Experimental Investigation of the Heat Transfer Rate in Perforated Fins

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Abstract: **This paper focuses on enhancing the convective heat transfer rate with help of fins and variations by providing perforations. Experiment is conducted for both natural convection and forced convection for constant base plate at temperatures. Forced convection is carried at air velocity of 3.1m/s just before fins. Fins are rectangular with square cross-section. Experimental trails are conducted for inline and staggered fin plates. The experiment is conducted in three variations. First variation is solid fins without perforation. Second variation is fins with one perforation at 25 mm from base plate. The third variation is fins with two perforations separated 50 mm from center to center. These experiment trails are carried under an experimental setup which is designed for fin testing purpose for different alignment of fins**

Keywords: **Natural convection, forced convection, perforated fins, heat transfer rate.**

I. INTRODUCTION

Heat transfer in a system occurs depending on three main components is surface area difference in temperature and convective heat transfer coefficient. Setup is provided with limited surface area. The process can be altered with variation of temperature. The convection heat transfer coefficient which cannot be increased after a certain fixed value. And variation in heat transfer coefficient is done with help of fans or pumps. So the possibility left out is by increasing the surface area of material which is exchanging heat with the surrounding fluid. Fins are the extended surface used in large number applications to increase heat transfer. And fins with perforations are the most common running operation in thermal field to enhance the heat transfer. The number of perforations and size and shape of perforations can be varied depending on the need of experiment. Fins are normally seen in automobiles engine, aerospace, industries, electronic equipment‘s, heat exchangers in thermal power plants as well as various industries. In this paper fins and base plates are made of aluminium. Aluminium metal used has fin material because of its high thermal conductivity and light weight as material property. The fin design used in this experiment is rectangular bar shaped which are fixed on a base plate.

II. EXPERIMENTAL SETUP

The fig 1 shows experimental setup **“Tunnel”** front view. The tunnel is made up of mild steel sheet. Tunnel size is by length 600 mm height 150 mm breadth 150 mm. The inlet tube is the first part which is connected to air blower for forced convection through which inlet air enters and it is closed in free convection experiment. It is provided with a K-type thermocouple to measure the inlet air temperature. The inlet tube is then connected to cone shaped convex tube. The convex tube leads to square tunnel which is the main part of experimental setup. In this tunnel the fin plate is placed for conducting experiment. This tunnel consists of electrical heating setup for heating the fins plate. Tunnel also contains 20 K-type thermocouple 18 of them use to determine temperatures of nine fins two thermocouples to each fin. One thermocouple is used to determine temperature of base plate and one thermocouple to determine temperature of outlet air at end of tunnel. The inner surface of tunnel is coated with fiber reinforced plastic or polymer for insulation to avoid heat loss from tunnel and to avoid rust of tunnel material.

Fig 1.Experimental set up

III. FIN PLATE DESIGN

The fig 2 shows the inline and staggered fin plate. The base plate and fins is made of aluminum metal. The base plate 250x125x6mm. The surface area of a fin is $5.3125X10^{-3}$ m^2. Total surface area of all fins is 0.0478 m^2. The surface area of base plate is 0.067 m^2. The total surface area of fin and base plate is 0.1148 m^2 (0.0478 + 0.067).

