A Review on Heat Transfer by Natural Convection with Staggered Fins

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Abstract— Fins are used for to enhance the heat transfer rate in many devices as they can enhance the heat transfer to particular environment. The application of fins enables the overall increase in the efficiency of device. As today emphasis is given on increase in effectiveness and efficiency of the heat exchanging devices now days use of different types fins becoming more and more popular in heat exchanging devices like heat exchangers , engines , radiators etc. the aim of this paper is to provide a review on use of horizontal rectangular staggered fins in natural convection to increase heat transfer rate and convective heat transfer coefficient.

Key words: Heat transfer enhancement, Natural convection, Fins

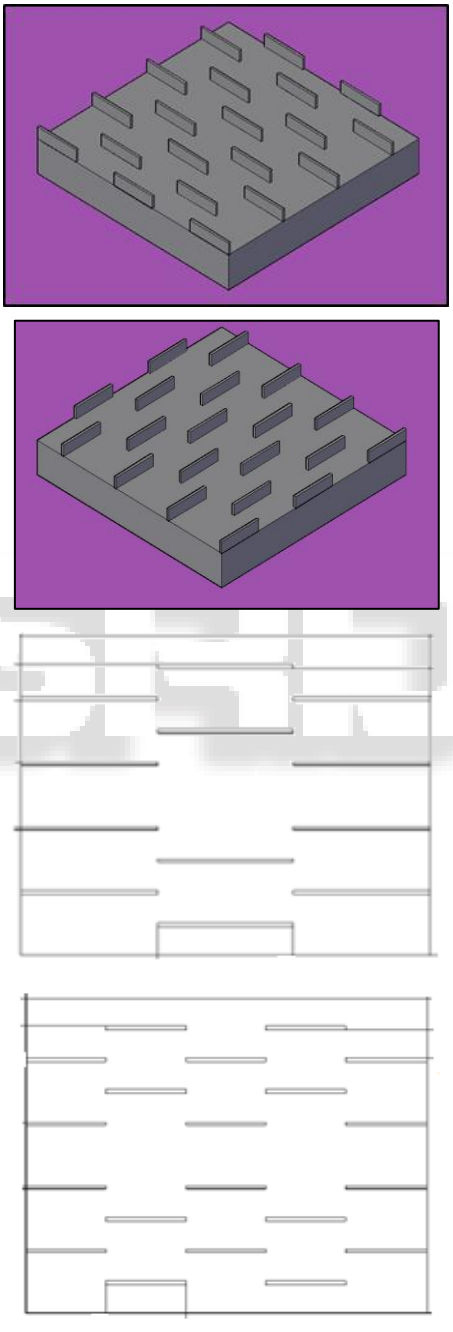
I. INTRODUCTION

Fins are extended surfaces which are used to improve the overall heat transfer rate when it is limited by low rate between a solid surface and surrounding fluids. Due to the high demand for lightweight, compact, and economical fins, the optimization of the fin size of great importance. Therefore, fins must be designed to achieve maximum heat removal with minimum material expenditure, taken into account, and also with the ease of manufacturing the fin shape. A large number of studies have been conducted on optimizing fin shapes. Other studies have introduced shape modifications by cutting some materials from fins to make cavities, holes, slot, groove, notches or the channels through the fin body to increase heat transfer area and the heat transfer coefficient [3].

Enhancement of natural convection heat transfer is necessary because of the continuous increase of power consumption rate of equipment. The heat can be removed effectively if the fluid flow and the resulting flow pattern are capable of removing the heat efficiently. The heat dissipation from fins under natural convection condition depends on the geometry and orientation of finned surface. Whenever the available surface of fins is found inadequate to transfer the required quantity of heat with the available temperature drop, staggered fin surfaces are used [5]. The heat transfer through staggered fins is greater than the normal fin pattern.

