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# PARAMETRIC STUDIES ON HEAT TRANSFER BY NATURAL CONVECTION IN VERTICAL CHANNEL USING INCLINED V-SLOT PLATE– AN OVERVIEW

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## ABSTRACT

Natural Convection flow in a vertical channel with internal objects is encountered in several technological applications of particular interest of heat dissipation from electronic circuits, refrigerators, heat exchangers, nuclear reactors fuel elements, dry cooling towers, and home ventilation etc. This study deals with the study of natural convection inside inclined v-slot plate placed in vertical channels. The parameters varied during the experimentation are heat input, aspect ratio (the ratio of length of inclined v-slot plate to the spacing between vertical plates) and elevation of inclined v-slot plate from bottom plate. The present study aims to determine the heat transfer characteristics, temperature distribution along the inclined v-slot plate to develop a correlation in the form of $Nu = c\ (Ra)^n$ for different values of aspect ratio, for the selection of optimum dimension for design purpose. Further, the influences of inclination of plate and aspect ratio on the performance characteristics of heat transfer will be studied.

**Key Words:** Natural convection, Inclined V-slot plate, Vertical plate, Aspect ratio

## 1. INTRODUCTION.

Heat transfer is the area that deals with the mechanism responsible for transferring energy from one place to another when a temperature difference exists. Convective heat transfer in general is the heat transfer process that arises from fluid flow over or through a hot or cold surface where the fluid flow acts as a carrier of energy. The heating or cooling process is called natural convection if the fluid motion is induced only by the buoyancy forces.

Latter of which buoyancy forces are induced from the density changes caused by the temperature gradient in the fluid region close to the heat transfer surface. In other words, a fluid attached to a hot or cold surface will change its temperature and therefore its density in the proximity of that surface, causing it to move up- or downward, depending on whether it is heated or cooled.

Natural convection heat transfer phenomena are two dimensional on vertical and horizontal plates but are three dimensional on inclined plates due to the circumferential and axial developments of the boundary layers making the flow as well as heat transfer behavior complex. A number of correlations are available in literature for the estimation of natural convection heat transfer from vertical as well as horizontal plates, but little work has been reported on the effect of plate inclination on the mean heat transfer coefficient. Inclination of containers filled with fluid, inside which convective heat or mass transfer occur, may have either desirable or undesirable effects depending on the application.

Due to modern application of natural convective heat transfer in V-slot plate geometry has been widely studied for its applications in heat loss from piping, heat exchangers, HVAC systems, refrigerators, nuclear reactors fuel elements, dry cooling towers and cooling of electronic components such as printed circuit boards, there has been resurgence of interest in studying natural convection in vertical channels. Understanding the flow and heat transfer pattern in this equipment may significantly improve their design & consequently their operational performance.

## 2. LITERATURE REVIEW.

**Natural Convection from plate:-**

**Sparrow and Azevedo[1].** conducted experimental and numerical studies on the effect of inter-plate spacing on natural convection heat transfer characteristics of a one sided heated vertical channel. The 50 fold variations of inter-plate spacing enabled the investigation between the two limits of fully developed channel flow and single vertical plate. The experiments were performed in water at Prandtl number Pr =5. The numerical solutions were carriedout by taking into account both natural convection in the channel and conduction at the wall. It was reported that the heat transfer process is particularly sensitive to changes in inter-plate spacing for narrow channels.

**Said and Krane[2].** investigated the problem of natural convection heat transfer in a vertical channel with a single obstruction was both experimentally and analytically.Optical techniques were used to obtain measurement of both quantitative data (heat flux and temperature) and qualitative data (flow visualization), with uniform wall temperature boundary conditions in experimental investigation. Inthe numerical study, finite element computer code NACHOS was used with the two thermal boundary conditions of uniform wall temperature and uniform heat flux. It concludes that the location of the obstruction along the wall affects the rate of heat transfer. Moving the obstruction away from the entrance towards the exit was found to reduce the net heat transfer rate from the channel.

**Kihm[3]**Investigated natural convection heat transfer characteristics in converging vertical channels flows by measuring the wall temperature gradients using a laser speckle gram technique. The local and average heat transfer coefficients were obtained for forty different configurations, including five different inclination angles from the vertical (.= 00, 150, 300, 450 and 600) with eight different channel exit openings for each inclination angle. Correlations were obtained for local and average heat transfer coefficients in the arrangement of Grashoffs numbers up to 7.16×106; however the flow regimes for all considered cases were laminar. It reported that as the top opening of channel decreased, both local and average Nusselt number values started decreasing below that of a single plate.

**Kihm[4].**in another experiment investigated the phenomenon of flow reversal in natural convection flow between two isothermal vertical walls. They reported the existence of a recirculating flow region accompanied by vena-contract like streamlines at the entrance when Rayleigh number exceeded a certain critical value. These results in, insufficient volume flow rate through the channel, which in turn, limited the increase of heat transfer as Rayleigh number increases.

**Naylor and Tarasuk[5]** conducted an interferometric study on two dimensional laminar natural convection in an isothermal vertical divided channel for two different positions of the dividing plate. The average Nusselt number obtained experimentally was found to be 10% less than the one obtained Numerically.

**Tanda[6]**experimentally investigated the problem of heat transfer between two staggered vertical plates inthe presence of natural convection regime with theeffect of inter plate spacing and magnitude of vertical Stagger on the heat flux from each plate.

