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Computational Analysis on Performance of Heat Sink with Different Configurations of Fins Array

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Abstract

Objectives: The aim of present work is to find out the thermal performance of solid and perforated heat sink with various perforated designs (Rectangular, Circular and Slotted). **Methods/Statistical Analysis**: The CFD analysis was performed to investigate the thermal performance of different perforation design. The test has been conducted in a horizontal rectangular duct equipped with forced draft fan. The data was obtained by varying flow velocities of air from 2, 5 and 8m/sec and maintaining constant heat input 100 Watt taken over a period of time. **Findings:** In this computational analysis we calculate the Heat transfer coefficient, Reynolds number and Nusselt number and obtain the result. The results show the heat transfer coefficient is more in circular perforated fin as well as more Nusselt number as compared to slotted and rectangular Perforation. **Application/Improvements:** Electrical component, higher-power lasers, refrigerator, air condition, Computers etc.

Keywords: Air, Heat Source, Heat Sink, Wind Tunnel

1. Introduction

In modernization, heat sink plays a key role to enhance heat transfer. The extended surface of heat sink helps to increase the surface area in contact with air. Extended surface that are well known as fins are usually used to enhance the heat transfer rate in many industries. Fins are commonly used for heat management in electrical appliances such as computer power supplies, refrigerators, etc. Other application such as internal combustion engine cooling, car radiator, etc. Different types of fins like rectangular plate fins, pin-fins, etc. are commonly used for both forced and natural convection heat transfer. The heat transfer from any surface may be enhanced by increasing the heat transfer coefficient or increasing the area or by both. In[1] experimentally investigated the effect of various patterns like Reynolds number, geometry and friction factor on the heat transfer in a horizontal rectangular fin embedded with circular and square perforations. They observe that the parameter which mostly affecting that effect on heat dissipation is Reynolds number and the geometry of perforation. As the Reynolds number and number of perforation or size of perforation increases the Nusselt number and heat transfer coefficient will also increases. The friction slightly increased with increasing the size of perforation. In[2] conducted an experimental analysis to investigate the turbulent heat transfer performance of rectangular fin array, both solid and circular perforation along the length of fins. They observe that the Nusselt number, heat transfer coefficient and pressure drop increases by increasing Reynolds number for all the fins. The perforated fins show higher heat transfer coefficient and Nusselt number and low pressure drop than solid fin. They also found that larger and number of perforations, dimensionless pressure drop and thermal resistance decreases whereas efficiency and effectiveness increases. In[3] compared the thermal performance of plate-fin and pin-fin heat sink analytically and experimentally in natural convection. They develop two new correlations of the heat transfer coefficient for plate fin and pin fin heat sink. The objectives functions are heat dissipation per unit mass and total heat dissipation. They conclude

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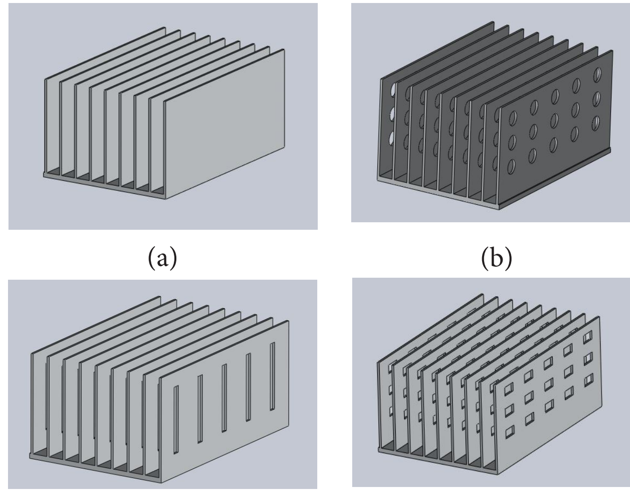
that the optimized plate-fin heat sink dissipates a large amount of total heat dissipation and the optimized pin fin heat sink dissipates a large amount of the heat per unit mass. In[4] studied convective heat transfer over an array of rectangular solid and new design of perforated fin with different numbers and two various sizes of perforation. They vary the Reynolds number for calculations 2000 to 5000 based upon fin thickness and pr = 0.71. From the numerical computation they observe that with increasing the perforation the flow becomes complex and decreases the average friction coefficient. The drag force reduces in the perforated fins and by increasing the Reynolds number the drag ratio become. They conclude that New perforated or more perforated fins having higher total heat transfer rate and considerable weight reduction as compare to solid fins.In[5] done an experimentally analysis to find out the thermal performance of rectangular plate fin heat sink with circular perforation by natural convection. They observed that perforated dimension and lateral spacing plays an important role for maximum heat dissipation rate in perforated fins. By decreasing the dimension of perforation, the rate of temperature drops decreases along the perforated fin. They also observe that the large number of perforation have higher heat transfer coefficient than fin with small number for perforation. In[6] this research metaheuristic technique of PSO and GA are exploit for designing pin fin heat sink by objective of decrease of produced entropy. Twice methods could discover optimum solutions for design changeable properly, but PSO was more rapidly in obtaining the solution, in total onwards computation time. Showed this results from study that using metaheuristic technique one can obtain more appropriate designs for pin fin of heat sinks which leads to additional efficiency of electronic devices, and less risks of breakdown and indemnity due to produced heat.

