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Experimental study on vertical perforated plate under naural convection

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ABSTRACT

The objective of present study is to experimentally quantify and compare natural convection heat transfer enhancement in perforated aluminum vertical fin plate (200*200*15mm) with different number of perforation (percentage of material removal 5%, 10%, 15%, 20%) and different heat inputs, consequently to check the suitability of perforated fins (as opposed to solid fins) for industrial applications as far as the heat transfer enhancement is concerned. The study will investigates the steady state heat transfer from the vertical plate with solid and perforated fins in natural convection the comparison will studied for heat transfer performance results of perforated fin plate to solid fin plate. The validation of perforated aluminum vertical fin plate will be studied with eallier investigation. The correlation equation will be developed for given range of dimension. In this study, the steady state heat transfer from the solid fin and perforated fin will be measured.

***Keywords*— a Heat transfer enhancement, Natural convection, Perforated fin , Perforation diameter.**

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I. INTRODUCTION

There are various types of fins but rectangular plate fins are commonly used due to simplicity in manufacturing. Natural convection from a block with fins may be used to simulate wide variety of engineering applications as well as provide better insight into more complex systems of heat transfer such as heat exchangers, refrigerators, electric conductors, etc. Convection heat transfer may be enhanced by using perforated fins instead of solid fins with optimum angle of inclination of the fins. A large number of studies have been conducted on shape modifications by cutting some material from fins to make holes, cavities, slots, grooves or channels through the fin body to increase the heat transfer area and/or the heat transfer coefficient. Fins as heat transfer enhancement devices have been quite common. As the extended surface technology continues to grow, new design ideas emerge, including fins made of anisotropic composites, porous media, and perforated and interrupted plates. [1], [2]

One of the primaries aimed in the design of modern thermal systems is the achievement of more compact and efficient heat exchangers. Reducing energy loss due to ineffective use and enhancement of energy transfer in the form of heat has become an increasingly important duty for the design engineers of thermal systems, considering the world wide increase in energy demand. This duty requires employing heat transfer surfaces with high heat transfer coefficients and high area compactness. A particular attention is required in surface area design when use the gas in heat exchangers. Fins as heat transfer enhancement devices have been quite common. As the extended surface technology continues to grow, new design ideas emerge, including fins made of anisotropic composites, porous media, and perforated and interrupted plates. The requirements of lightweight fins and economical, so the optimization of fin size is very important in fin's design. Therefore, fins must be designed to achieve maximum heat removal with minimum material expenditure, taking into account, however, the ease of manufacturing of the fin shape. [4], [5]

II. LITERATURE REVIEW

"Numerical investigation of turbulent heat convection from solid and longitudinally perforated rectangular fins" by Md. FarhadIsmail , M.O. Reza, M.A. Zobaer, Mohammad Ali Thermal performance of perforated and solid fins is numerically investigated. Generally optimization of fins is focused on to maximize heat dissipation rate and to minimize pressure drop for a given mass or volume of the heat sink. "Numerical analysis of turbulent convection heat transfer from an array of perforated fins," International Journal of Heat" by Shaeri M.R., M. Yaghoubi, Numerical study of turbulent fluid flow and convective heat transfer over an array of solid and perforated fins are performed. Perforations such as small channels in several numbers are arranged along the length of fins. Effects of flow and perforations on heat transfer rate are determined and comparison between solid and perforated fins is accomplished.

"An Experimental Investigation of Natural Convection Heat Transfer Enhancement from Perforated Rectangular Fins Array at different Inclinations", Umesh V. Awasarmol, Ashok T. Pise. The experimental study was carried to examine the thermal performance of perforated fin array for different perforation diameter and angle of inclination, in natural convection environment. The temperature along the perforated fin length is consistently smaller than that on of an equivalent non-perforated fin. The perforated fin can enhance heat transfer. "Heat transfer analysis of lateral perforated fin heat sinks", byShaeri M.R., Yaghoubi M., Jafarpur K. Three-dimensional numerical computation is made for turbulent fluid flow and convective heat transfer around an array of rectangular solid and new design of perforated fins with different numbers and two various sizes of perforations. Calculations are performed for a range of Reynolds numbers from 2000 to 5000 based on fin thickness and Pr = 0.71 and result shows that By increasing number of perforations, temperature difference between the fin base and fin tip becomes larger. "Experimental Study of Heat Transfer Rate by Using Lateral Perforated Fins in a Rectangular Channel", by A.B. Ganorkar and V.M. Kriplani Experimental was carried out to examine the overall performance of suitably designed lateral perforated fins in a rectangular channel is analyzed with passive heat transfer augmentation technique. In the rectangular channel, different types of perforated fins are used. Effect of perforated fins in a rectangular channel is analyzed for different Reynold Numbers. "Enhancement of natural convection heat transfer from Rectangular fins by circular perforations", by Wadhah Hussein Abdul Razzaq Al- Doori, An experimental study was conducted to investigate heat transfer by natural convection in a rectangular fin plate with circular perforations as heat sinks. The heat transfer rate and the coefficient of heat transfer increased with an increased number of perforations."Thermal Analysis of Square and Circular Perforated Fin Arrays by Forced Convection" by Kavita H. Dhanawade , Vivek K. Sunnapwar, and Hanamant S. Dhanawade, experimental study is carried out to investigate the heat transfer enhancement over horizontal flat surface with rectangular fin arrays with lateral square and circular perforation by forced convection. The cross sectional area of the rectangular duct was 200 mm x 80 mm. It is observed that the Reynolds number and size perforation have a larger impact on Nusselt number for the both type of perforations.

