EXPERIMENTAL STUDY OF THE PERFORATED RECTANGULAR FINS BY NATURAL CONVECTION

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ABSTRACT

The importance of heat transfer by natural convection can be found in many engineering applications, such as energy transfer in buildings, solar collectors, nuclear reactors and electronic packaging. This study examined heat transfer enhancement from a vertical rectangular fin embedded with circular perforations under natural convection compared to the equivalent solid (non perforated) fin. The parameters considered were geometrical dimensions and thermal properties of the fin and of the perforations. The study considered the gain in fin area and extent of heat transfer enhancement due to perforations. It showed that for circular dimension perforations there is an improvement in perforated fin heat dissipation over that of the equivalent non perforated solid fin.

Keywords: Natural Convection, Heat Transfer Enhancement, Circular Perforations, Heat Dissipation.

I. INTRODUCTION

For a number of industrial applications, heat generation can cause overheating which occasionally leads to system failure. Therefore, the enhancement of heat transfer is an import subject of thermal engineering. The heat transfer from surfaces may in general be enhanced by increasing the heat transfer coefficient between a surface and its surroundings, by increasing the heat transfer area of the surface, or by both. In most cases, the area of heat transfer increased by utilizing extended surfaces in the form of fins attached to walls and surfaces. Extended surfaces (fins) frequently used in heat exchanging devices for the purpose of increasing the heat transfer between a primary surface and the surrounding fluid in many industries.

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. Large number of studies has been conducted on optimizing fin shapes. Other studies have introduced shape modifications by cutting some material from fins to make cavities, holes, slots, grooves, or channels through the fin body to increase the heat transfer area and/or the heat transfer coefficient. One popular heat transfer augmentation technique involves the use of rough or interrupted surfaces of different configurations. The surface roughness or interruption aims at promoting surface turbulence that is intended mainly to increase the heat transfer coefficient rather than the surface area. It was reported that non-flat surfaces have free convection coefficients that are 50% to 100% more than those of flat surfaces.

A. M. &, the other. Treats the natural convection heat transfer from perforated fins. The temperature distribution was examined for an array of rectangular fins (15 fins) with uniform cross-sectional area(100x270 mm) embedded with different vertical body perforations that extend through the fin thickness. The patterns of perforations include 18 circular perforations (holes). Experiments were carried out in an experimental facility that was specifically design and constructed for this purpose. The heat transfer rate and the coefficient of heat transfer increases with perforation diameter increased.

Abdullah H. AlEssa, Ayman M. Maqableh and Shatha Ammourah were enhancement of natural convection heat transfer from a horizontal rectangular fin embedded with rectangular perforations of aspect ratio of two. The results of perforated fin compared with its equivalent solid one. An experimental study was carried out for geometrical dimensions of the fin and the perforations. The study investigated the gain in fin area and of heat transfer coefficients due to perforations. They concluded that, values of rectangular perforation dimension, the perforated fin enhances heat transfer. The magnitude of enhancement is proportional to the fin thickness and its thermal conductivity.

G. D.gosavi and the others. Study and investigates the concept of heat transfer through perforated material is one method of improving the heat transfer characteristic in the natural convection. A solid and perforated material of brass, aluminum, copper is selected for the experimentation. As the review is concerned it is found that, the heat transfer through perforated fins is much greater than 50-60% the solid one.

This Study is aimed mainly at examining the extent heat transfer enhancement from vertical rectangular fins under natural convection. Conditions as a result of introducing body modification (perforations) to the fin body. The modification in this work is circular perforations made through the fin thickness. The patterns of perforations include 52 circular perforations (holes). The study investigates the influence of perforations on heat transfer rate or heat dissipation rate of the perforated fin. The modified fins (perforated fins) are compared to the corresponding solid (Non perforated) fin in terms of heat transfer rate.

II.EXPERIMENTAL DETAILS

The experiments were carried out in an experimental setup that was designed specifically and constructed for this purpose. Figure 1.shows a view of the experimental apparatus. The experimental setup included a heat sink supplied with heating elements. Heat was generated within the heat sink by means of one heating element with a power of 250 W. The heat sink chosen for these experiments was an aluminum cylinder 50 mm in diameter and 270 mm in length. One hole was drilled in the cylinder in which one heating element was placed. Two aluminum straight fins were fitted vertically. The fins were 100 mm long, 270 mm wide and 2 mm thick.

Fig.1.Experimental Apparatus.

Fig.2. View of Heat Sink and Fins.

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 12 calibrated type-k thermocouples to measure the temperature at different locations. The measured parameters, specifications and their ranges during the experiments were as follows:

1. Heat supplied: 20-220 W
2. Perforation shape: circular
3. Number of perforations: 52 (13 cross 4 array)
4. Diameter of perforation: 12mm
5. Length of heat sink and fin: 270mm
6. Width of the fin: 100mm
7. Diameter of heat sink: 50mm

The 12 thermocouples were divided equally onto the 2 fins. Each thermocouple was fixed to the surface of the test fin with equal spacing (15 mm) 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.

