CFD analysis of Natural convection process through asymmetrically heated vertical plates with adiabatic auxiliary plate in steady state

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**Abstract** - The effect of natural convection in an asymmetrically heated vertical channel with an auxiliary plate is studied numerically in laminar regime. The computational procedure is made by solving steady state two dimensional Naiver- stokes and energy equations. This system is then integrated by a finite volume approach. More than twelve simulations are performed to find the optimum position of the adiabatic plate at which maximum heat transfer occur in the vertical channel. Contour maps are plotted and then used to precise the enhancement rates of mass flow and heat transfer for the vertical plates. The area average temperature obtained gives the optimum position of the adiabatic plate.

**Keywords** — Vertical channel, Adiabatic auxiliary plate, Natural convection, Heat transfer rate, Laminar flow, Numerical simulation, Nusselt number.

**I. INTRODUCTION**

Natural convection of air along vertical channels are widely studied because of their importance in the engineering applications like : cooling of electronic equipment's like transistors and IC chips, solar collectors, cooling of main frame computers and in nuclear industry. Due to their immense applications experiments and numerical analysis are still going on.

Elenbaas [1942] was the first person to do an experimental work on buoyancy actuated natural convection in a vertical channel. T.Aihara [1963] was the first person to introduce an auxiliary plate with a vertical channel. Andreozzi and Manca [2001] studied natural convection inside a vertical channel using an auxiliary plate either with constant heat flux or adiabatic. In their analysis it was found that an adiabatic auxiliary plate kept on the centre line of the vertical channel reduces chimney effect, while the auxiliary plate with uniform heat flux increase the mass flow rate.

The main objective of the present numerical study is to find the optimum position of adiabatic auxiliary plate inside two parallel plate vertical channel which increases the heat transfer rate.

**II. PROBLEM FORMULATION**

Air at 295k temperature enters across two vertical parallel plate channels of height 1500mm, held at a distance 120mm between each other. An adiabatic auxiliary plate of height 750mm and width 2mm is kept in between the two vertical plates. Six different positions of adiabatic plate is tried in order to obtain maximum heat transfer across the vertical channels which is asymmetrically heated with two different heat flux.

![Fig.1 physical model](http://www.ijettjournal.org)

Fig 1 shows the physical model in two dimensional. The flow inside the vertical channel is purely induced by buoyancy. In order to get accurate results a computational I domain is added to the physical model. Fig 2 shows the computational model.
III. NUMERICAL TECHNIQUES

The governing equations are discretised by finite volume method. With second order upwind scheme. The unknown parameters at the mesh faces are found out by using multidimensional linear reconstruction method.

SIMPLE scheme of pressure velocity coupling is used as solution method to solve the pressure based equations that are derived from the continuity and momentum equations. Above equations are then solved sequentially using Fluent 14.5.

IV. RESULT AND DISCUSSION

Analysis was performed on proposed model of vertical channel with auxiliary adiabatic plate by using ANSYS Fluent software. Velocity and nusselt number profiles along the length of vertical channel are plotted under laminar conditions. Computation was done on vertical channel for two Rayleigh numbers $10^3$ and $10^5$ by varying heat flux. The adiabatic auxiliary plate was kept at 6 different position.

1) Effect of position of auxiliary plate on heat transfer.

The adiabatic auxiliary plate was held at 3 different positions along the bottom in between the vertical channels and 3 different position along the top for two Rayleigh numbers. A sum total six position was analysed for $10^3$ Rayleigh number and six position for $10^5$ Rayleigh number. Area average temperature along heated vertical channel was found out using function calculator for each six positions of both Rayleigh number. It was found that top left position near to the heated channel close to outlet helps in maximum heat transfer, while other positions of the adiabatic plate especially bottom positions does not help that much in heat transfer.

From Fig.3 it is found that nusselt number decreases drastically from 0 to 0.75m, from 0.75m it increases (presence of adiabatic plate) and further nusselt number decrease. So it can be confirmed that there is increase in heat transfer with addition of auxiliary plate.

Fig.2 computational model

Fig.3 Nusselt number v/s length

Fig.4 velocity profiles at different length

Fig.4 shows the velocity profiles at different heights of vertical channel. It is found that there is significant decrease near to auxiliary plate and after that there is drastic increase in velocity which shows that high heat transfer occurs.
V. CONCLUSION

The effect of adiabatic auxiliary plate on natural convection in asymmetrically heated vertical channel is numerically investigated. Following conclusions are obtained from present study:

1) Heat transfer can be increased or decreased by changing position of the adiabatic auxiliary plate.
2) The optimum position of the adiabatic auxiliary plate which increases heat transfer is near to the heated vertical channel at top close to channel exit.
3) The auxiliary plate will be a cost efficient tool that can be used in natural ventilation systems.

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REFERENCES