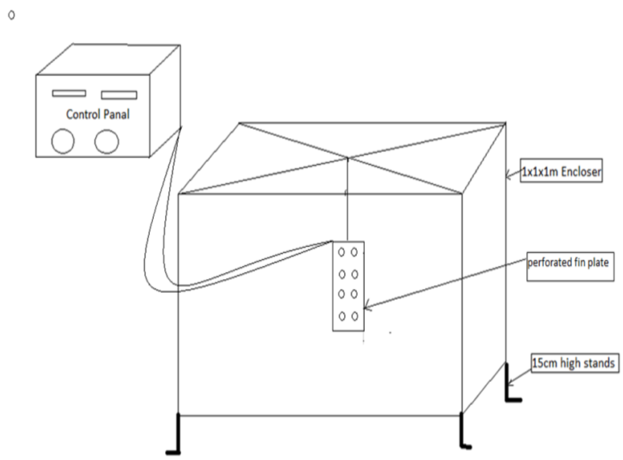
III.PROPOSED EXPERIMENTAL STUDY

The experiments will be carried out in an experimental setup that was designed specifically and constructed for this purpose. The experimental setup included a heat sink supplied with heating elements. Heat was generated by four cartridge heater with a power of 250 W. The fins will be use of length 200 mm long, 200 mm wide and 15 to 20 mm thick. [6]

A transformer of type with an input of 220 V at 50 Hz and an output of 0-230 V, was used to regulate the voltage supplied to the heating element. The experimental data were measured by 8 calibrated type-k thermocouples to measure the temperature at different locations. The proposed parameters, specifications and their ranges during the experiments were as follows:

i. Heat supplied: 230 W
ii. Perforation shape: circular
iii. Number of perforations: 12 Nos
iv. Diameter of perforation: depending on % of material removal
v. Length of heat sink and fin: 200 mm
vi. Width of the fin: 200 mm

The 8 thermocouples were divided equally onto the fins. Each thermocouple was fixed to the surface of the test fin with equal spacing along the fin length. The apparatus was allowed to run for about 30 minutes until the steady state was achieved. The recording of temperature began after the steady state had been reached. [6]



Proposed experimental set up

Specifications of instruments required for heat transfer analysis :

ELECTRIC HEATER : CARTRIDGE TYPE CU, MICA CLADDED,

WATTAGE : 100 W

WATTMETER : PORTABLE, SINGLE PHASE TYPE,

AE MAKE, TYPE DVS

RANGE – 75/150/300 VOLTS 4 AMPERES

PORTABLE TEMPERATURE INDICATOR : QUARTZ MAKE.

RANGE – 0.0 TO 199.9^{0}C

DIMMERSTAT : TYPE 2D-1P,2 AMP MAX.

MAX. LOAD – 2 KVA

SERVO STABILIZER : DIKIBI MAKE, (SR. NO. 98053104)

THERMOCOUPLES : 8GAUGE, TEFLON QUOTED,

IV. PROPOSED OBSERVATIONS AND RESULTS

TABLE I

Sr no	Observation	reading
1	"Q" heattransferin Watt.	
2	Mean temperature over the fins T_{m1} in ^oC.	
3	Mean outside temperature T_{m2} in ^oC.	
4	"ΔP" pressure drop in mm of water.	
5	"h" heat transfer rate in W/mm^{2o}C	

TABLE II

Heater input (W)	AvgTs ^oC	T_∞ ^oC	ΔT ^oC	T_1 ^oC	T_2 ^oC	T_3 ^oC	T_4 ^oC
5% material removal							
7.5% material removal							
10% material removal							
12.5% material removal							

Proposed Observation table (for solid fin, perforated fin, and perforated plate with emissivity 0.98)

V.CONCLUSION

- Heat transfer from the heat sink is strongly affected by perforation, as no of preformation is increased, heat transfer may be enhanced.
- Convective heat transfer coefficient can increased in circular perforation with reduction in weight of fin plate.
- Effect of radiation on heat transfer also can be calculated by this study by using plate with emissivity 0.98.
- Correlation for perforated vertical plate may be developed.

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