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STUDY OF TEMPERATURE VS DISTANCE PROFILE AND MEASUREMENT OF TEMPERATURE FOR NATURAL CONVECTION HEAT TRANSFER MODE IN A CLOSED RECTANGULAR CAVITY

S. Ahmed[1], M. S. Islam[2], M. M. R. Chowdhury[3], M. A. R. Sarkar[4]

[1]Department of Mechanical Engineering, BUET, Dhaka, Bangladesh
[2]Department of Mechanical Engineering, BUET, Dhaka, Bangladesh
[3]Department of Mechanical Engineering, BUET, Dhaka, Bangladesh
[4]Department of Mechanical Engineering, BUET, Dhaka, Bangladesh

saad.me05@gmail.com*, ramin_023@yahoo.com, sami_buet05@yahoo.com, rashid@me.buet.ac.bd

Abstract- *Natural convection in rectangular cavities has been the subject of numerous studies carried out using numerical methods but none of them have done any experimental study. So, the majority of numerical studies lack comparisons with experimental data. In this paper a temperature vs. distance profile is established both experimentally and with the help of simulations. The experimental objective of this paper is to develop a temperature vs. distance profile for natural convection heat transfer mode in a rectangular cavity and as well as to make a time saving, accurate and highly efficient temperature measuring device using pc interfacing. Then COMSOL Multiphysics 3.5 is used to develop the same model and do the simulations. After that the comparisons between experimental and simulation methods are done.*

Keywords: Natural Convection, Temperature, Sensor, Simulation.

1. INTRODUCTION

The study of temperature vs. distance profile and précis measurement of temperature is very important not only in scientific field but also in engineering applications. In modern industries everything works on automation. Here time saving is very much important. Temperature measuring and controlling are needed in various fields of industries. Sometimes large amount of data have to be processed. In this case digital processing of temperature measurement can lessen all the difficulties.

Natural convection in rectangular cavities has been the subject of numerous studies carried out using numerical methods, and also of some experimental studies. In general, however, the majority of numerical studies lack comparisons with experimental data. In this paper the authors establish a temperature vs. distance profile experimentally using the experimental setup and then compared it with a simulated temperature vs. distance profile using COMSOL Multiphysics 3.5. Here COMSOL Multiphysics 3.5 is used to develop a model of the experimental setup.

Two-dimensional convection flow have also been investigated numerically by [1] in a differentially heated cavity containing a heat source above the bottom surface of the cavity, and by [3] for a low viscosity flow with zero thermal diffusivity. In this paper, the authors approach is close to the one used by [2]. The difference lies in that; it is an experimental investigation of temperature vs. distance profile. To accomplish this, the authors have to build up their own experimental setup.

So the two objectives of this paper are to-

- Build a time saving, accurate and highly efficient temperature measuring device using pc interfacing.
- Establish temperature profile in a rectangular cavity experimentally.
- Comparison of the experimental profile with a simulated profile using COMSOL Multiphysics 3.5.

2. EXPERIMENTAL PART

This project consist of a mechanism which measures temperature of air (fluid) in any position of a rectangular cavity. A thermal sensor (LM-35) measures the temperature. At first x, y, z co-ordinates aregiven as input from keyboard. Then the mechanical device carries out the thermal sensor to the desired location and the thermal sensor measures the temperature and shows output in the monitor of the computer. Four stepper motors are used: two are connected parallel for X-axis movement, one for Y-axis movement and the last one for Z-axis movement.

2.1 Experimental Setup

Main features of the setup –

- Four Stepper motor (24 volt)
- Nichrome wire: used as heating source
- Threaded shaft and nuts are used for the movement of the whole mechanism via stepper motor.
- Relay Switch (12 volt)
- Transistor (BD 135)
- LM-35- temperature sensor. This series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to Celsius temperature.
- Power supply
- Resistor (2.2 KΩ)

Fig1: Set up

2.2 Data collection

C programming language is used. The program is written so that at a particular coordinate the thermal sensor measures five temperatures and arithmetic mean of these five temperatures is taken to make data collection more accurate.

Detail sample data is shown in Table1.

Table 1: Displacement (cm) and corresponding temperature (K)

Distance (cm)	Temperature (K)
0	455
10	453
15	449
20	438
25	453
30	429
35	425
40	415
45	408
50	403
55	455
60	383
65	377
70	360
75	353
80	346
85	340
90	331
95	328
100	328
105	325
110	321
115	316
120	316

3. SIMULATION PART

COMSOL Multiphysics 3.5 is used for simulation process. Model is developed according to the boundary condition of the experimental setup.

