section

The convection section is located above the radiant section where it is cooler to recover additional heat. Heat transfer takes place by convection here and the tubes are finned to increase heat transfer. The first two tube rows as seen in the picture below are in the bottom of the convection section and at the top of the radiant section. This area of bare tubes (without fins) are known as the shield section, so named because they are still exposed to plenty of radiation from the firebox and shield the convection section tubes, which are normally of less resistant material from the high temperatures in the firebox. These tubes may be of the same material as the radiant coil tubes. The area of the radiant section just before flue gas enters the shield section and into the convection section called the bridgezone. Crossover is the term used to describe the tube that connects from the convection section outlet to the radiant section inlet. The crossover piping is normally located outside so that the temperature can be monitored and the efficiency of the convection section can be calculated. The sightglass at the top allows personnel to see the flame shape and pattern from above and visually inspect if flame impingement is occurring. Flame impingement happens when the flame touches the tubes and causes small isolated spots of very high temperature.

Burner

The burner in a vertical, cylindrical furnace as above, is located in the floor and fires upward. The burner tile is made of high temperature refractory and is where the flame is contained in. Air registers are devices with movable flaps or vanes that control the shape and pattern of the flame, whether it spreads out or even swirls around. Flames should not spread out too much, as this will cause flame impingement. Air registers can be classified

as primary, secondary and if applicable, tertiary, depending on when their air is introduced. The primary air register supplies primary air, which is the first to be introduced in the burner. Secondary air is added to supplement primary air. Burners may include a premixer to mix the air and fuel for better combustion before introducing into the burner. Notice that in the picture of the floor of the furnace, it is a different material from that of the wall. It is made of hard castable refractory known as kastolite so the floor can be walked on during maintenance. The brown dust on the floor is soot from the flame and rust from the tube.

The pilot flame here is lit by an ignition transformer. The pilot flame in turn lights up the main flame. The pilot flame uses natural gas while the main flame can use both diesel and natural gas.

Sootblower

Sootblowers utilize flowing media such as water, air or steam to remove deposits from boiler tubes. There are several different types of sootblowers used. Wall blowers are used for furnace walls and have a very short lance with a nozzle at the tip. The lance has holes drilled into it at intervals so that when it is turned on, it rotates and cleans the deposits from the wall in a circular pattern. After it has turned a predetermined number of rounds, the sootblowing is completed and stops. Below is a convection section sootblower utilizing medium pressure (10-12bar) steam.

Stack

The flue gas stack is a cylindrical structure at the top of all the heat transfer chambers. The breeching directly below it collects the flue gas and brings it up high into the atmosphere where it will not endanger personnel.

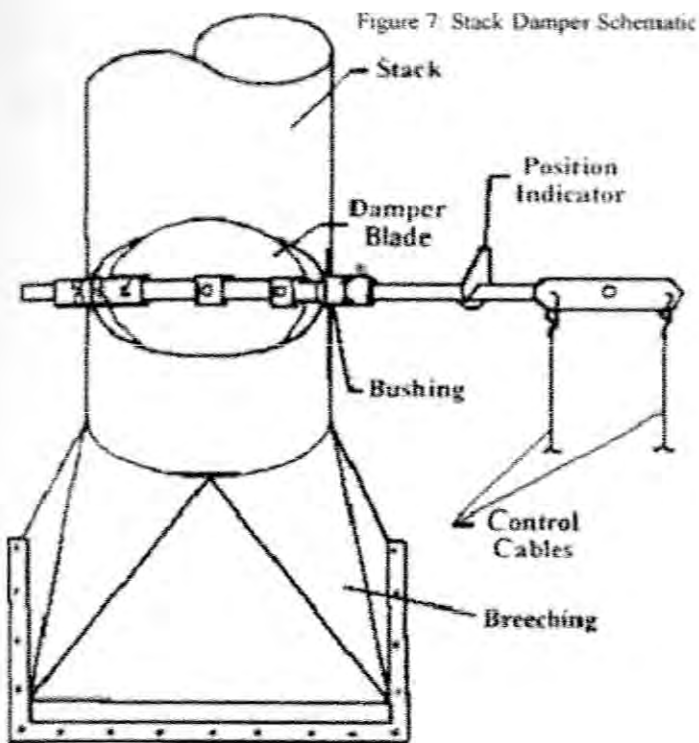


Figure 1.2 : Stack damper

The stack damper contained within works like a butterfly valve and regulates draft in the furnace, which is what pulls the flue gas through the convection section. The stack damper also regulates the heat lost through the stack. As the damper closes, the amount of heat escaping the furnace through the stack decreases, but the pressure or draft in the furnace increases which poses risks to those working around it if there are air leakages and the flames can then escape out of the firebox.

Insulation

Insulation is an important part of the furnace because it prevents excessive heat loss. Refractory materials such as firebrick, castable refractories and ceramic fibre, are used for insulation. The floor of the furnace is normally castable since it has to be hard enough

to walk on during maintenance. Ceramic fibre is commonly used for the roof and wall of the furnace and is graded by its density and then its maximum temperature rating.

CHAPTER 2
STUDY
BACKGROUND