Experimental Study of Perforated Pin Fins with Perforations around the Circumference of the Fins

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Abstract— *Nine fins with inline arrangement and eight fins in staggered arrangement with each fin having the diameter of 16 mm and the perforation diameter of 3 mm are modeled to study the heat transfer performance. The Nusselt number for staggered perforated fins is obtained in the range of 90 to 235 while for solid pin fins in the similar arrangement, obtained in the range of 80 to 220 with Reynolds number in the range of 15000 to 82,000. The convective heat transfer coefficient in case of perforated fins with staggered arrangement is obtained in the range of 25 to 60 W/m^{2}K while for solid pin fins, it in the range of 20 to 50 W/m^{2}K. Overall analysis showed perforated pin fins with staggered arrangement performed better in terms of heat transfer as compared sold pin fins.*

Keywords— Fins, Heat transfer, Perforation, Inline, staggered

I. INTRODUCTION

With the demand of the new technology, many products in the industries are focused to make compact in size, economical and energy efficient. Various electronic devices are strictly focused to make them very small so as to provide sufficient flexibility in portable and aesthetic aspects. Equal efforts are also concentrated on compact engines and many other mechanical products. These all systems dissipate heat and have to be removed efficiently for smooth operation of the system. In order to facilitate better heat transfer, various types of fins are studied extensively and various modifications are made in the design till date.

Several types of fins are extensively used in the electronics and in the mechanical industries. Some of the types are cylindrical pin fins, rectangular fins, tapered pin fins, threaded pin fins, triangular pin fins. In this project, the main focus is given to pin fins and the analysis of fins with respect to inline and staggered arrangement is experimentally conducted. The heat transfer parameters like Nusselt number, convective heat transfer coefficient etc are discussed in detail and comparisons are made between inline and staggered arrangement fins. The perforated fins are also analyzed and compared to solid pin fins

II. EXPERIMENTAL SETUP

Fig.1: Experimental setup

Heat transfer equipment consist of tunnel box for the passage of air, control panel with respective connections, heater with dimmer stat, blower, thermocouple, anemometer and base plate with suitable pin fins and another set of base plates with perforated fins. Thermocouple generates thermal signal which shows the raise in temperature in the fins, generated thermal signal will be sent to the control panel for display of the temperature from the respective thermocouple, heater is controlled using a dimmer stat to get desired base plate temperature and at that constant base plate temperature respective temperature readings in pin fins are noted for further calculation and analysis. Natural and Forced convection heat transfer in solid pin fins and perforated pin fins is studied. Increase in Surface contact area increases the heat transfer and hence we use fins to increase the rate of convective heat transfer where air is used as the cold fluid and we have studied the effect of heat transfer with different number of perforations around the fins.

III. BASE PLATE AND PIN FIN DESIGN

The base plate is 6mm thick, length is 250mm and width is 125mm. This base plate is placed on the heater setup firmly with the help of two steel bars and bolt. The fins are arranged on the base plate firmly with help of the screws.

Fig.2: Base Plate

Perforations having diameter of 3mm and thickness of perforation is 16mm. Perforation is done with help of drilling using drill bit of 3mm diameter. The location of these perforations is at 30 mm from the base plate around the circumference.

Fig.3: Fin with perforations

Solid pin fins are arranged in inline pattern with a horizontal spacing of 62.5 mm and vertical spacing of 31.5 mm from one pin fin center to another pin fin center respectively. Nine solid fins are used and diameter of each fin is 16 mm. The fins are mounted on base plate 125 mm width and 6mm thickness. Solid pin fins are arranged in ascending pattern in staggered arrangement with a horizontal spacing of 62.5 mm and vertical spacing of 25 mm from one pin fin center to another pin fin center respectively. Nine solid fins are used and diameter of each fin is 16 mm.

