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A REVIEW ON NATURAL CONVECTIVE HEAT TRANSFER FROM STAGGERED INTERRUPTED RECTANGULAR FINS

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Abstract— Heat sinks with fins are generally used to enhance the heat transfer rate in many industrial applications such as cooling of electronic, power electronic, telecommunication and automotive components. In many situations where heat transfer is by natural convection fins offer economical and trouble free solutions. The weight and volume of the equipment are the most important parameters of design. Now days the general trend is to use compact systems especially in electronic field which leads to higher packing density of systems causing higher heat generation. It affects the performance of system and may cause the system failure. The most preferred method for cooling electronic and telecommunications devices is passive cooling since it is cost effective and reliable solution. It doesn't require costly enhancing devices. This features leads to focus on development of efficient fin heat sink. The important element that defines the geometry of the heat sink is its fins. The fins generally used in industry are straight, circular and pin shaped. Here in this work the focus is on interrupted fins. The objective of this work is to enhance the heat transfer rate by providing proper interruptions. The staggered interruptions are provided on the heat sink. The proper selection of the interruption length increases the heat transfer rate and in addition providing fin interruptions results in considerable weight reduction that can lead to lower manufacturing cost.

Keywords— Fin geometry, Heat sinks, Interrupted fins, Natural convection, staggered interruptions, Thermal boundary layer, Thermal Performance.

INTRODUCTION

Heat sinks are commonly used for cooling of various electronic components in industries. Passive cooling heat sinks are widely used in CPU cooling, audio amplifiers and power LED cooling. Fins are used to increase the heat transfer rate between the heat sink and surrounding fluid. Now days there are a high demand for light weight, compact and economical heat sinks. Fins are the important aspect in geometry of heat sink. A fin is generally a flat surface extended from heat sink surface. It is used for increment in heat transfer to and from environment by increasing the convective heat transfer surface area. The common fin geometries that are used and studied in literature are straight, circular and pin shaped. The provision of interruptions on continuous rectangular fins increases the heat transfer rate from heat sink. It is due to fact that the interruptions provided on fins disrupt the thermal boundary layer growth and thus maintains thermally developing flow regime along the fins which leads to higher natural heat transfer coefficient. In addition provision of interruptions reduces the weight and can lead to lower manufacturing cost. On the other hand provision of interruptions leads to reduction in heat transfer area which decreases the heat transfer. Therefore it indicates that an optimum interruption exists that can provide the maximum heat transfer rate from heat sinks. It is found that the work has been done on in line interruption. Now here this work is extended to staggered interruptions.

Thermal boundary layer:

When a fluid flows over a hot or cold surface, a temperature field is setup within the fluid near the surface. This region where the temperature gradient exists is known as Thermal boundary layer. The thickness of thermal boundary layer is the distance y from the plate surface at which the temperature difference between the 99%.

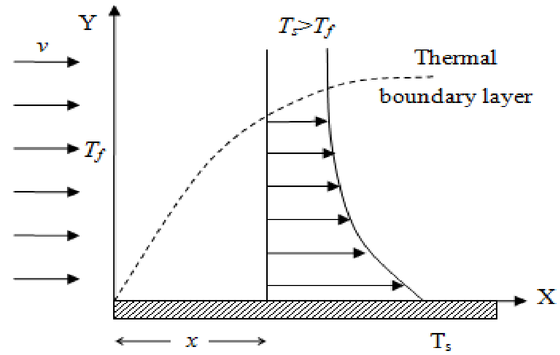

Figure 01 Thermal Boundary Layer.

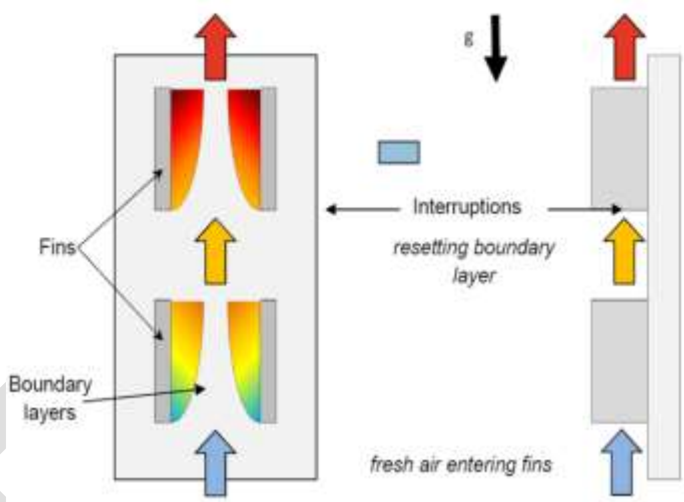

Figure 02 Effect of adding interruptions on the boundary layer growth in natural heat transfer from vertical fins [7].