II. NEED OF STAGGERED FIN

With the increase of circuit density and power dissipation of integrated circuit chips and other microelectronic devices, electronic packagers have underlined the need for employing effective cooling devices and cooling methods to maintain the operating temperatures of electronics components at a safe and satisfactory level. The heat sink industry, traditionally the supplier of cooling products, is always searching for new technologies which enhance thermal performance with no cost penalties. For this reason, a comparison of various geometries of pin fin heat sinks is of interest and needs to be carried out to determine applicability as a general cooling product. . The concept of heat transfer through staggered fins is one method of improving the heat transfer characteristics in natural convection.



a) 20% staggering b) 40% staggering
Fig. 1: Horizontal staggered fin array with 20% & 40% staggering

III. LITERATURE REVIEW

As the fins are very important parts to enhance the heat dissipation rate so it is necessary to study by considering various parameters it may be theoretical or by experiments,

Baskaya *et al.* [1] works by using aluminum material for his parametric study They studied each of the variables of fin spacing, height, and length and temperature difference produces an effect on the overall heat transfer rate They investigated the effects of a wide range of geometrical parameters like fin spacing, fin height, fin length and temperature difference between fin and surroundings; to the heat transfer from horizontal fin arrays. However, no clear conclusions were drawn due to the various parameters involved. Finally they concluded that, it is not possible to obtain optimum performance in terms of overall heat

Tanda *et al.*[5] studied the thermal field and the heat transfer characteristics of a system consisting of two staggered vertical plates cooled by air in free convection were experimentally studied. The parameters investigated included the inter plate spacing, the magnitude of the vertical stagger, and the Rayleigh number based on the overall convective heat flux from each plate. The experiments were performed in air. The schlieren optical technique was employed to obtain the thermal field around the plates and the local heat transfer coefficients along the vertical sides of plates.

Staggering was found to markedly affect the local heat transfer characteristics of the facing sides of the plates when the inter plate distance was relatively small. In general, the Nusselt number averaged on the inner face of the lower plate was enhanced (up to over 40%) & compared with that for the case of the unstaggered plate channel. Conversely the mean Nusselt number on the facing side of the upper plate was reduced up to 15%.

Starner *et al.*[6] studied the Free-Convection Heat Transfer from Rectangular staggered-Fin Arrays and average heat-transfer coefficients are presented for four fin arrays positioned with the base vertical, 45 degrees, and horizontal while dissipating the heat to room air. The fins were analyzed as constant-temperature surfaces since the lowest fin efficiency encountered was greater than 98 %.

It was found that coefficients for the vertical arrays fell about 10 to 30 percent below those of similarly spaced parallel plates. The 45-degree arrays yielded results from 5 to 20 percent below to those of vertical plates. Two flow patterns were investigated for the horizontal arrays, and it was found that the coefficients could be reduced sharply by preventing a three-dimensional flow**.**

L.Dialameh *et al.* [7] performed a numerical study to predict the natural convection from an array of aluminum horizontal rectangular thick fins of 3 mm < t < 7 mm with short lengths (L=50 mm) attached on a horizontal base plate. The three-dimensional elliptic governing equations of laminar flow and heat transfer were solved using finite volume scheme. For 128 fin geometries, typical results have been compared with the available experimental data from the literature and good accuracy were observed. Based on the verified model, fluid flow and thermal structure around various fins were illustrated and two types of flow patterns in the channel of the fin arrays were observed. Effect of various fin geometries and temperature differences on the convection heat transfer from the array was determined for Rayleigh numbers based on fin spacing of 192‑6784 and applied correlations are developed to predict Nusselt numbers with corresponding non-dimensional parameters.

IV. CONCLUSION

The earlier investigators have studied the problems concerned with the arrays having vertical fins on vertical base surfaces, extensively both theoretically and experimentally. Out of which the staggered fin arrays are intended to improve the convective heat transfer under natural convection. The findings of some of the studies are as under.

(1) It can be said that the staggered arrangement with some optimum spacing (which needs to be found out from the experimental study) can be used for augmentation of heat transfer in vertical fins. Each arrangement has higher value of Nusselt number for higher height. This is due to increased heat transfer area.
(2) The thermal performance of the staggered fin configuration was better than the planar fin configuration over the power and flow ranges examined. This enhanced thermal performance, however, was realized at the expense of an additional pressure drop.
(3) Adding too many fins on a surface decrease the overall heat transfer coefficient when the decrease in height offsets any gain resulting from the increase in the surface area.
(4) Staggering was found to markedly affect the local heat transfer characteristics of the facing sides of the plates when the inter plate distance was relatively small.

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