**Manca[7]**Performed experimental study of laminar natural convection in an asymmetrically heatedvertical channel with uniform flush mounted discrete heat sources. The effect of wall emissivity was taken into account. The wall temperature profiles as a function of emissivity, strip heat flux, channel spacing, the number strips and their arrangement werepresented. A correlation for Nusselt number in terms of Rayleigh number was proposed for Rayleigh numbers ranging from 10 to $10^6$.

**Daloglu and Ayhan[8].** conducted measurements of natural convection in a rectangular channel with fins connected periodically to both plates. The channel had an aspect ratio of 66 and the walls are maintained at uniform heat flux. Results were obtained for the modified Rayleigh numbers ranging from 20 to 90 and it was found that the Nusselt Number for finned channels is less than that for smooth channels for all values of Rayleigh number.

**C.E.Kwak and T.H.Song[9]**investigated natural convection from two dimensional vertical plates withhorizontal rectangular grooves both experimentally and numerically. A Mach-Zehnder inter ferrometer was used in the experiment and local Nusselt number at each groove surface (outer, bottom, inner and topsurface) were measured quantitatively from the inter Ferrograms. The effect of Rayleigh number for eachaspect ratio was studied. The results were summarized using the average Nusselt number Vs Rayleigh number correlations. The correlations may be used for selecting proper aspect ratio and dimension.

**La Pica[10]** studied experimentally the free convection of air in a vertical channel in a laboratory model of height (H) = 2.6m and rectangular cross section b × s; with b = 1.2m and the channel width variable. One of the channel walls is heated with a uniform heat flux. Tests are made with different values of channel gap and heating power (s = 7.5, 12.5, 17cmand qc = 48 to 317 w/m2). The following correlations are developed and the geometrical parameter s/H; Nu = 0.9282Ra0.2035 (s/H) 0.8972 Re = 0.5014Ra 0.3148 (s/H) 0.418

**M. Miyamoto and Y. katoh[11]** numerically investigated free convection heat transfer from vertical and horizontal short plates using finite difference method. The present results regarding average Nusselt number on vertical and horizontal thin plates can be closely approximated by the following equation.For vertical thin plate
NuL = 0.448 + 0.46GrL
1/4, Pr=0.72 and 15 = GrL =27000
NuLD = 0.353 + 0.509GrD
1/5, pr = 0.72 and 4 = GrD =27000
The average Nusselt number on the vertical plate(height = l) with finite thickness (d) can beapproximated by the above correlation for a thin vertical plate with an error within about 6% using characteristic length (l+d) in both Nusselt and Grashoff numbers instead of l in the range L =5 and D= 10,where L= dimensionless plate height and D=dimensionless plate thickness.

**Naylor[12]**Conducted numerical study on developing free convection flow between isothermal vertical plates with aspect ratios between 10 and 24. The Navier-stokes and energy equations were solved numerically assuming a special inlet flow boundary conditions in the range of Grashof number 50 = Gr =5×104. The results showed a new recirculating flowzone in the entrance region when Gr = 104 for a channel of length to width ratio of 24.

**Said[13].** Conducted numerical investigation of natural convection heat transfer in a uniform convergent vertical channel with air as working medium. Half angle of convergence in the range of 00 to 100 was employed and solutions were obtained for modified Rayleigh number ranging from 1 to 2×104. To obtain a correlation for Nusselt number suitable for merging the convergent channel results with those of the parallel walls channel, three characteristic dimensions based on the minimum, average and maximum channel interval spacing were considered. It was found that the maximum interval spacing is the most appropriate as a characteristic dimension.

**3. PROPOSED WORK:**

The aim of the present work is to investigate experimentally the natural convection heat transfer inside inclined V-slot plate placed in vertical channel. The details of the experimental set- up are as follows.

**Table 1** Details of experimental set-up

| Sr No. | Description | Dimensions/Range |
|---|---|---|
| 1 | V-Slot plate 1no. | 300x245x8mm |
| 2 | Vertical plate (Mild Steel) 2 no. | 500×400×6mm |
| 3 | Heat Flux supplied | 20-300 W/m$^2$ |

The parameters varied during the experimentation are heat input, aspect ratio and elevation of v-slot plates from bottom. The temperatures at various locations of V-Slot plate are measured with the help of calibrated chromel-alumel thermocouples. Heat input is supplied by the use of dimmerstat.

**4. CONCLUSIONS:**

The exhaustive literature survey was carried out on the said topic; the literature survey revealed that most of the work was carried out considering various configurations as follows.

The experimental studies on free convection .

The experimental work carried out on natural convection heat transfer from inclined V-Slot plate and an empirical equation of average Nusselt number as a function of Rayliegh number was deduced for each angle of inclination.

The problem of natural convection heat transfer in a vertical channel with a single obstruction was studied experimentally as well as analytically.

Natural convection heat transfer in converging vertical channels was studied experimentally.

The natural convection heat transfer from inclined V-Slot plate with square cross section situated in a square enclosure, vented symmetrically from the top and the bottom are experimentally investigated.

Another experimental study performed on natural convection flow of air in a vertical channel.

The experimental work carried out on laminar natural convection from an isothermal inclined V-Slot plate confined between vertical walls, at low Rayleigh numbers.

The experimental study of natural convection heat transfer inside smooth and rough surfaces of vertical and inclined equilateral triangular channels of different inclination angles with a uniformly heated surface are performed and also correlation are develop.

The numerical investigation of mixed convection in a vertical heated channel is studied.

The present work aims to study and to develop a correlation in terms of Nu = c (Ra) n for inclined V-Slot plate placed in vertical channel of the dimensions mentioned earlier which will enhanced the rate of heat transfer considerably.

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