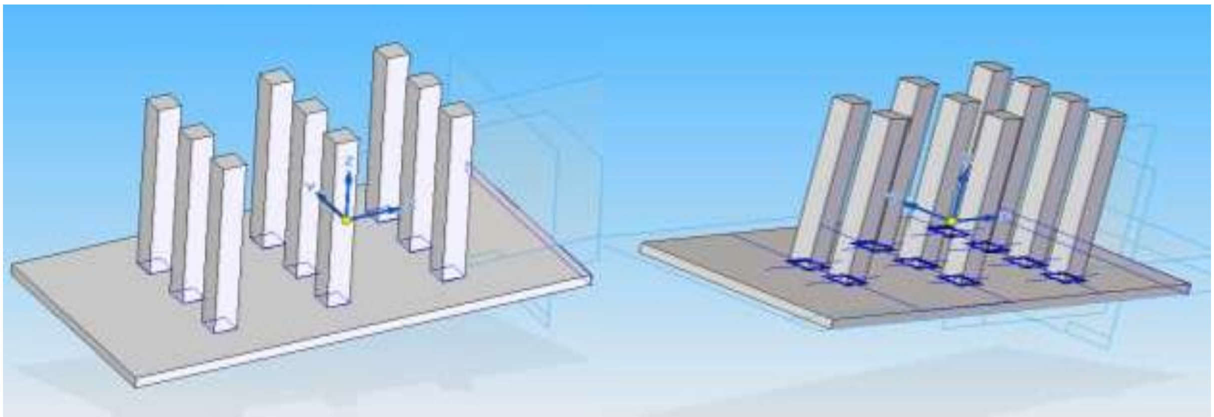


Fig 2.Fin Plate with Solid Fin arranged In-line and Staggered

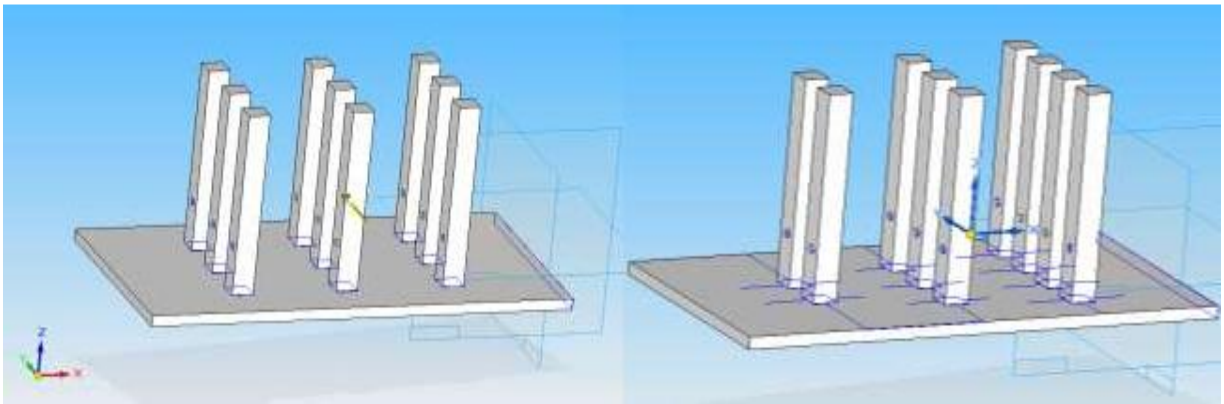


Fig 3.Fin Plate with One Perforation on Each Fin arranged In-line and Staggered

The fig 3 shows fins with one perforation in inline and staggered fin plate. Perforation has diameter of 4mm and thickness of perforation is 12.5mm. The location of this perforation is at 25 mm from the base plate. The surface area of perforation is $1.319X10^{-4}m^2$. Hence total area of perforation is $1.1871 X 10^{-3} m^2$ ($9 X 1.319X10^{-4} m^2$). The total surface area of the fin and base plate with perforation is $0.1159 m^2$

