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# To study natural convection heat transfer in open cavity

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**Abstract - Electronic components Burnout quickly when they heated up beyond certain range. Many researchers, scientist find this problem genuine and work hard on it. Steady state natural convection heat transfer from open cavity with side and top opening have been studied for different aspect ratios using air as medium. A single isothermal wall which is vertical used as the heat source in the cavity and all other walls were well insulated. Hot wire anemometer and thermocouples were used to measure velocity and temperature along the top opening of the cavity. Velocity and temperature profiles are shown for different aspect ratios.**

**Keywords** – *open boundary, isothermal wall, emissivity*

## I. INTRODUCTION

Natural Convection heat transfer can be easily identify in many thermal engineering systems. Natural convection occurs in numerous Engineering applications which include air as heat transfer medium such as solar energy collectors, energy efficient buildings, cooling of electronic components, double pane windows and so forth. Heat transfer coefficient of natural convection is very low in comparison to forced convection [1] but still it is preferred due to cost effective, noiseless and simple design.

An open cavity is a cavity in which top is open so that air or caring fluid can leave the cavity. Heat transfer from the bottom of the sidewall is important due to its application in cooling of electronic components [2]. Though simple in design this experiment setup shows some interesting facts about velocity and temperature profiles.

Natural Convection in open cavity studied by many research scholars such as Sarris et at (2004)[3] made a numerical study in order to gain understanding of certain aspects of natural convection in a glass melting tank heated locally from below. They studied the effects of location of heated strip by placing it at center and off-center positions at the tank bottom wall.

Katsavos et al (2001) [4] studied experimentally and numerically the natural convection of a fluid above a heated wire placed on the bottom of a rectangular tank with the use of an in-house PIV system.

Frederick (1997) [5] studied the natural convection in a cubic cavity that one of its sides was divided into two equal vertical portions so that one of them acts as a heat source and another one as acts as a heat sink. Other sides of the cavity are insulated. He concluded that a delay occur in the transition of conduction to convection mode due to the position of the heat source and the heat sink so that the convection dominates in cavity at relative high Rayleigh number $10^5$.

Varol et al (2009) [6] found that Nusselt number and flow field increases with Ra number. They also reported that Nusselt number is reduced when the heat source is close to the lower horizontal wall. Aspect ratio was reported to only modify the circulation cell in length.

Chao et al (1983) [7] solved the problem to show the effects of inclination angle in a partially heated rectangular cavity and they found that the inclination angle is a good control parameter in these kinds of systems.

Corvaro et al (2011) [8] used the PIV and interferometer techniques to obtain the temperature distribution and flow field in a partially heated square cavity.

Torrentz and rocket in 1969, Frederick in 1997 [9], Varol et al in 2008 [10], Ravi Shankar Prasad Singh, Amit Kumar Gupta in 2018 [11].

A review of literature provide enough evidence of the importance of natural Convection heat transfer in cavity the objective of the present study is to study the velocity and temperature variation vertical to isothermal heat wall along the opening at the top.

## II. EXPERIMENTAL SETUP AND PROCEDURE

The experimental setup consists of four sides walls, bottom and top walls.

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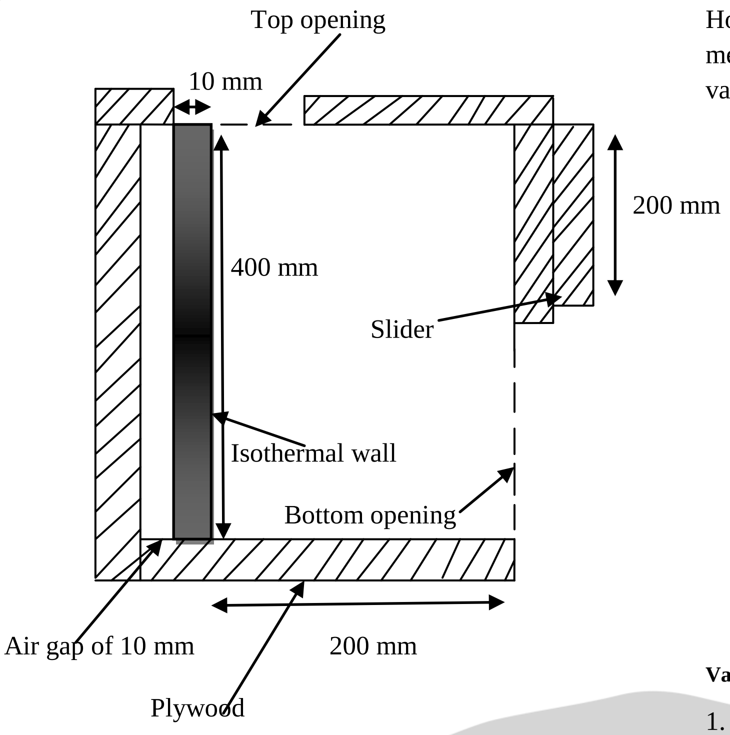



**Fig. Experimental setup**

An opening at the bottom of the right wall considered whose size can be changed according to the desire. There is also an opening of 30% on the top wall of the cavity adjacent to the left wall.