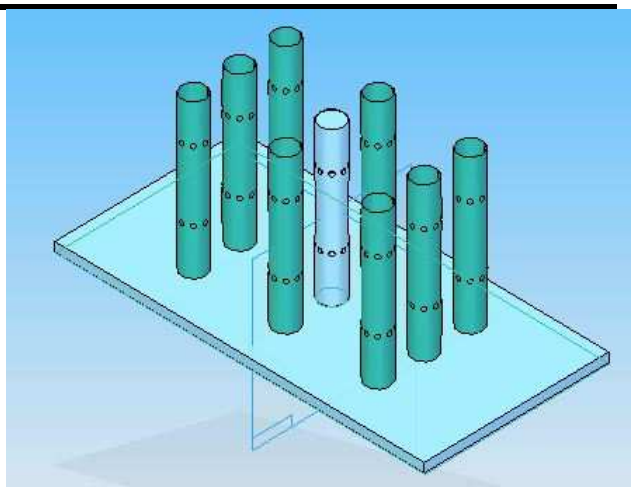

Fig.4:Inline arrangement of Fin with perforations

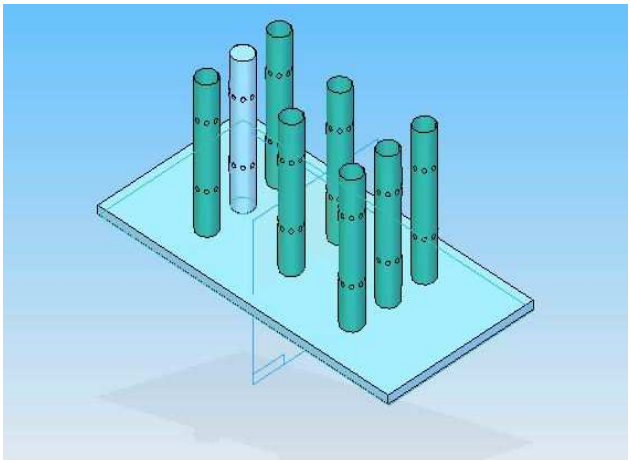

Fig.5: Staggered arrangement of Fin with perforations

IV.RESULTS AND DISCUSSIONS

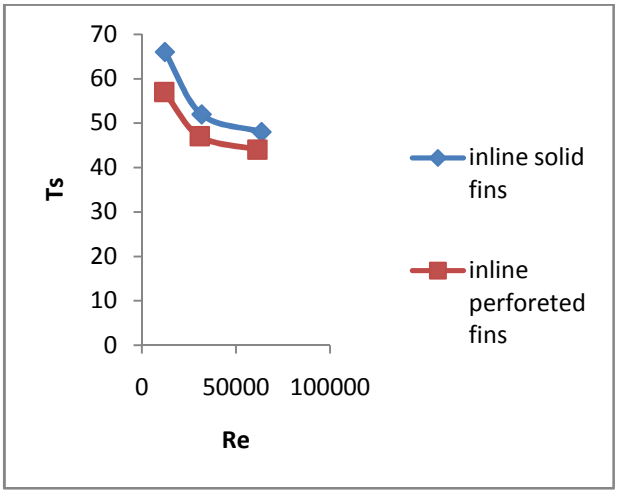

Fig.6: Reynolds number V/s Surface temperature

The figure shows Reynolds number V/s Surface temperature for inline solid fins and inline perforated fins. From the graph it can be observed that the temperature distribution is high in inline solid fins as compare to perforated fins because due to increase in surface area by making perforation on the fin surface. The temperature of the surface varied from 44^0C to 66^0C.

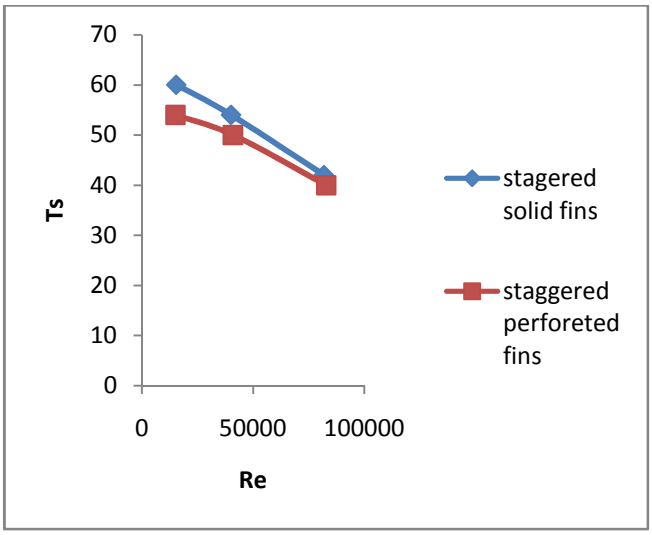

Fig. 7: Reynolds number V/s Surface temperature

The figure shows Reynolds number V/s Surface temperature for staggered solid fins and staggered perforated fins. From the graph it can be observed that the temperature distribution is high in staggered solid fins as compare to perforated fins because due to increase in surface area by making perforation on the fin surface. The temperature of the surface varied from 40^0C to 60^0C.