LITERATURE SURVEY

[1] Mehran Ahandi et.al investigated numerically and experimentally steady state natural convection heat transfer from vertically mounted inline interrupted fins. They have done 2D numerical simulation to find fin interruption effects by using fluent software. They developed a custom design test bed to verify theoretical results. They performed comprehensive experimental and numerical parametric study to investigate the effects of fin spacing and fin interruptions. The results show that the interruptions increased the heat transfer rate by resetting the thermal and hydrodynamic boundary layer. They machined and tested 12 heat sink samples for validation the present numerical study. It is shown that the heat flux from heat sink increased when interruptions were added. They developed new compact co relation to calculate optimum fin interruption for targeted rectangular heat sink.

[2] A Ledezma et.al studied the geometric optimization of an assembly of staggered vertical plates that are installed in fixed volume they performed optimization for spacing, no of plates, plate dimension and stagger between columns. The range used is Pr=0.72 and $10^3 \leq Ra \leq 10^6$ where Ra is Rayleigh number based on the vertical dimension of assembly. They concluded that it is possible to optimize geometrically the internal architecture of a finite size volume by reducing the global thermal resistance.

[3] Shivdas S kharche et.al investigated experimentally and theoretically natural convection heat transfer from vertical rectangular fin arrays with and without notches at the center. They analyzed the notches of different geometrical shapes. After the experimental study they have concluded that the heat transfer rate in notch fins is more than the unnotched fins.

[4] Wadhah Hussein et.al conducted experimental study to investigate heat transfer by natural convection in rectangular fin plates with circular perforations as heat sinks. The pattern of the perforations included 24 circular perforations for the first fin, and the perforations were increased as 8 for each fin to 56 in fifth fin. They distributed the perforations in 6-14 rows and four columns. They observed that the temperature along the non-perforated fins was from 30 to 23.7^0 at lower power 6 W. They observed that the drop in temperature between the fin base and the tip increased as the diameter of perforations increased. The temperature drop at the highest power of 220 W was from 250 to 49 ^{0}C for non-perforated fins. They concluded that the heat transfer rate and the coefficient of heat transfer increased with increased number of perforations.

[5] M J sable et.al studied that the tall vertical fins restrict the heat transfer enhancement because of boundary layer development. They investigated the heat transfer enhancement technique for natural convection adjacent to vertical heated plate with multiple V type partition plates in ambient air surrounding. They found that V shaped partition plates with not only act as extended surface but also as flow turbulator. For heat transfer enhancement they had attached v shaped partition plates with edges faced upstream to base plates. They observed that when the plate height exceeds certain critical values the heat transfer in downstream region of the partition plate is enhanced because of the inflows of lower temperature fluid in to the separation region. They observed that among the three different fin array configurations on vertical heated plate, V type fin array design performs better than rectangular vertical fin array and V fin array with bottom spacing design.

SYSTEM DEVELOPMENT

The interrupted fins are the more general form of fins. It includes continuous and pin fin which is obtained when the fin interruption reaches up to zero as shown in figure 3. It can be seen that the continuous fins and pin fins are the two extreme cases of targeted staggered interrupted fins. The analysis can be start based on proper fin spacing and interruption length leads to higher thermal performance. This is due to fact that interruptions provided disrupt the boundary layer growth, which leads to increase in heat transfer [1]. The objective of this study is to investigate the effects of providing interruptions to fins and to find out the optimum geometrical parameters of fin array. The focus is mainly on the fin length and interruption length in staggered interruptions. The aim is to developed compact easy to use thermal models that can provide the natural convective heat transfer from staggered interrupted vertical walls to the ambient. Experimental and numerical analysis will be performed to find maximum heat transfer rate from heat sink by obtaining the optimum geometry of staggered interruptions.

A schematic of the considered fin geometry with the salient geometric parameters is shown in Figure 3.When a heat sink is heated, Due to buoyancy force the surrounding fluid start moving and as a result thermal boundary layers start developing at the bottom edges of the fins. The boundary layers merge if the channels form by fins is sufficiently long and creates a fully developed channel flow. Interruptions provided disrupt this flow and improves the Thermal performance.

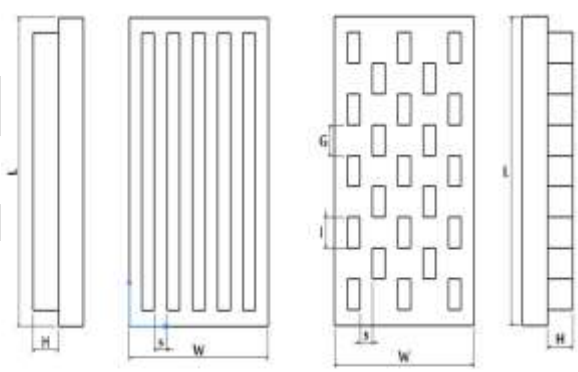

Figure 3 Schematic of the considered heat sink geometry, a) continuous rectangular fin heat sink; b) Staggered interrupted rectangular fin heat sink.

CONCLUSION

The earlier investigators have studied the problems concerned with various fin geometries, extensively both theoretically and experimentally. Out of which the interrupted fins with staggered fin arrays are intended to improve the convective heat transfer under natural convection. Based on the studies undertaken in literature review it can be said that a proper selection of interruption length leads to a higher thermal performance.

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