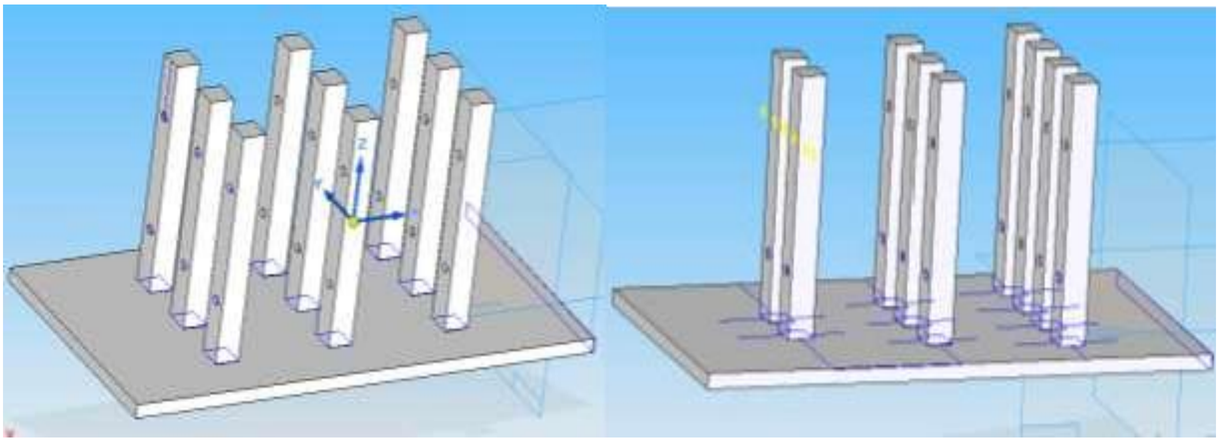
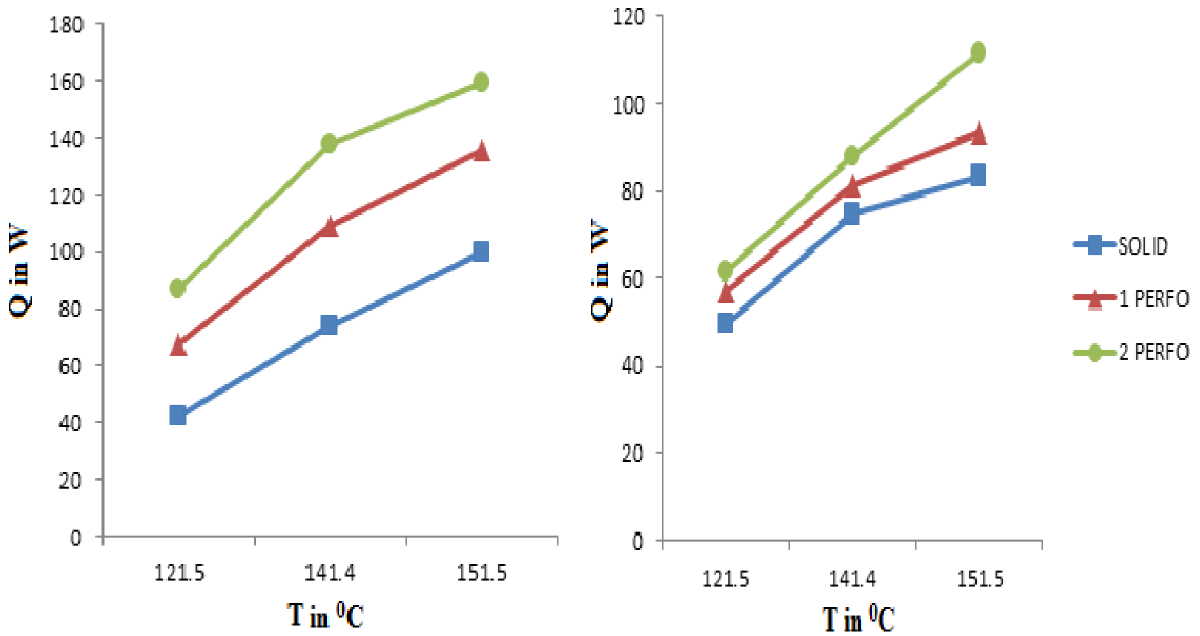


Fig 4.Fin Plate with two Perforation on Each Fin arranged In-line and Staggered

The fig4 shows fins with two perforations in inline and staggered fin plate. Each perforation has diameter of 4mm and thickness of perforation is 12.5mm. The location of this perforation is at 25 mm from the base plate. The center to center distance between two perforations is 50mm. The area of perforation is $157.09mm^2$. Hence total area of perforations is $2.3742 X 10^{-3} m^2$ ($2x9x 157.09mm^2$). The total surface area of the fin and base plate with perforation is $0.1171 m^2$ ($0.1148 + 2.37 X 10^{-3}$).

IV. RESULTS AND DISCUSSIONS



A. ***Free convection:***

Fig 5.Temperature v/s rate of heat transfer for inline fins (i) and staggered (ii)

From fig 5 the heat transfer rate is more in fins with two perforations compared to fins with one perforation and solid fins. But when we consider inline fins against staggered fins

- At 155.5^0C inline fins has heat transfer rate 156.78 W which is comparatively higher than of staggered fins. Hence in inline fins with two perforations heat transfer rate has in- creased by 30.18% compared to staggered arrangement.
- Similarly at 141.4^0C for fins with two perforations and inline arrangement transfers 135.44 W and for staggered arrangement 86.27 W. Hence in inline fins with two perforations heat transfer rate has increased by 36.30% compared to

staggered fin arrangement.

- At 120.5^{0}C fins with two perforations inline arrangement has heat transfer 88.13 W and staggered arrangement has 60.30 W. Hence in inline fins with two perforations heat transfer rate has increased by 31.5% compared to staggered fin arrangement.