III. EXPERIMENTAL CALCULATIONS

Perforated fins can be used to increase the heat transfer coefficient and effective heat transfer rate. The change in magnitude of the surface area depends on the geometry of the fin with the perforations. In this experiment, the number of perforations N_x in the X- direction (L) and N_y in the Y- direction (W) can be assumed and perforation diameter b. Also the dimensions of fin are known. Circular perforation pattern is studied. The directional perforations spacing S_x and S_y, the analytical calculations of fin as calculated as follows,

$$L = N_x \times b + (N_x + 1)S_y \qquad \text{..............(1)}$$

An experimental h is the heat transfer coefficient Nu is the nusselt number. K is the thermal conductivity, L is the effective length, Gr is the grashof number, P_r is the prandalt number and correlation to estimate the convection heat transfer coefficient of an array of vertically oriented parallel flat plates is given by,

$$Gr = \frac{g\beta L^3 \Delta T}{V^2} \qquad \text{..............(2)}$$

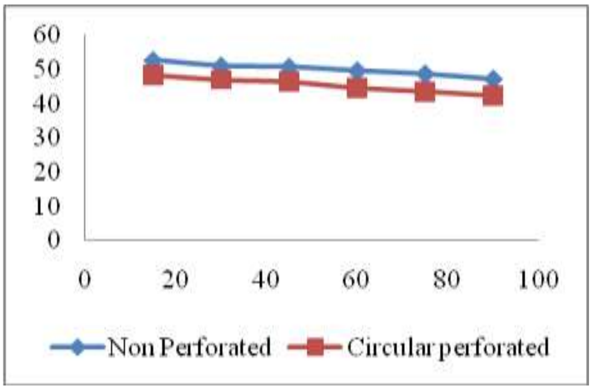
$$N_u = 0.59(Gr \times P_r)^{0.25} \qquad \text{..............(3)}$$

$$h = \frac{N_u \times K}{L} \qquad \text{..............(4)}$$

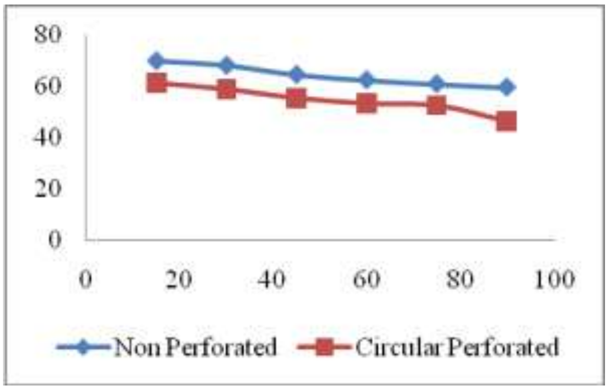
IV. RESULTS AND DISCUSSION

In this experimental work was conduct to investigate the perforation shape geometry effect on the convection heat transfer from the fins by natural convection. Were the study will be compared between circular shape of perforations and then with non-perforated fin. The temperature distribution along the fin is one of the factors that reflect the performance of the fins, which it can be used to compare between fins. The results show that the graphs of temperature v/s distance, the highest temperatures were along the non-perforated fin, and lower temperatures distribution along the perforation fins was along the perforation fin with circular shape and these results are shown in figure 3.for different values of the heat supplied.