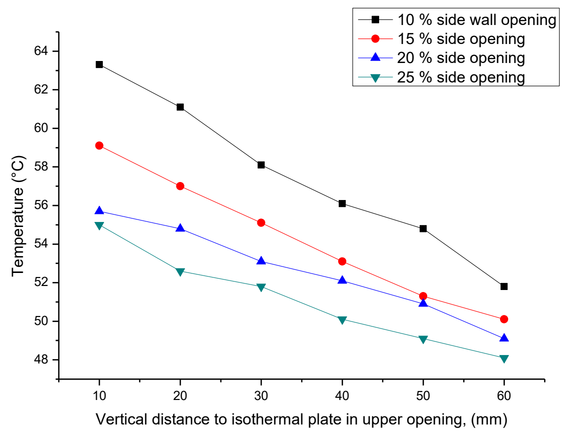
Right wall consists of aluminum plate of following dimensions 400 mm, height 10 mm thickness and 200 mm depth. On one face of the aluminum wall a foil heater is used to energized the plate. Temperature of the aluminum foil on the face inward cavity is 80 °C ($T_p$) and surrounding ambient air temperature is 39.4 °C (T), ($T_P > T_\infty$). Temperature of the plate is maintained by thermostat. The face of the aluminum plate on which wall heater used as well insulated by plywood of 0.14 w/m K, thermal conductivity and air gap of 10 mm between them. All walls of the cavity are made of plywood of thermal conductivity of 0.14 W/m K and then two mm of thermocol of thermal conductivity of 0.047 w/m k is used.

Blackboard paint of emissibility of 0.85 is used in order to maintain high value of emissivity on the walls because radiation effect inside the cavity cannot be neglected. Dimensions of the cavity are as follows 400m height, 200 mm breath, and 200 mm length.

In order to maintain steady state conditions experimental setup run for long time about 3 hours, after this long time when the readings are static or steady state conditions achieved readings were measured. Readings are collected for four different openings of the right wall at the bottom 10%, 15%, 20%, 25% and opening at the top wall remains 30%.

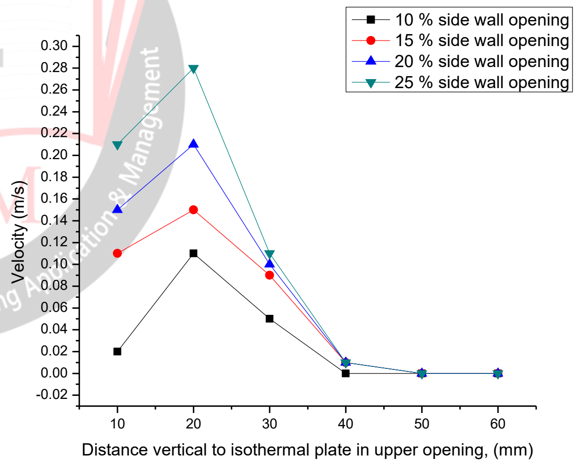
Hot wire anemometer and thermocouples are used to measure the velocity and temperature of the air flow at various points on the top wall opening.

## III. Observations




**Variation of temperature along top opening**

1. Shows the variation of temperature along the top cavity at various points for various opening sizes in the right wall at the bottom. Temperature decreases away from the isothermal wall.




**Variation of velocity along top opening**

2. Velocity profile along the top cavity at various points were measured. velocity was measured for various percentage of opening of the right wall at the bottom. Velocity first increase and then decreases to almost zero along the top opening.

## IV. Result and Discussions

A. Following assumptions made in the development of this report

1. Ambient air temperature is constant.

2. The air is still outside cavity.

3. Fluctuation of electricity is negligible.

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B. Following results have been found

1. Temperature of the air along top opening increases with the decrease in the percentage of the bottom side opening of the right wall.

2. Velocity of the air decreases with the decrease in the percentage of the opening of the right wall at the bottom.

3. Temperature decrease with the increase in the distance from the heated left wall.

4. Velocity first increases and then decreases with the increment of distance away from the right wall.

5.Increasing rate of air velocity is exponential initially then reaches to maximum value and then decrease.

## V. Conclusion

This report concludes that for maintaining the low temperature inside cavity opening in the right wall at the bottom should be increase. As the opening on the right wall at bottom increases the magnitude of the velocities also increases and temperature decreases along the top opening. Velocity increases in exponential way near isothermal left wall and reaches to the maximum value. Its decreasing rate is also high after maxima point but smoothen as distance from isothermal plate increase. Temperature of air along decreases in a uniform way along the top opening.

Nomenclature

| | |
|---|---|
| $R_e$ | Reyonlds number |
| $\rho$ | Density of air (Kg/m$^3$) |
| $\mu$ | Absolute Viscosity (Ns/m$^2$) |
| $\gamma$ | Kinematic viscosity (m$^2$/s) |
| $Pr$ | Prandtl number |
| $K_{air}$ | Thermal conductivity of air (W/mK) |
| K | Thermal conductivity of aluminium (W/mK) |
| $K_{eff}$ | Effective thermal conductivity |
| Gr | Grashof number |
| Nu | Nusselt number |
| $\beta$ | Thermal expension coefficient |
| $T_p$ | Temperature of isothermal plate |
| $T_\infty$ | Temperature of ambient air |

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