DESIGN AND FABRICATION OF CONDUCTOMETER

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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CERTIFICATE OF EVALUATION

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The thesis of the project work submitted by the above students in partial fulfillment for the award of the degree of Bachelor of Mechanical Engineering of Anna University, Chennai was confirmed to be the work done by the above students and then evaluated on ______________________

INTERNAL EXAMINER **EXTERNAL EXAMINER**

ABSTRACT

Thermal conductivity is the fundamental property of materialwhich is to be considering essentially for characterizing the heat transfer process by conduction mechanism. The measurement of thermal conductivity includes themeasurement of the heat flux and temperature difference among its end. This study aimsto design, fabricate and develop a reliable and portable instrument to measure the thermal conductivity of the material. The level of reliability that based on the accuracy and consistent of the instrument will be proven by comparing the experimental value with the theoretical value. The instrument is designed for determining the thermal conductivity for the material which have melting point below "mention temp in degree Celcius". To test the level of reliabilityof the instrument the aluminum is used for testingitsthermal conductivity. The result of the experiment depicted that still a small difference between the theoretical value and experimental value, but the best part of the instrument is it able to present almost constant temperature value and thermal conductivity value. This instrument could estimate the thermal conductivity of materials with±10% error. The temperatures are measured by thermocouple are recorded using IOT technique and the corresponding thermal conductivity is calculated using a software programming.

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CHAPTER 1

INTRODUCTION:

Thermal conductivity is the ability of material to conduct the heat. It is the base to differentiate the materials as conductors, insulators, etc. Thermal Conductivity plays a major role in selectingthe material for particularapplication. Hence determination of thermalconductivity is very essential. Various methods have been developed inthe recent past for this. In our project, we have used Fourier law of heat conduction principle to determine the thermal conductivity by steady state method.

The apparatus consists of the Mild steel rod of 120 mm test section. Heat is provided continuously by means of heating plateinupward direction at one end of the rod. Thermocouples are profiled at the two ends of the test Specimen.Temperatures are taken after the workpieceattainssteady state.

The temperatures obtained from the thermocouples are displayed by LCD through Arduino.After getting steady state thermal conductivity can be calculated and displayed in LCD.Proper insulation is provided to minimize the heat loss. Cabin is provided to achieve the steady state as soon as possible.

CHAPTER 2

SOLIDWORKS/PRO-E MODEL:CRE0 5.0

2.1.HEATER PLATE:

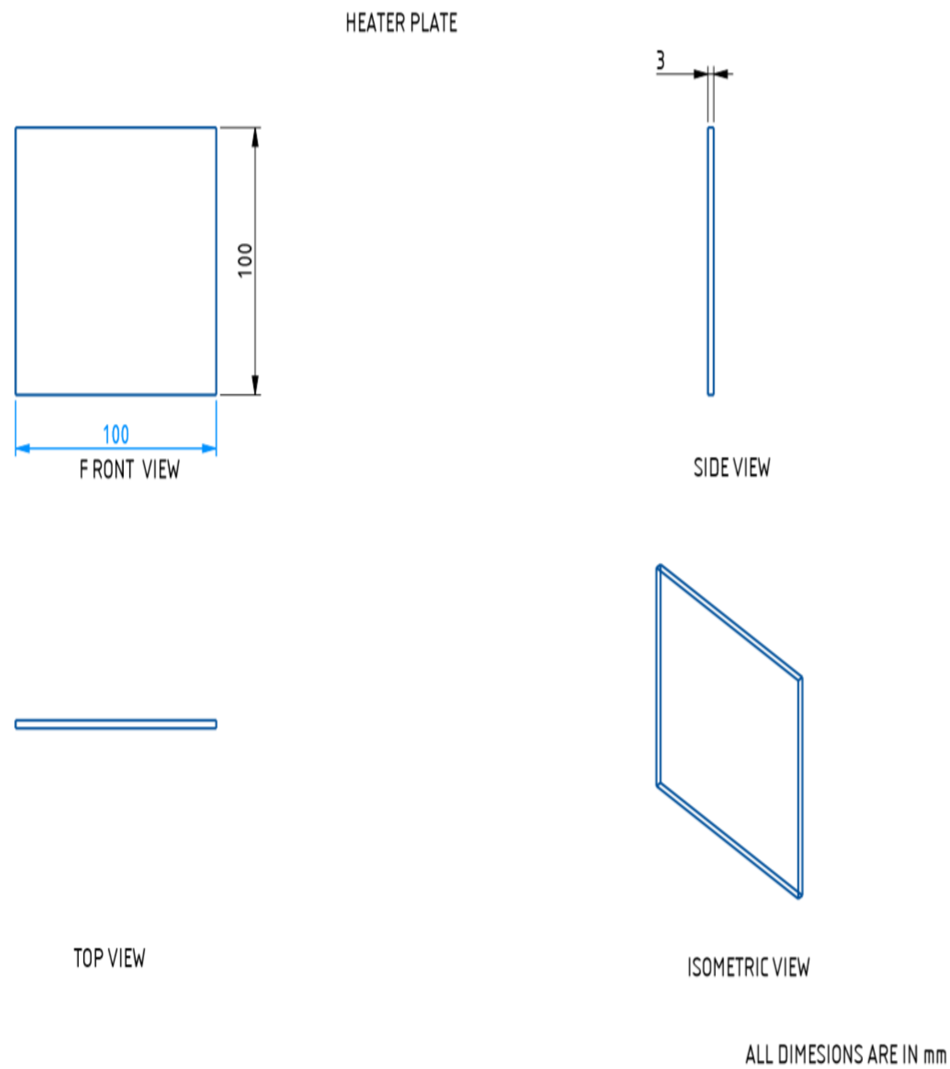

Fig2.1.Heater Plate

2.2.BASE PLATE:

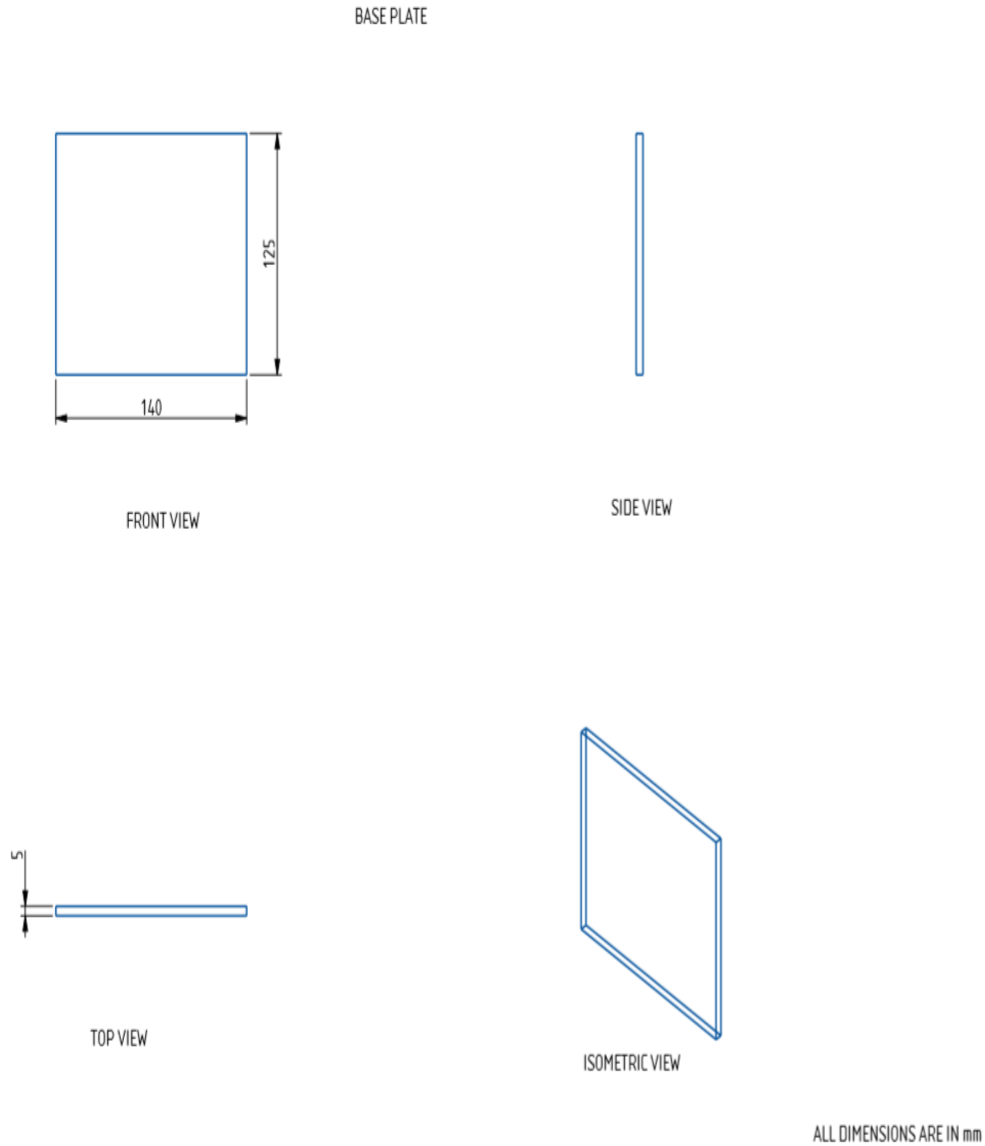

Fig2.2.Base Plate

2.3.ALUMINIUM ROD:

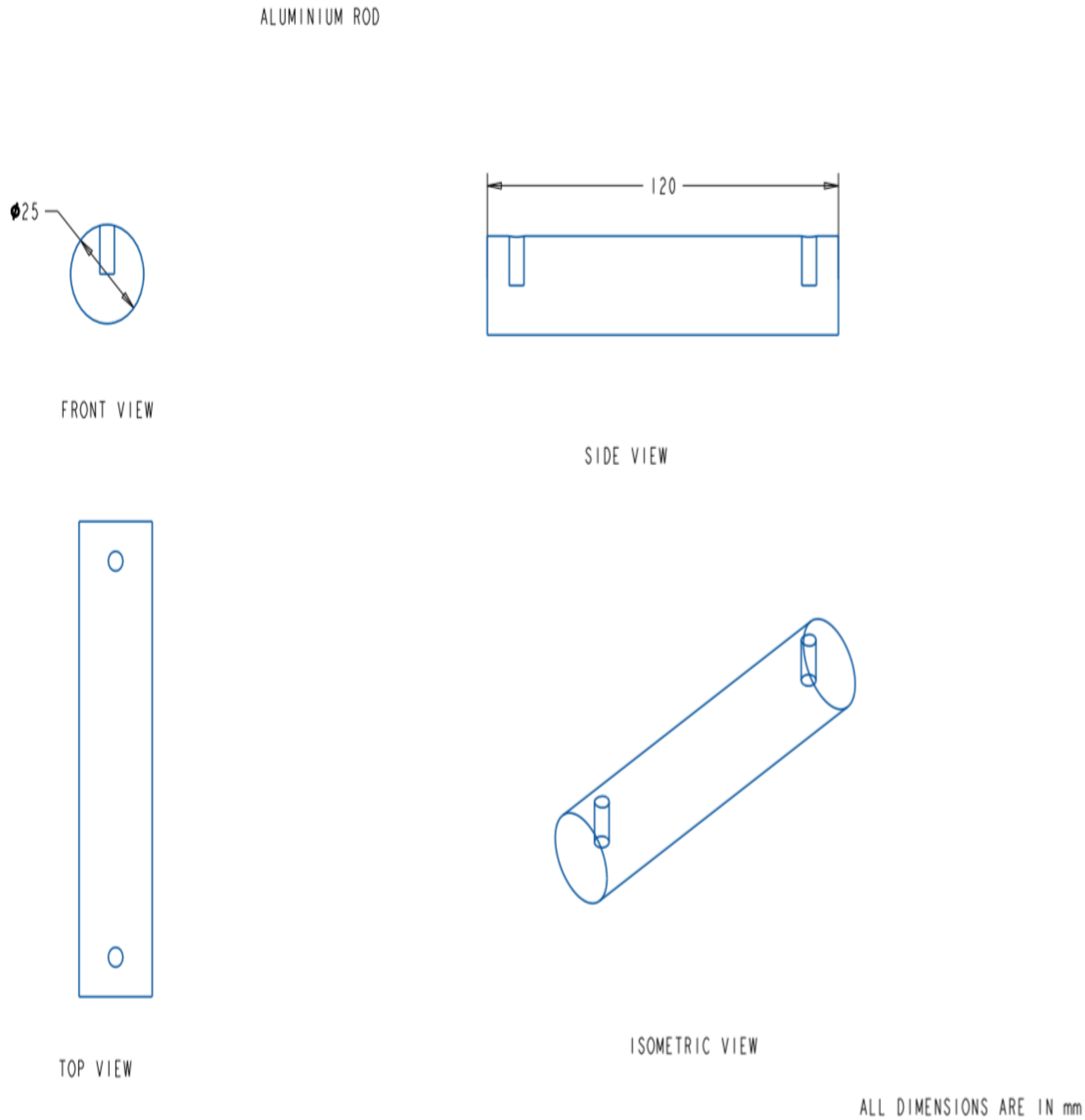

Fig2.3.Aluminium Rod

2.4.CABIN:

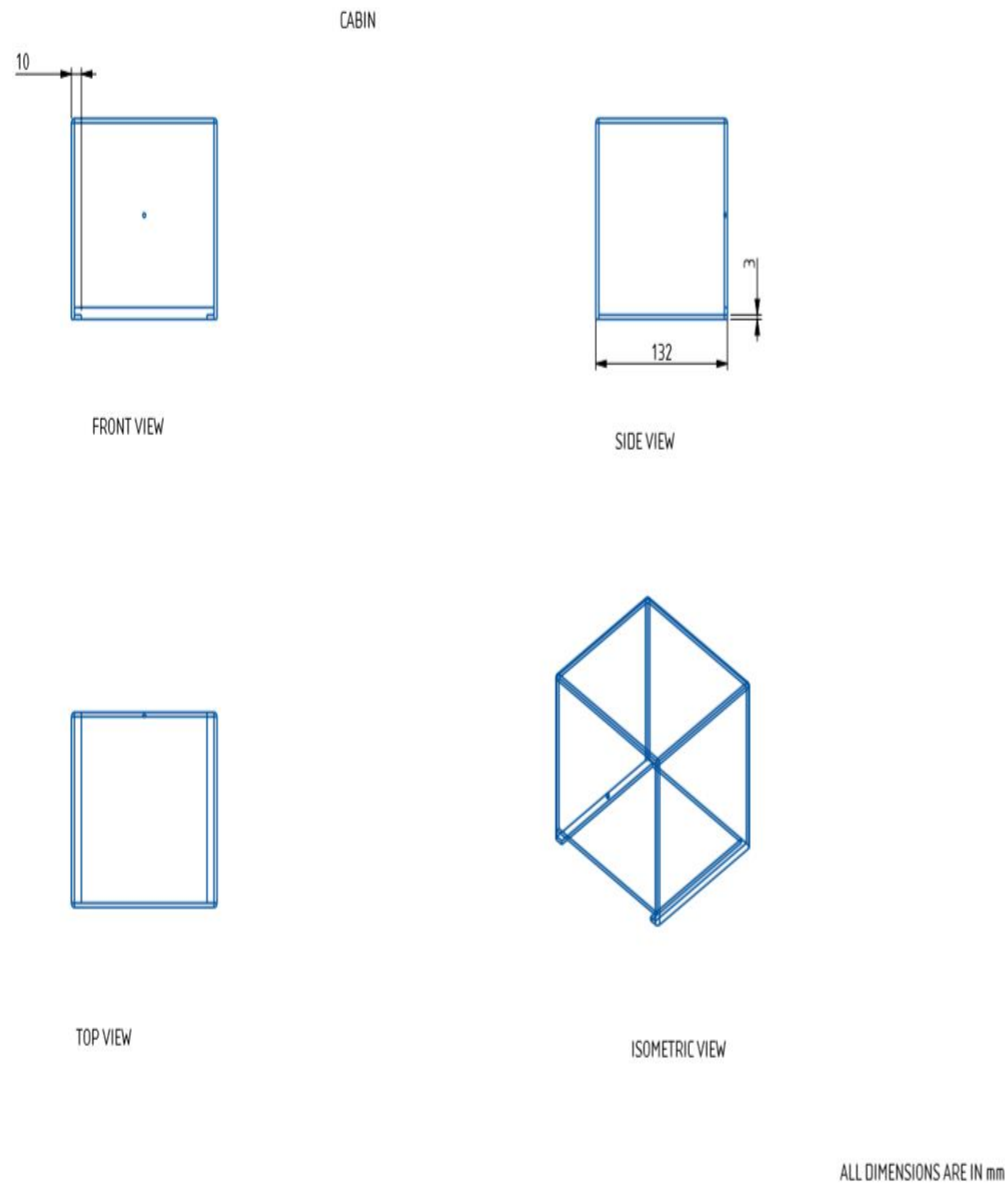

Fig2.4.Cabin

2.5.ASSEMBLED VIEW OF CONDUCTOMETER:

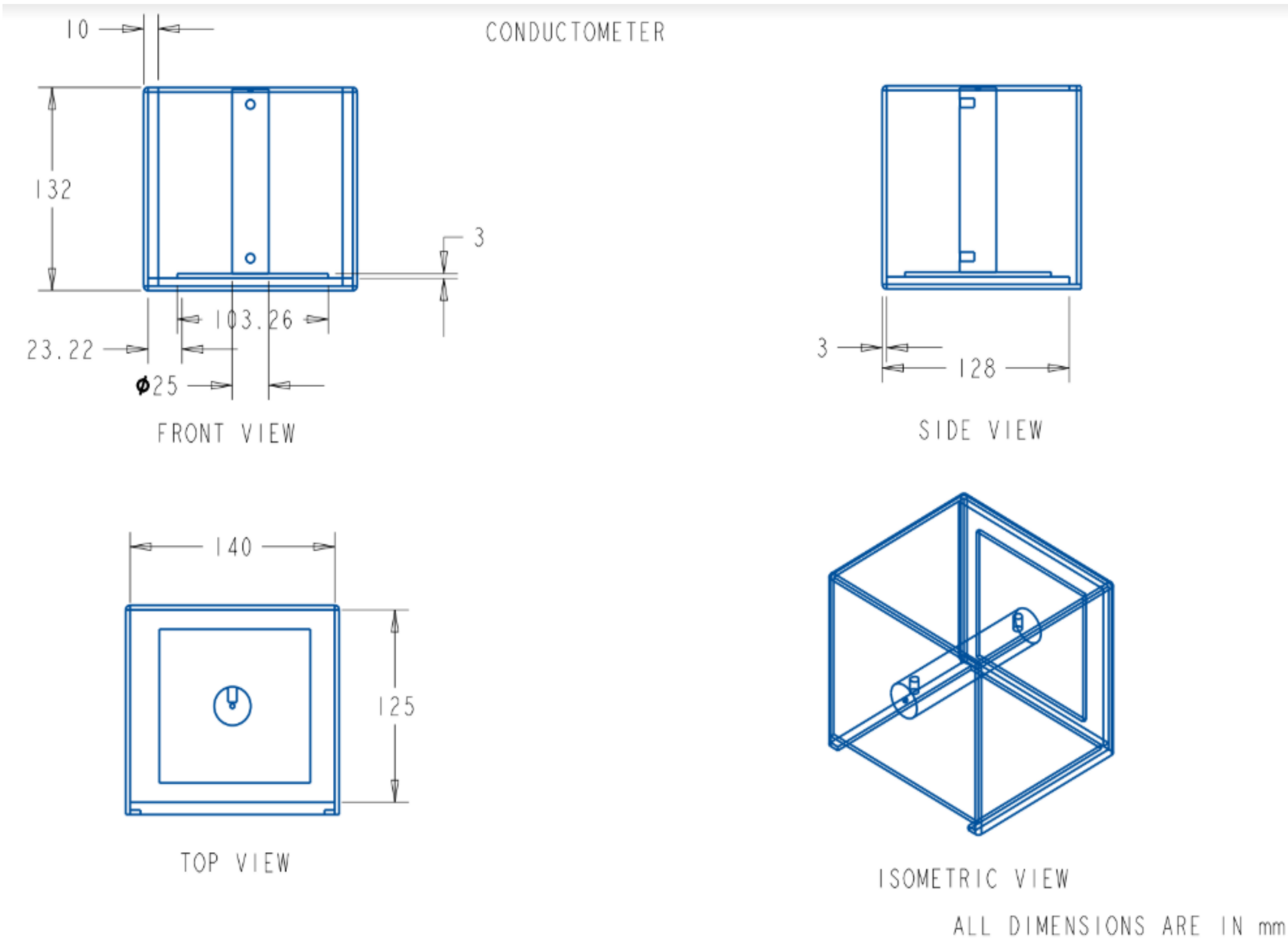

Fig2.5.Assembled View of Conductometer

CHAPTER 3

3.1 MAIN COMPONENTS

3.1.1 HEATER PLATE:

Electro thermal Plate heating material is mainly electric alloy wire, its working principle is very simple, simple is the electric effect. Electric heating plate work, electric current through the electric alloy wire, electric alloy wire will be hot, energy conversion to heat, and conduction to the outer shell. Electric heating board design has insulating materials, ensure that the electric heating alloy wire when the current does not use the safety hazard.

Fig3.1.1.Heater Plate

3.1.2THERMOCOUPLE:

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. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created.

Fig3.1.2.THERMOCOUPLE

3.1.3.MAX6675 module :

The MAX6675 performs cold-junction compensation and digitizes the signal from a type-K thermocouple. The data is output in a 12-bit resolution, SPI™-compatible, read-only format. This converter resolves temperatures to 0.25°C, allows readings as high as +1024°C, and exhibits thermocouple accuracy of 8LSBs for temperatures ranging from 0°C to +700°C. The MAX6675 is available in a small, 8-pin SO package.