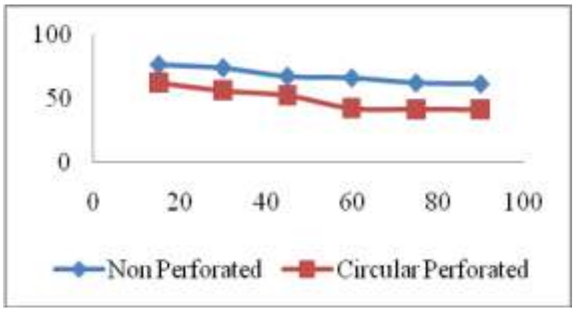
Graph Temperature v/s Distance



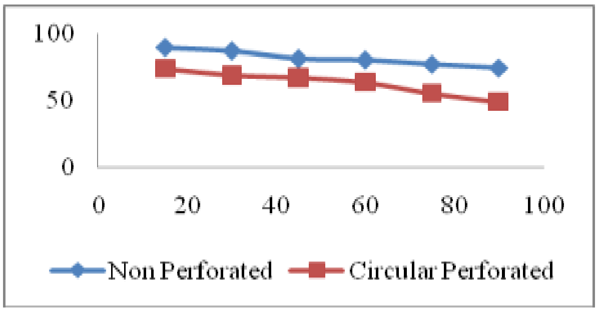
(a)20W



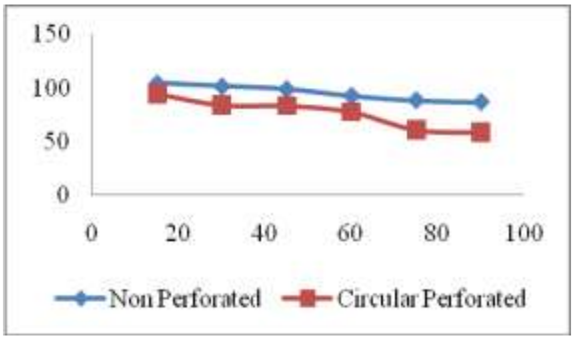
(b) 40W



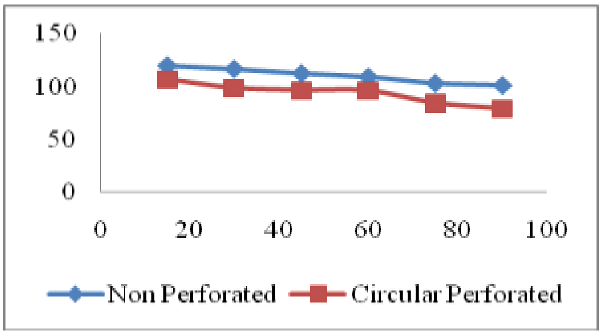
(c) 60W



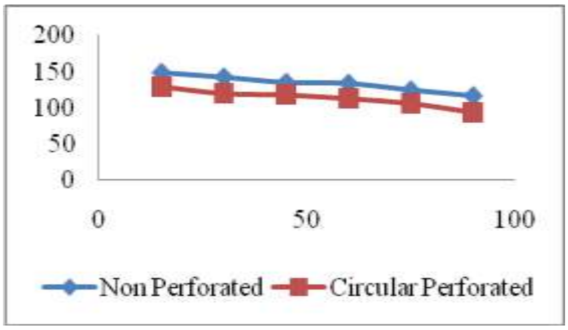
(d) 80W



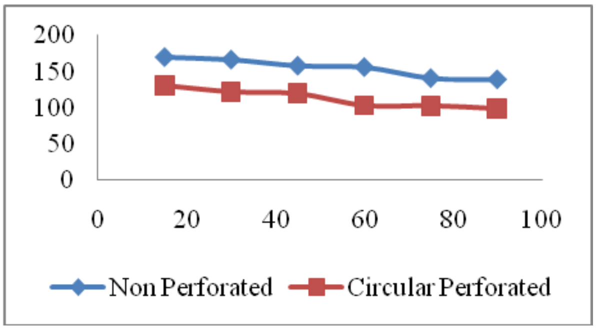
(e) 100W



(f) 120W



(g) 160W



(h) 200W

Fig.3. The Temperature Distribution along Fins with Different Locations

The heat transfer coefficient regarded one of the main factors on the performance of fins, which varies with the perforation. From figure.4 the heat transfer coefficient appears with different values of heat input, where the results show that the highest values of the heat transfer coefficients were in the fins with circular shape. The lower values for the heat transfer coefficient were a non-perforated fin.

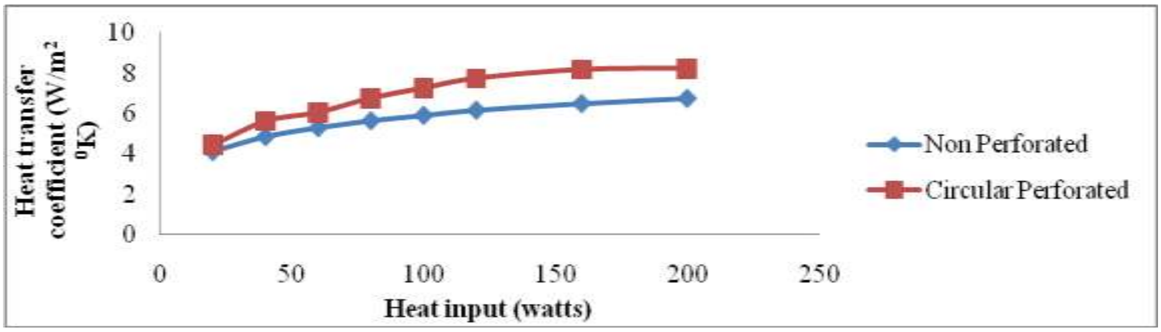


Fig.4.The Relation between Heat Transfer Coefficient and Power Supplied

V. CONCLUSION

The temperature drop along the length of the perforated fins was consistently higher than for the equivalent non-perforated fin. The increase in the heat dissipation rate for the perforated fin was strongly dependent on the perforation dimensions. Heat transfer coefficient for circular perforated fin is higher than the non perforated fin.

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