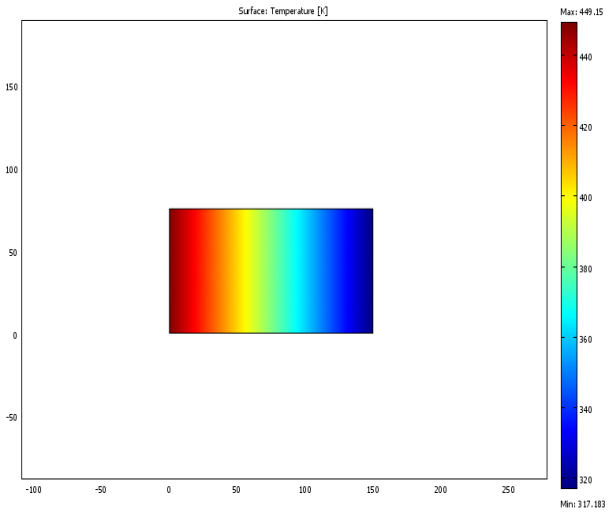

Fig 2: Temperature distribution of the simulation based model

It is depicted from Figure 2 that temperature is maximum at the proximity of the heating source (red zone in the figure) and temperature gradually decreases with the increase of distance from the heating source to the edge of the model (blue zone in the figure).

Here as convection medium, properties of air are used in developing the model.

4. RESULTS AND DISCUSSION

One of the objectives of this paper is to establish a device that can measure temperature in any desired places in a three dimensional coordinate system. Despite

of technological inadequacy the device provides us with quite accurate temperature up to a certain cycle of the thermal sensor (LM-35). Further involvement of technological devices would improve the data reading accuracy of the gadget as well as sufficient amount of data would be taken.
The second objective of this paper is to establish a temperature profile with the variation of distance for natural convection heat transfer mode in a closed rectangular cavity which is shown in Figure 2.

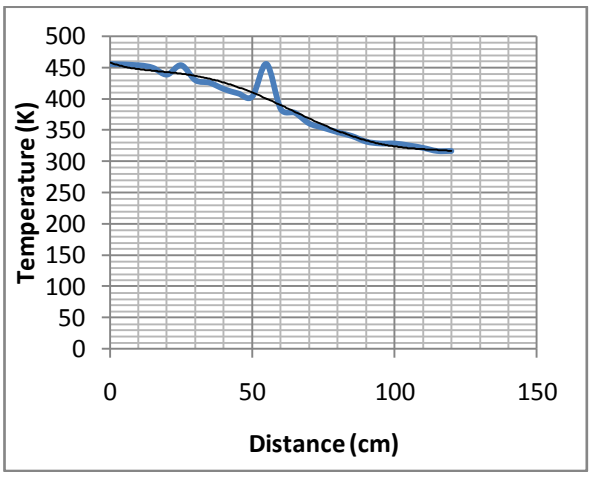

Fig 3: Experimental temperature vs. distance graph

Final objective of this paper is to compare the experimental temperature vs. distance profile with a simulated temperature vs. distance profile to validate the results. For post-processing results MATLAB is used.

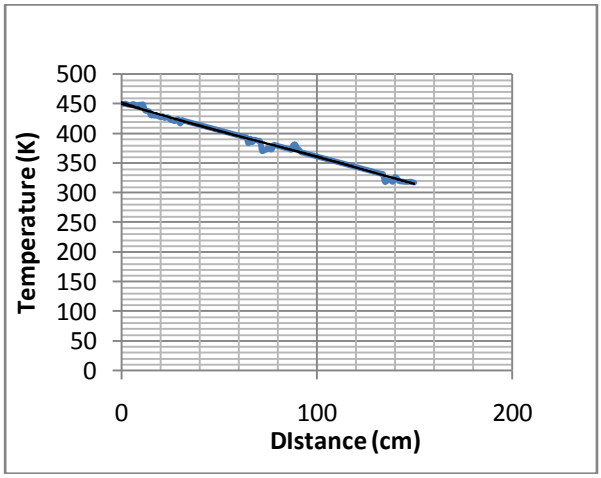

Fig 4: Temperature vs. Distance profile of the simulated model

Here best fitted curve is drawn in both Figure 3 and Figure 4.
In the experimental temperature profile (Figure 3) there are some points (temperature) which are deviating from the main trend line. In the experimental part some assumptions are made during taking data:

- Heat flow is assumed two dimensional
- Upper and lower part of the experimental set up is considered insulated
- Heat transfer occurs only by convection mode inside the cavity.

In actual case it is very hard o maintain these conditions. Low accuracy of the thermal sensor is another reason for digression of some of the points. After every cycle of operation, thermal sensor (LM-35) lost its accuracy. For this reason only 22 number of temperature readings were recorded accurately.
In Figure 4 almost all the points are following the trend line and temperature vs. distance profile of Figure 3 and Figure 4 are similar in nature, showing highest temperature vicinity of the heat source and gradually decreasing with the increase of temperature from the heat source.

. 4. CONCLUSION

In this paper a device is developed to measure the temperature inside a rectangular cavity when heat is generated by natural convection mode of heat transfer. Natural convection flows in a rectangular two dimensional cavity have been experimentally studied. The heat flow is generated by placing a heating coil at one side of the rectangular cavity and all the other sides are assumed as heat sink. It is also assumed that the whole system is thermally adiabatic, means no heat will flow outside of the cavity by any modes of heat transfer and only convection heat transfer occurs inside the rectangular cavity.
The behavior of heat transfer by natural convection in a confined geometry is also developed using COMSOL Multiphysics 3.5 and then compared with the experimentally developed profile. Both the experimental and simulated temperature vs. distance profile depicts similar trend.

5. REFERENCES

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