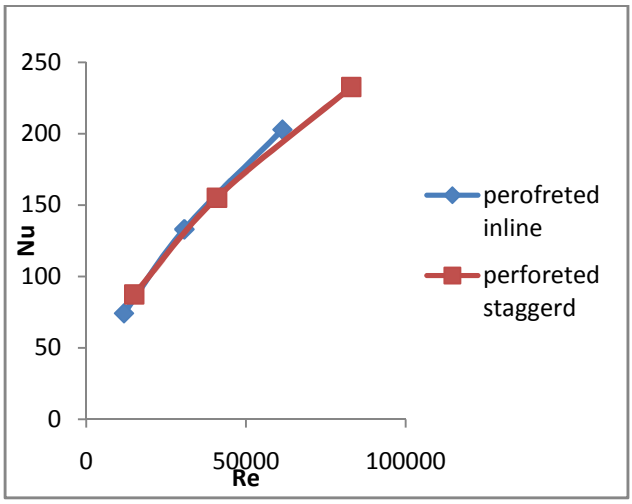

Fig.8: Reynolds number v/s Nusselt number

The above figure shows the Reynolds number v/s Nusselt number for perforated inline fins and perforated staggered fins. The Nusselt number increases in staggered perforated fins at higher rate as compare to inline arrangement because increase in direct contact of air with fins. Nusselt number of inline and staggered arrangement varies between75 to 250.

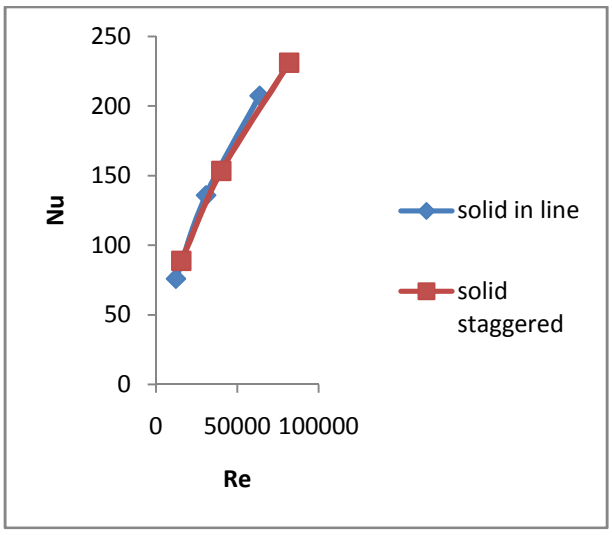

Fig.9:Reynolds number v/s Nusselt number

The above figure shows the Reynolds number v/s Nusselt number for solid inline fins and solid staggered fins, it can be observed in solid staggered Nusselt number is high as compare to solid inline fin. The Nusselt number obtained in the range of 75 to 230.

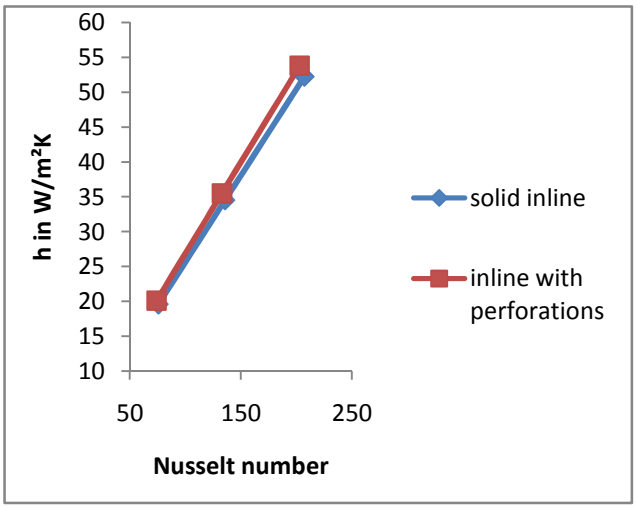

Fig.10: Nusselt Number vs. heat transfer coefficient

The above figure shows the Nusselt number v/s heat transfer co efficient for solid inline fins and in line perforated fins, the heat transfer rate is more in inline perforated fins compare to solid inline fins because of more surface area of contact with air in perforated fins. The heat transfer coefficient is varies from 20 to 54 W/m^2K for the Nusselt number in the range of 75 to 210.

IV. CONCLUSIONS

- In a wider picture, perforated pin fins with staggered arrangement performed better in terms of heat transfer as compared to solid pin fins with inline and staggered arrangement.
- The perforated fins enhanced heat transfer rate at a higher rate as compared to solid fins due to increase in surface area
- The Nusselt number and the convective heat transfer coefficient is increase with increase in Reynolds number. The Nusselt number for perforated pin fins with staggered arrangement is obtained in the range of 90 to 235 with Re in the range of 15000 to 82000. While for sold pin fins with similar arrangement, the Nusselt number is in the range of 80 to 220 in a given range of Re.
- The convective heat transfer coefficient in case of perforated fins with staggered arrangement is obtained in the range of 25 to 60 W/m^2K while for solid pin fins, it came in the range of 20 to 50 W/m^2K.

Overall analysis shows perforated pin fins with staggered arrangement are more attractive in terms of heat transfer enhancement.

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