2. Methodology

Design of perforated heat sinks has been showed in Figure 1 while Figure 2 shows the assembly of perforated heat sink and duct. The Figure 1(a) is solid fin array and Figure 1(b), Figure 1(c) and Figure 1(d) are the perforated fin arrays. The material selected for perforated heat sinks is aluminum while the duct is of acrylic sheet. The specification of the perforated heat sink is given in Table1.

CFD analysis on perforated heat sink has been performed with air as working fluid. The area of all the



(c) (d)

Figure 1. (**a**) Solid fin arrays (**b**) circular perforation fin arrays (**c**) slotted perforation fin arrays (**d**) rectangular perforation fin arrays.

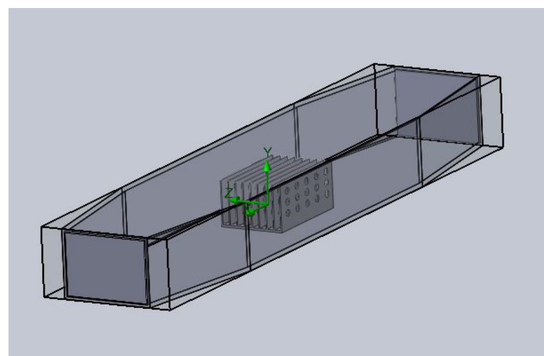


Figure 2. Assembly of duct and fin arrays.

Table1. Specification of perforated heat sink

Type of fins	Size of Fin(lxhxt) (mm)	Total No of fins	Size of perforation	No of perforations
Without perforation	90x40x1	9	-------	0
With Circular perforation	90x40x1	9	6mm dia	15
With Slotted perforation	90x40x1	9	26.7x3	5
With Rectangular perforation	90x40x1	9	7.08x4	15

perforations taken as same in all the fins. The readings obtained have been recorded. These readings used for calculations so as to find the result.

The steps of calculation procedure followed are as:

1. Reynolds Number

$$Re = \frac{\rho v d_h}{\mu} \quad \text{(i)}$$

2. Heat Transfer Coefficient

$$h = \frac{q}{A_s \Delta t} \quad \text{(ii)}$$

3. Nusselt Number

$$N_u = \frac{h d_h}{k} \quad \text{(iii)}$$

3. Results and Discussions

Through the CFD analysis we find the comparative relationship between heat transfer coefficient vs Reynolds no. for different perforated fins. It is found that circular perforation heat sink has higher heat transfer coefficient compared to other different perforated fins as shown in Figure3(rectangular perforation, slotted perforation and solid fin arrays).

Through the experiment analysis we find the comparative relationship between Nusselt number vs Reynolds number for different perforated fins. It is found that circular perforation heat sink has higher Nusselt number compared to other different fins shown in Figure4(rectangular perforation, slotted perforation and solid fin arrays).

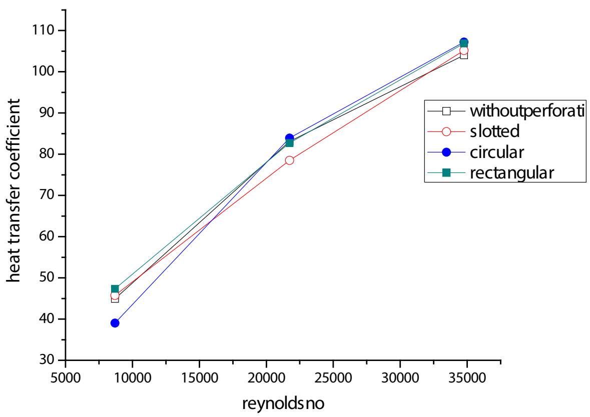


Figure 3. Variation of heat transfer coefficient with Reynolds number.

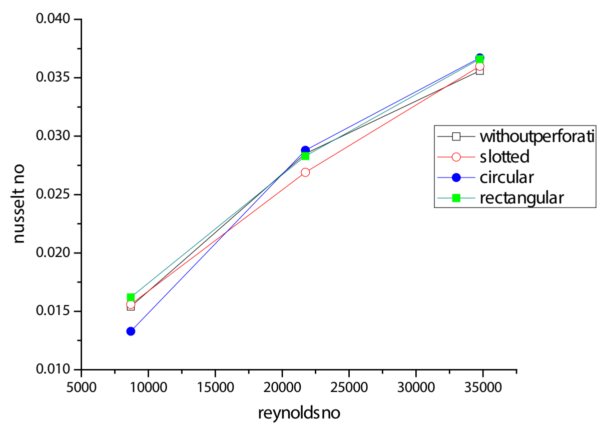


Figure 4. Variation of Nusselt number with Reynolds number.

4. Conclusion

From the present experimental work have been carried out to calculate the characteristics of heat transferson perforated heat sink in a horizontal rectangular duct using air as working fluid. It has been observed that heat transfer coefficient is increase in circular perforation than the other rectangular and slotted perforation. The circular perforation has more heat transfer as compare to the rectangular and slotted perforation. As the Reynolds no. increases the heat transfer coefficient also increases. The Nusselt number of perforated fin arrays is higher as compared to solid fin arrays. The circular perforated fin array has more Nusselt number than the other perforation. As the Reynolds number increases the Nusselt number also increases.

5. References

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