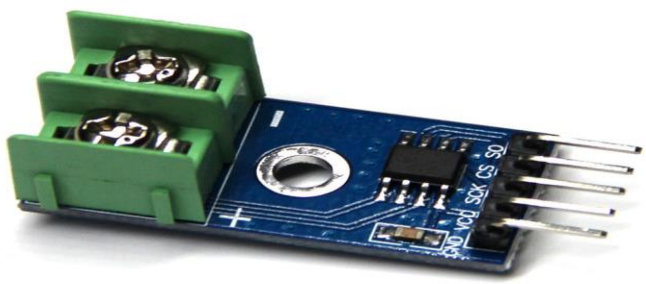

Fig3.1.3.MAX6675 MODULE

3.1.4.ARDUINO UNO:

The Arduino Uno is an open-source microcontroller board based on the Microchip Amega328P microcontroller and developed by Arduino.The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

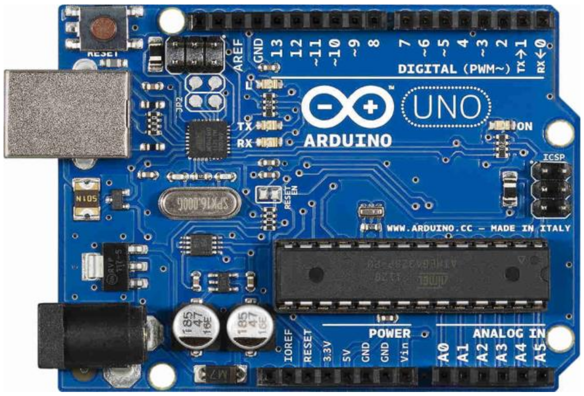

Fig3.1.4.ARDUINO

3.1.5.LCD1602:

LCD1602, or 1602 character-type liquid crystal display, is a kind of dot matrix module to show letters, numbers, and characters and so on. It's composed of 5x7 or 5x11 dot matrix positions; each position can display one character. There's a dot pitch between two characters and a space between lines, thus separating characters and lines. The model 1602 means it displays 2 lines of 16 characters. Generally, LCD1602 has parallel ports, that is, it would control several pins at the same time. LCD1602 can be categorized into eight-port and four-port connections. If the eight-port connection is used, then all the digital ports of the Sun Founder Uno board are almost completely occupied. If you want to connect more sensors, there will be no ports available. Therefore, the four-port connection is used here for better application.

Fig3.1.5.LCD1602

3.1.6.I2C BUS:

The I2C (Inter-IC) bus is a bi-directional two-wire serial bus that provides a communication link between integrated circuits (ICs). I2C is the de-facto solution for embedded applications. There are three data transfer speeds for the I2C bus: standard, fast-mode, and high-speed mode. Standard is 100 Kbps. Fast-mode is 400 Kbps, and high-speed mode supports speeds up to 3.4 Mbps. All are backward compatible. The I2C bus supports 7-bit and 10-bit address space devices and devices that operate under different voltages.

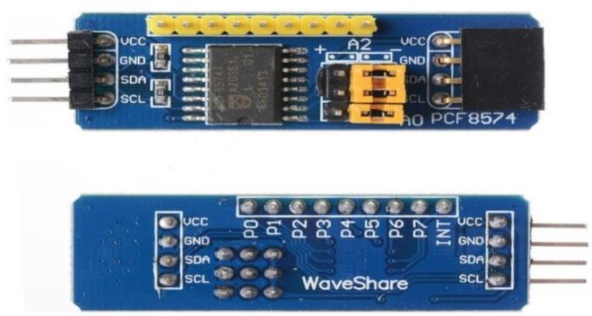

Fig3.1.6.I2C BUS

CHAPTER 4

FACTORS DETERMINING THE SELECTION OF MATERIALS

The various factors which determine the selection of material are discussed below;

4.1.PROPERTIES:

The material selected must possess the necessary properties for the proposed application .The requirements to be satisfied can be weight, surface finish, rigidity, service life, reliability etc.,

The following four types of principle properties of materials decisively affect their selection

a. Physical
b. Mechanical
c. From manufacturing point of view

4.2. MANUFACTURING CASE:

Sometimes the demand for lowest possible manufacturing cost of surface qualities obtainable by the application of suitable coating substances may demand the use of special materials.

4.3. QUALITY REQUIRED:

This generally affects the manufacturing process and ultimately the material. For example, it would never be desirable to go casting of less number of components which can be fabricated much more economically by welding or hand forging the steel.

4.4. AVAILABILITY OF MATERIAL:

Some materials may be scarce or in short supply it then becomes obligatory for the designer to use some other material which though may not be a perfect substitute for the material designed the delivery of materials and the delivery date of product should also be kept in mind.

4.5. SPACE CONSIDERATION:

Sometimes high strength materials have to be selected because the forces involved are high and space limitations are there.

4.6. COST:

As in any other problem, in selection of materials the cost of materials plays an important part and should not be ignored.Sometimes the factors like scrap utilization, appearance and non-maintenance of the designed part are involved in the selection of proper materials.

CHAPTER 5

DESIGNCALCULATION:

Specimen material: Aluminium

Heating plate material :Aluminium

Our specimen dimensions are,

Diameter of specimen - 25 mm

Length of specimen - 120 mm

According to Fourier's law of heat conduction,

$$q = -kA(dT/dx)$$

Where,

k - Thermal conductivity in W/mK

Q - Heat developed in W.