B. Forced convection:

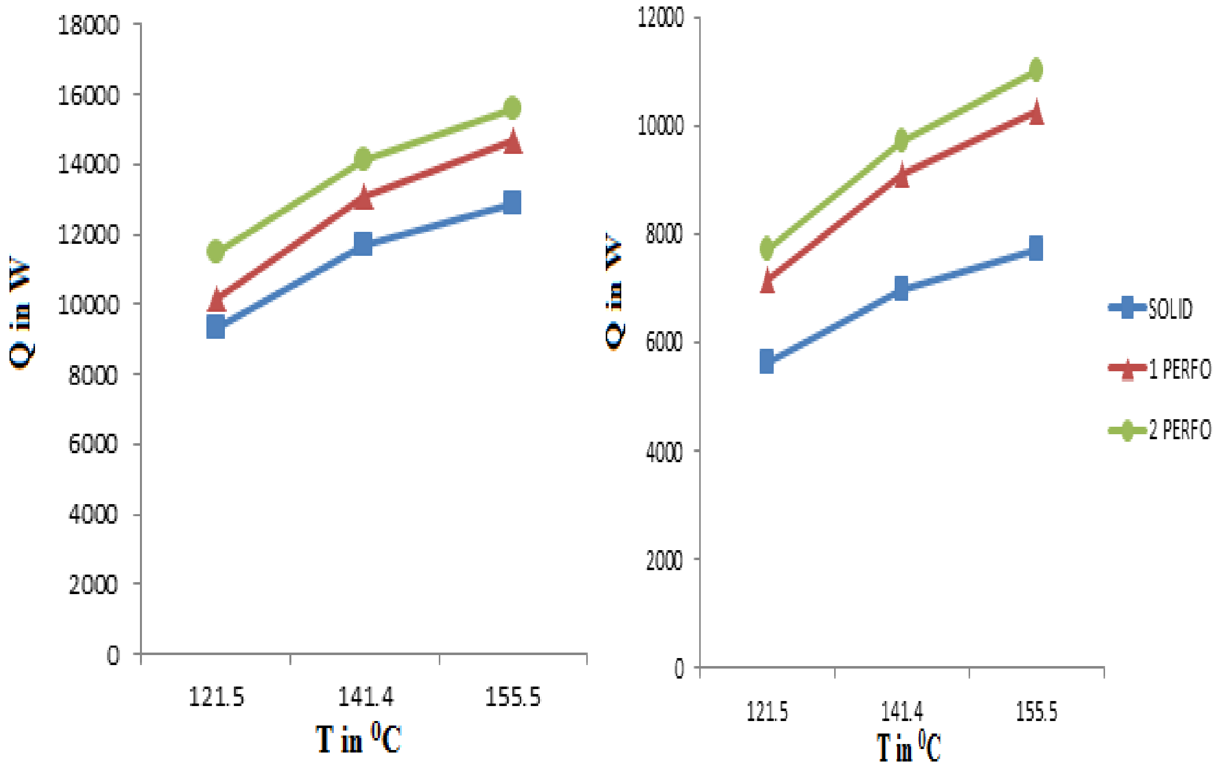


Fig6. Temperature v/s rate of heat transfer for inline fins (i) and staggered (ii)

From fig 6 we can see heat transfer rate is more in fins with two perforations compared to fins with one perforation and solid fins. But when we consider inline fins against staggered fins

- Inline fins at 155.50C has heat transfer rate is comparatively higher than staggered fins. Hence in inline fins with two perforations heat transfer rate has increased by 29.62% compared to staggered fin arrangement.

- Similarly at 141.4^{0}C in inline fins with two perforations heat transfer rate has increased by 31.18% compared to staggered fin arrangement.

- At 120.5^{0}C in inline fins with two perforations heat transfer rate has increased by 33.14% compared to staggered fin arrangement.

V. CONCLUSION

- From results and discussion we have found that heat transfer rate is more in fins with two perforations in both natural as well as in forced convection compared to solid fins and fins with one perforation.

- Even in staggered fin plate‘s heat transfer rate is more in fins with two perforations in both natural as well as in forced convection compared to solid fins and fins with one perforation.

- But when we compare inline fins v/s staggered fins inline fin plate has more heat transfer rate than staggered fin plate.

- It is also true for all constant base plate temperature 120.5^{0}C, 141.4^{0}C and 155.5^{0}C.

- Hence it is clear that fin plate with two perforations is the best design for heat transfer rate in this experiment.

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