Heat Transfer Analysis of an Array of Different Fin Configuration under Forced Convection

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Abstract— The main part of the study concerns about the comparison of temperature and pressure difference between flat plate without fins and inline circular fins and staggered circular fins at the heat sink test section. In the design of a heat sink test section, the plate thickness, the hole diameter, the hole centre pitch and the plate pitch are some of the important geometric parameters. Diameter (10mm o/d, 7mm i/d) and height (100mm) of the all fins and centre pitch span and stream wise (50mm) is selected throughout the dissertation. In whole process mass flow rate is kept at constant and power input is varied. Initially, temperature at inlet, outlet and at flat plate without fins are measured. Then same process is repeated for inline and staggered fins. The heat sink is heated by a plate heater and temperatures and pressure drop are measured at the various positions. All thermocouples are connected to a digital recorder to record the temperature once the steady state is achieved. The power input to the heater is controlled by a variac. A digital wattmeter is use for recording the power of the heater. An enhancement of heat transfer was observed in the given case as compare to the heat sink having a conventional duct.

Key words: Heat Transfer Analysis, Fin Configuration

I. INTRODUCTION

The study of compact heat sink is an important field for the last decade. The reason is mainly the possibilities of reducing the duct size, weight and cost of the heat sink compared to the current designs. Claude-cycle cryogenic refrigerators require a highly effective compact counter-flow heat exchanger. Perforated plate heat exchangers have been gradually developed so as to satisfy these needs. The earliest analysis and researches on the characteristics of perforated-plate heat exchangers were experimented on the friction factor and heat transfer coefficient of glue-stick perforated plate heat exchangers in which the holes were arranged in a square pattern, and they presented a heat-transfer criterion. For the application of heat sink, it is necessary to have accurate design tools for predicting heat transfer and pressure drop. The present dissertation aims to add the knowledge of fluid flow and heat transfer through the compact perforated heat sink, thereby aiding in the development of this new interesting technology with possibility of providing the better cooling and increasing the energy efficiency of thermal process and thermodynamics cycles through enhanced heat transfer. ins is commonly used in electronic equipment such as cooling, heat dissipating devices etc. There is different type of fin used in multipurpose cooling system. Kavita H. Dhanawade et al [1] experimentally worked on rectangular, circular and solid fins. Also they increased the number of size. It has been found that friction factor slightly increases in as the perforation increases. The effectiveness drop as the perforation increases. The nusselt number and heat transfer coefficient increases in perforation shape compared to solid fins.P.A. Deshmukh [2] have been experimentally investigated elliptical and circular pin fin heat sink under the combined action free and forced convection. The inline and staggered elliptical arrangement has been used .The thermal performance of staggered arrangement has been more effective compared to inline arrangement. Also the elliptical arrangement has higher value of heat transfer coefficient than in circular arrangements. M.R. Shaeri [3] study the turbulent fluid flow and convection heat transfer around an array of rectangular solid with different number of perforation and different size. Experiments were conducted for the range of Reynolds no. from 2000 to 5000 based on fin thickness and pr= 0.71. In numerically investigated on solid fins and array of rectangular perforated fins. It has been found that average nusselt number will be increased in solid fins as the Reynolds number increases. Average friction coefficient increase in solid fins compared to array of rectangular perforated fins. With the increase in perforation the average temperature increases. Also find out the light weight fins are most beneficial and effective.

II. METHODOLOGY AND EXPERIMENTAL SET UP

An experimental setup was fabricated to study the heat transfer and fluid flow characteristics for an ordinary heat sink and staggered and inline fin heat sink arrangements. In the design of a perforated plate heat sink, tubes of 10 mm outer diameter and 7 mm inner diameter and fin height of 100 mm is selected. The centre pitch span and stream wise of 50 mm is selected. In whole process mass flow rate is kept at constant and power input is varied. Initially, temperature at inlet, outlet and at flat plate without fins are measured. Then same process is repeated for perforated plates with fins. Power input is changed in each step and process is repeated for both plates and all thermal properties are measured. The heat sink is heated by a plate heater and temperatures and pressure drop are measured at the various positions. All thermocouples are connected to a digital recorder to record the temperature once the steady state is achieved. The power input to the heater is controlled by a variac. A digital wattmeter is use for recording the power of the heater. An enhancement of heat transfer was observed in the given case as compare to the heat sink having a conventional duct. All the results are represented in graphical forms.