A- Area of specimen in m^2

Assumptions:

1. Flow is one dimensional.
2. No internal heat generation.
3. Steady state process

For heating plate,

V = 150V and I = 0.720A

Heat input, Q = V * I

= 150*0.9

Q = 135W

Area of plate, $A = \pi * D * L$

$= 3.14 * 0.025 * 0.10$

$A = 0.00785 \text{ m}^2$

Thermal conductivity of Aluminum (K),

$K = Q/A(dT/dx)$

$= (150 * 0.9) / ((0.00785)(10/0.1))$

$K = 171.97 \text{ W/mK}$

Theoretical thermal conductivity value of Aluminium lies in the range of 88 to 251 W/mK.

Since the experimental thermal conductivity value obtained lies in theabove mentioned range,we have chosen Aluminum as our specimen and heater plate material.Hence, the material is selected.

CHAPTER 6

FABRICATION:

The action of process of manufacturing (or) inventing something.

VARIOUS FABRICATION PROCESSES INVOVED INCONDUCTOMETER:

6.1.CUTTING:

- Cutting is a process in which a piece of material is cut intodesired final shape and size by a controlled removal process.

Fig6.1.Cutting

Before Machining : 25*150 mm

After Machining : 25*120 mm

6.2.DRILLING:

- Drilling is a material removing process that uses a drill bit to hole of circular cross section in a solid material.

Fig6.2.Drilling

Drilled hole diameter : 5 mm

Drill depth : 10 mm

6.3.GRINDING:

- Grinding is a surface finishing process by means of a rotating abrasive wheel over the material.
- Surface grinding is used to produce a smooth finish on flat surfaces.
- It is a widely used to abrasive machining process in which spinning wheel covered in rough particles cuts chip of metallic or non-metallic substances from workpiece, making a face of it flat or smooth.

Fig6.3.Grinding

CHAPTER 7

WORKING:

- After ensuring the safety precautions of the apparatus, Electric supply is turned ON .
- The input Voltage and Current given to the heater are measured using multimeter and kept constant for entire experiment.
- Electrical heater is used to produce heat source for heating the specimen and this is working under principle of joule heating. (An electric current passing through the resister will convert electrical energy into heat energy).
- Heat is transferred by mode of conduction to the test specimen.
- The temperature differences in both end of a rod is sensed by two thermocouples(temperature sensor) profiled at each end of the specimen.
- The operating principle of the thermocouple is based on the Peltiereffect.The circuit consists of two metals joined together to form two junctions of different temperatures. A Peltier electro motive force (emf) is generated due to the difference in temperatures of the two junctions of the circuit.
- When the presetting time reaches for this experiment thermal conductivity will calculated and displayed automatically for the specimen.
- The automated works are done using Arduino by feeding algorithm into the Microprocesor.

FACTORS AFFECTING THERMAL CONDUCTIVITY:

Free electrons:

Metals are having more free electrons compared to that of liquid and gases, so metal are good conductors of heat due to the migration of free electrons. Metals are having closely packed lattice compared to liquids and gases.

Purity of material:

Thermal conductivity of the pure material is higher than that of alloy materials. Alloying of metals and presence of impurities cause a decrease in thermal conductivity.

E.g. thermal conductivity of pure copper is 385 W/mK but copper having content of arsenic, thermal conductivity is 142 W/mK.

Effect of forming:

Treatment of metals like heat treatment and metal forming like bending, drawing and forging decreases the thermal conductivity of material compared to the material before treatment.

High temperature

At elevated temperature lattice vibration increases and free electrons movement decreases, thus the thermal conductivity of metal decreases when the temperature is increased.

Pressure:

Thermal conductivity is weakly dependent on pressure of substance. Means change in pressure does not affect much in thermal conductivity.

Density:

Thermal conductivity is highly dependent on density of material. The increase in density increases thermal conductivity.

Crystalline structure:

Material having a regular crystalline structure has higher value of thermal conductivity compared to that of amorphous(irregular) form.

