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DESIGN AND IMPLEMENTATION OF HEAT FLUX MEASUREMENT SYSTEM

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ABSTRACT-Temperature and heat flux measurements are important factors that need to be considered in fire test experiment for aero-engine applications. These two factors require accurate sensors that can easily sense and correctly read the inputs and outputs. There are some uncertainties that arise in measuring the different forms of convection and radiation heat flux on the standard type of test that should be carried out, and on the temperature and load bearing capacity of structural components, as well as time to ignition and burning characteristics of materials and products. The main issues associated with measurement of flame temperature and heat flux are the sensors. The main objectives of this project is to implement a system to measure the heat flux of a given material.

Keywords: Temperature and Heat flux measurement, Sensors

1.INTRODUCTION:

Some important aspects that are to be kept in mind while designing system in aero-engine applications are Temperature and Heat flux measurement to examine the heat resistance of metals used. Over the years, Aluminium and copper have played a significant role in the industry. A good heat flux measuring device is required to check the heat resistance of material used in fire test. Previously, the problem that had arisen during the measurement is due to Thermopiles which are very cost. Among the other types of sensors Thermocouples are the most commonly used Sensors which has negligible uncertainities compared to others. So, it is clear that Temperature and Heat flux measuring devices depends fully on the Sensors

2. PROBLEM DEFINATION::

The Main problem is previously temperature and heat flux measurement techniques for aeroengine fire test was conducted using THERMOPILES. Thermopile is an electronic device that converts thermal energy into electrical energy. It is composed of several thermocouples connected in series. Adding more thermocouple pairs in series increases the magnitude of the voltage output. Thermopiles are frequently used in fire testing. Typically installed vertically and next to the sample under testing. Thermopiles are unprotected heat flux sensors, and that they are highly sensitive, costly and heat flux cannot measured on wide area.

3.DESIGN METHODOLOGY:

The block diagram of Design and Implementation of heat flux measuring system is shown in below figure.

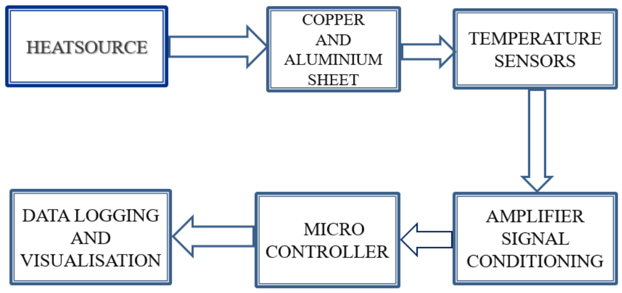

Figure No.1: Block Diagram

TEMPERATURE SENSORS:

The sensors used in this project are K-Type Thermocouple and LM35**.**

K-TYPE THERMOCOUPLE:

K-Type thermocouple refers to any temperature sensor containing Chromel and Alumel conductors having a temperature range of 0 degree celsius to 800 degree celsius**.** It requires an amplifier to amplify it's output.

LM35 TEMPERATURE SENSOR:

LM35 is an integrated analog temperature sensor whose electrical output is proportional to Degree Centigrade. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy).

MAX6675 THERMOCOUPLE AMPLIFIER:

The MAX6675 performs cold-junction compensation and digitizes the signal from a type-K thermocouple. It consists of a total of 7 pins where two are used to connect the thermocouple positive and negative leads, three for the SPI interface and two for the power and ground.

Figure No.2:MAX6675

Interfacing of MAX6675 Thermocouple with Arduino UNO is done. Next Temperature Readings are accessed in Arduino IDE by importing max6675 libraries in the sketch and the sketch is uploaded which is imported into an excel file. Now the data is visualised in Mat lab.

Heat Flux:

Heat flux is the amount of heat transferred per unit area per unit time to or from a surface.

In SI unit of heat flux density is measured in Watts per meter square (W/m^2). Heat flux is a vector quantity that has both magnitude and direction.

Fourier's law is an important application of these concepts. For a pure solid substance, the conductive heat flux JH_c in one dimension is expressed by Fourier's law.

The amount of energy flowing per unit are is considered as flux.

Q=-kA.dt/dx

here Q/A is heat flux.

Where,

- Q/A = conductive heat flux
- T = temperature
- k= thermal conductivity constant

FLOWCHART:

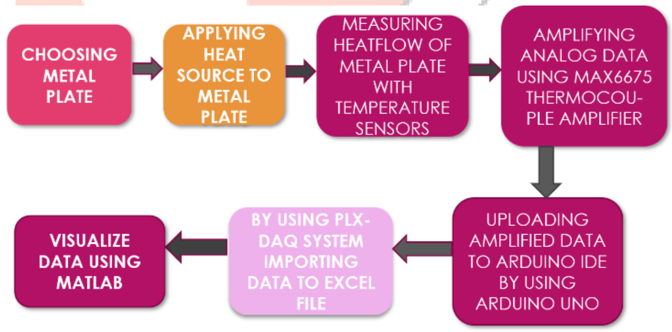

Figure No.3: Flow chart

The system is constructed through the use of MAX6675 K-Type Thermocouple, Arduino Uno, previous design is made of Thermophiles. The early design will be metal plate, heat source is applied to the metal plate with contact for measuring the heat distribution through the plate here using the MAX6675 thermocouple amplifier and LM35 temperature sensor. Here source temperature is measured using MAX6675 at one end of the metal plate and LM35 at other points of metal plate. And then the amplified data is uploaded to the Arduino IDE using Arduino UNO microcontroller. By using PLX-DAQ system data is imported to Excel file. Next the data is visualized using Mat lab.

The heat flux is calculated by taking heat flow data obtained. Finally, Heat flux calculated is compared with theoretical values.

The result provided that the objectives of the design satisfied the need.

4. EXPERMENTAL RESULTS:

For Aluminium Plate, when K-Type Thermocouple is used to measure source temperature and three LM35 s are placed at a distance of 4cm respectively. It is observed that, the used aluminium plate is suitable in aero-engine conditions by comparing the Heat flux results with the theoretical values.

Time(sec)	Source Temperature (°C)	Temperature at 4cm (Boundary 1)	Temperature at 8cm (Boundary 2)	Temperature at 12cm (Boundary 3)
1.0	31.25	30.68	30.39	30.14
114	393.00	139.22	94.45	84.49
250	172	127.85	113.59	100.06
350	89.25	77.02	78.58	69.94
450	55	56.46	57.96	52.9

Table No.1: Al temperature readings at different places

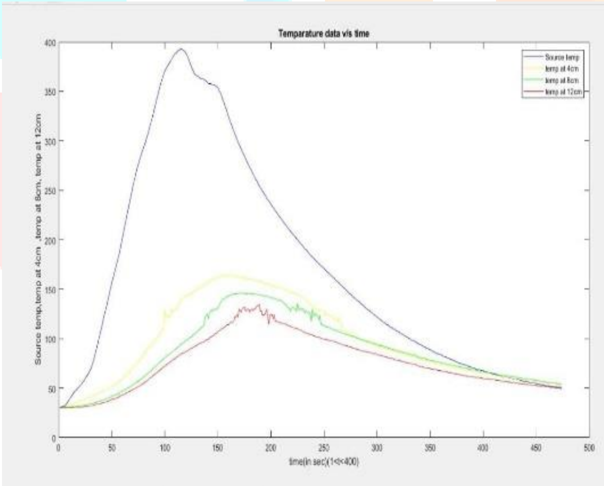

Figure No.4: Aluminium heat flow plotting

For copper plate, when K-Type Thermocouple is used to measure source temperature and three LM35 s are placed at a distance of 4cm respectively. It is observed that, the used aluminium plate is suitable in aero-engine conditions by comparing the Heat flux results with the theoretical values.

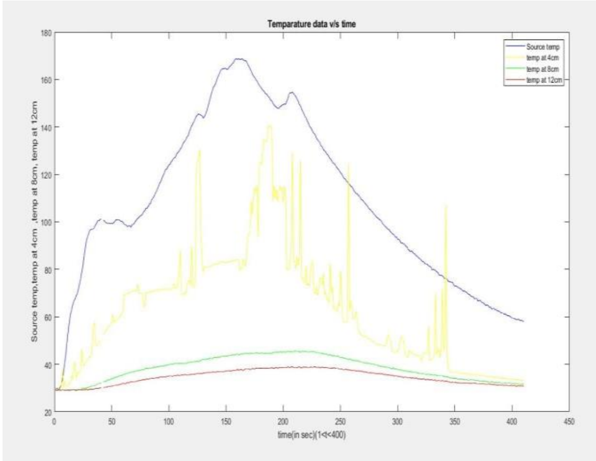

Figure No.5: Copper heat flow plotting

Table No.2: Cu temperature readings at different places

Time (seconds)	Source Temperature(°C)	Temperature at 4cm	Temperature at 8cm	Temperature at 12cm
1.0	29.5	29.56	29.12	29.21
100	124	71.3	39.81	34.98
162	168.75	80.48	44.3	37.66
250	120.75	79.56	42.98	38
400	59.75	33.71	31.71	31.02

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