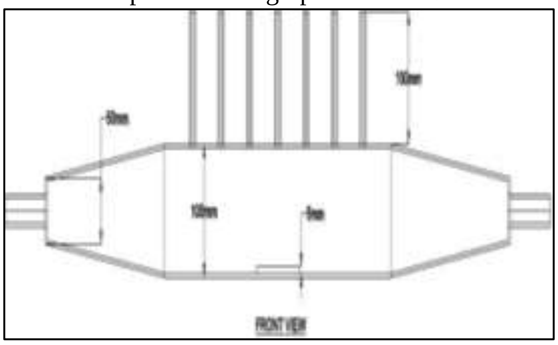

Fig. 1: Fin arrangement test section

Temperature profiles at different power input, comparison of variation of temperature for heat input, pressure drop between perforated heat sink with fins and without fins are plotted. It was observed that the perforated heat sink performance was better than the ordinary heat sink

III. RESULTS

A. Effect of Reynold Number versus Nusselt Number in Different Types of Fins Arrangements

For the sake of comparison, the heat sink (without fins and with fins at inline and staggered arrangements) as tested at 150W power input. Comparison of with fins and without fins at same power input and finally pressure drop between perforated heat sink with fins and without fins results orientation are shown in graphical forms. Fig.2 shows the effect of nusselt number as the reynold number increases in without fin, with fins in inline and staggered arrangements. Fig.2 shows that as the reynold number increases the nusselt number increases comparatively more in staggered circular fins followed by inline circular fins and without fin arrangements.

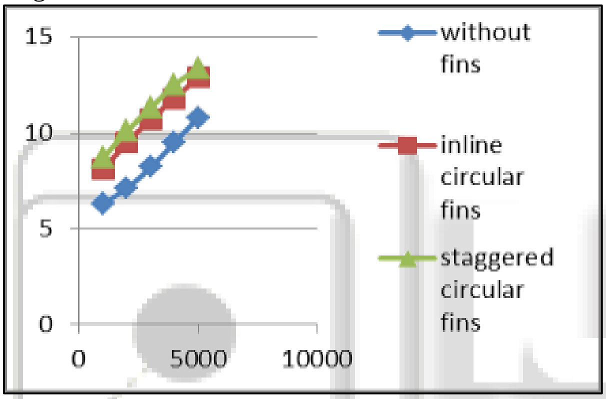

Fig. 2: Reynold no vs Nusselt no.at different fin arrangement

B. Effect of Reynold no vs effectiveness in different types of fin arrangements

Fig.3 shows the effect of effectiveness as the reynold number increases in without fins, inline circular fins, staggered circular fins.it has been observed that in without fins the effectiveness remains same as the reynold number increases. But in slightly drop of effectiveness in inline circular fins and staggered circular fins. Also we have seen that staggered circular fins have more drop of effectiveness followed by inline circular fins and without fin arrangements.

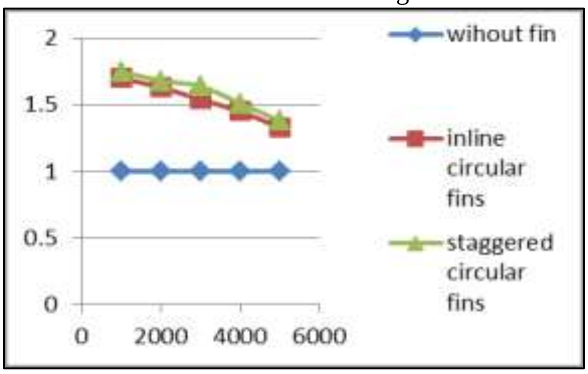

Fig. 3: Reynold no vs effectiveness in different types of fin arrangements

C. Effect of Reynold no vs Friction factor in different types of fin arrangements

Fig 4 shows that effect of friction as the reynold number increases .It has been seen that friction factor remains constant as the reynold number increases. It has also observed that value of friction factor is different for inline, staggered and without fins. The staggered fins have slightly much higher value followed by inline and without fins. We have seen that without fins having least friction factor.

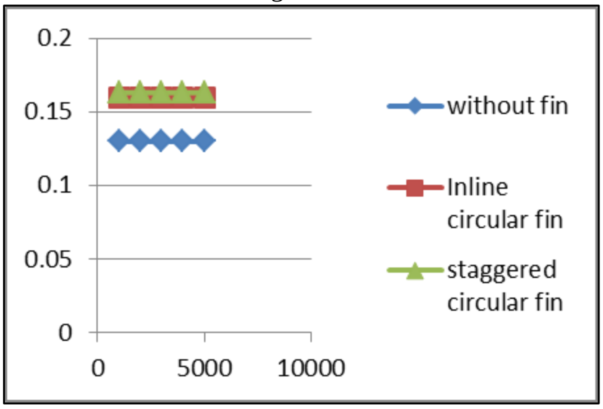

Fig. 4: Reynold no vs friction factor in different types of fin arrangements

IV. CONCLUSION

- It has been observed that as the reynold number increases the nusselt number also increase in all type of arrangements.
- Fins having staggered arrangements much higher heat transfer coefficient followed by inline circular fin arrangement and without fin arrangement.
- As the reynold number increases the effectiveness drop slightly in staggered fin and inline fin arrangement.
- The effectiveness remains constant in without fin arrangement and its equal to unity.
- The reynold number does not adverse effect on friction factor. But generally the friction factor in staggered fin arrangement has slightly higher compared to inline and without fin arrangements.

The thermal performance of staggered fin arrangement has better than the inline fins and without fins

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