CHAPTER 8

BILL OF MATERIALS:

Table No.8.1. Bill Of Materials

S.No	Description	Quanitty	Dimensions (mm)	Material
1.	Heater plate	01	100*100	Aluminium
2.	Thermocouple (Type - K)	02	-	Fe-CuNi
3.	Specimen	01	120	Aluminium
4.	Base plate	01	140*125	Mild steel
5.	Arduino (UNO)	01	-	-
6.	LCD (1602)	01	-	-
7.	MAX6675 module	02	-	-
8.	I2C bus	01	-	-

CHAPTER 9

COST ESTIMATION:

Table No.9.1 Cost Estimation

S.No	Description	Quanitty	Material	Amount In Rupees
1.	Heater plate	01	Aluminium	400
2.	Thermocouple (Type - K)	02	Fe-CuNi	380
3.	Specimen	01	Aluminium	450
4.	Base plate	01	Mild steel	50
5.	Arduino (UNO)	01	-	400
6.	LCD (1602)	01	-	140
7.	MAX6675 module	02	-	1000
8.	I2C bus	01	-	120
Total				**2940**

CHAPTER 10

ADVANTAGES & DISADVANTAGES:

ADVANTAGES:

- It's simple design.
- Its large linear dynamic range.
- Its generalresponse to both organic and inorganic species.
- Time consumption is less to determine the thermal conductivity of the material.

DISADVANTAGES:

- Less accurate values can only be obtained.
- Thermal conductivity of solid alone shall be measured
- Thermal conductivity of materials having melting point below 480^0C only be measured.

CHAPTER 11

APPLICATIONS:

11.1.COMPOSITES:

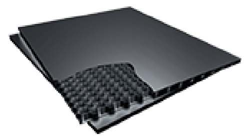

Fig11.1.Composites

Exploring the depths of composites to be used as building materials and furthermore, phase change materials.

11.2.CONSTRUCTION:

Fig11.2.Construction

Testing building materials, such as concrete and insulation, to ensure the highest of quality and the safest of products are used for construction.

11.3.INSULATION:

Fig11.3.Insulation

Investigating the quality and improving the efficiency of industrial and household insulation materials.

CHAPTER 12

FUTURE SCOPE:

- It can be used to find out the thermal conductivity of various materials.
- This can be used to determine the thickness and bonding resistance.
- This method can also be used for the identification of materials.
- It will play an vital role in thermal fields.

CHAPTER 13

CONCLUSION:

This paper lead to the design and fabrication of thermal conductivity measuring equipment sourced from readily available at low cost materials. The system was designed to determine the thermal conductivity for composite materials. Though conventional equipment for this experiment is available in versatile, we done this project by updating into automated way using Arduino. In this paper Automation is deployed to reduce the human work and time to determine thermal conductivty. In this project thermal conductivity(k) has been tested on aluminium rod and got thermal conductivity(K)=202.2 Wm-1K-1 actual value of thermal conductivity for an aluminium (k)=205 Wm-1K-1 from this we had observed that there is ± 10 % error occurs due to uncertainty. This is very useful for both Educational institutes and industries available to test the thermal conductivity value for composites materials. It is still being used in insulations , constructions etc.

CHAPTER 14

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CHAPTER 15

APPENDIX 1

CODING:

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,20,4);
int so1Pin = 4;
int cs1Pin = 5;
int sck1Pin = 6;
int so2Pin = 8;
int cs2Pin = 9;
int sck2Pin = 10;
float V=150;
float I=0.9;
float A=0.07853;
float T_1,t_1;
float T_2,t_2,k,a,b;
float L = 0.65;
MAX6675 thermocouple1(sck1Pin, cs1Pin, so1Pin);
MAX6675 thermocouple2(sck2Pin, cs2Pin, so2Pin);
void setup()
{
lcd.init();
lcd.init();
lcd.backlight();
```

```
lcd.print("CONDUCTOMETER");
lcd.setCursor(4,1);
lcd.print("READINGS");
Serial.begin(9600);
delay(3000);
 }
void loop() {
Serial.print("t_1 = ");
  t_1=(thermocouple1.readCelsius());
  T_1=t_1;
Serial.println (T_1);
Serial.print("t_2 = ");
  t_2=(thermocouple2.readCelsius());
  T_2=t_2;
Serial.println (T_2);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("T_1=");
lcd.setCursor(4,0);
lcd.print(T_1);
lcd.setCursor(10,0);
lcd.print((char)223);
lcd.setCursor(11,0);
lcd.print("C");
lcd.setCursor(0,1);
lcd.print("T_2=");
```

```
lcd.setCursor(4,1);
lcd.print(T_2);
lcd.setCursor(10,1);
lcd.print((char)223);
lcd.setCursor(11,1);
lcd.print("C");
delay(1000);
if (T_1>90);
    a=(V*I);
    b=T_1-T_2;
    k=((a)/(A*b));
lcd.clear();
lcd.setCursor(0,0);
lcd.print("conductivity=");
lcd.setCursor(0,1);
lcd.print(k);
Serial.println(k);
delay(1000);
delay(1000);
  }
```

CHAPTER 16

PROJECT PHOTOGRAPHY: