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A REVIEW ON EXPERIMENTAL INVESTIGATION OF STAGGERED FINS

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ABSTRACT

It is proved till today that special surface geometry or special fin pattern may enhance heat transfer coefficients. The area selected for investigation is experimental analysis of one of the special fin pattern i.e. staggered fin arrays and software validation. They are compared with continuous fin array. From the literature survey, test section and fin arrays under study are designed. For each 33.33 % and 50% lengthwise staggering is done. Then by performing an experiment, readings of 12 temperatures were recorded for four different heater inputs. From these readings Nusselt number for each array for given range of heater input is calculated. Conduction and radiation losses are also calculated. The arrays under study are compared. It was predicted that array with staggered fins will have higher values of Nusselt number for all values of heater input and increases when % staggering is increased and the experiment gave the same results. Thus it is concluded that the staggered arrangement enhances the heat transfer rate. In other words it can be concluded that the staggered arrays may be used for augmentation of heat transfer in vertical fins. Software analysis results are compared with experimental results.

KEYWORDS: Heat transfer enhancement, Percentage staggering, Staggered fins, etc

1. INTRODUCTION

Extended Surface (Fins) is used in a large number of applications to increase the heat transfer from surfaces. Typically, the fin material has a high thermal conductivity. The fin is exposed to a flowing fluid, which cools or heats it, with the high thermal conductivity allowing increased heat being con-ducted from the wall through the fin. Fins are used to enhance convective heat transfer in a wide range of engineering applications, and offer practical means for achieving a large total heat transfer surface area without the use of an excessive amount of primary surface area. Fins are commonly applied for heat management in electrical appliances such as computer power supplies or substation transformers. Other applications include IC engine cooling, such as Fins in a car radiator. Fins are widely used in trailing edges of gas-turbine blades, in electronic cooling and in aerospace industry.

The need for more efficient cooling techniques of devices prompted study into heat transfer and flow characteristics of various configurations of finned surfaces. Literature survey shows various areas where the work is distributed like (I) Horizontal and vertical fin arrays (II) Various fin geometries and fin patterns (III) Various combinations of convection and radiation (IV) Effects of obstructions that is shrouds. Many of the earlier investigators have studied the problems concerned with the arrays having vertical fins on horizontal and vertical base surfaces, extensively both theoretically and experimentally.

It is proved that the use of special surface geometries and special fin patterns may allow higher heat transfer coefficients than those given by plain extended surfaces. In this connection, fin surfaces made by staggered plates aligned parallel to flow are employed in compact heat exchanger and electronic equipment cooling, because of their capability of high heat transfer rates per unit volume. The heat sink is a very important component in cooling design. It increases the component surface area significantly while usually increasing the heat transfer coefficient as well. Using fins is one of the cheapest and easiest ways to dissipate unwanted heat and it has been commonly used for many engineering applications successfully.

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Heat transfer enhancement techniques

Passive techniques
They employ special surface geometries, or fluid additives for enhancement.

Active techniques
They require external power, such as electric or acoustic fields and surface vibration

2. LITERATURE REVIEW

Dhumne [1] Studied the review on heat transfer enhancement and the corresponding pressure drop over a flat surface equipped with cylindrical cross-sectional perforated pin fins in a rectangular channel. The friction factor increased with decreasing clearance ratio and inter-fin distance ratio, Enhancement efficiencies increased with decreasing Reynolds number. Therefore, relatively lower Reynolds number led to an improvement in the heat transfer performance. The most important parameters affecting the heat transfer are the Reynolds number, fin spaces (pitch) and fin height.

Siddiqui [2] Presented the experimental analysis of heat transfer over a flat surface equipped with Square perforated pin fins in staggered arrangement in a rectangular channel. The average Nusselt number calculated on the basis of projected area increased with decreasing clearance ratio & inter-fin spacing ratio by 10%. The friction factor increased with decreasing clearance ratio and inter-fin distance ratio by 6%. Enhancement efficiencies increased by [8 to 10 %] with decreasing Reynolds number pin fins in staggered arrangement in a rectangular channel. It consist of square plate at base having the dimension 250 mm x 250 mm, thickness is 6mm and the pin fins and base plate made of the same material i.e. Aluminum because of the considerations of conductivity, machinability and c,

Sreedev [3] Studied with a new mechanism in which heat transfer rate in rectangular array is enhanced by means of staggered perforations. ANSYS Gambit 2.4 has been used for geometry creation and ANSYS Fluent 6.2.4 for simulation. The result shows that the fins with staggered holes possess increased heat transfer capacity. From the analysis it is also concluded that when perforations in staggered manner are introduced on fin surface, the turbulent effect of air passing through the holes gets increased. Analysis of flow field and heat transfer has been carried out for two different orientations It is observed that flow path lines around solid and perforated fin are different. From the analysis it is also concluded that when perforations in staggered manner are introduced on fin surface, the turbulent effect of air passing through the holes gets increased. This in turn enhances the heat carrying capacity of the perforated fins.

Kumar [4] Studied to analyse free convection heat transfer in an air filled triangular cavity with rectangular staggered finned base plate. Experiments have been carried out in two orientations i.e. horizontal and vertical. In total 104 experiments were run to observe the effect of fin spacing, fin height, fin thickness and Rayleigh number on the Nusselt number. The fins having thickness 1mm were more effective than the fins having thickness 3mm. So, thin fins are more suitable inside the enclosures.

Kobus [5] Theoretical and experimental study was carried out investigating the influence of thermal radiation on the thermal performance of a pin fin array heat sink with the purpose of developing accurate predictive capability for such situations, and to determine the particular design parameters and environmental conditions under which thermal radiation might be advantageous to the thermal performance. Several different types of experimental tests were run with the corresponding physical parameter variations including the emissivity of the heat sink, elevated ambient air temperature, the temperature of a visible hot surface, and its radiation configuration factor.

Saurabh [6] Studied on Fin arrays on horizontal and vertical surfaces are used in variety of engineering applications to dissipate heat to the surroundings. Studies of heat transfer and fluid flow associated with such arrays are therefore of considerable engineering significance. In case of short horizontal arrays, it is observed that the air entering symmetrically from both the ends gets heated as it moves towards the centre of the fin channel, as well as it rises due to decrease in density. So, the central portion of the fin becomes ineffective

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because hot air-stream passes over that part and therefore it does not bring about large heat transfer. The purpose of the present study is to investigate thoroughly the possibility of performance improvement of such arrays by providing triangular perforation at the centre and suggest for selection of optimum notch dimensions and spacing by analyzing variety of fin arrangements.

In this experimental study, an attempt is made to improve the performance of horizontal rectangular fin array by removing the less effective portion of the fin flat in the form of triangular perforations. It is observed that 1. Total heat flux as well as the heat transfer coefficient increase as the perforations depth increases. 2. As area removed from the fin is compensated at the air entry ends of the fin it provides chance to get greater amount of fresh cold air to come in contact with hot fin surfaces.

Nada [7] Gives Natural convection heat transfer and fluid flow characteristics in horizontal and vertical narrow enclosures with heated rectangular finned base plate have been experimentally investigated at a wide range of Rayleigh number (Ra) for different fin spacing and fin lengths. Quantitative comparisons of finned surface effectiveness (e) and heat transfer rate between horizontal and vertical enclosures have been reported. In comparison with enclosure of a bare base plate, insertion of heat conducting fins always enhances heat transfer rate. Optimization of fin-array geometry has been addressed. The results gave an optimum fin spacing at which Nusselt number (NuH) and finned surface effectiveness (e) are maximum.

Summary of the literature review
From the all above literatures it can be concluded that,
1. Array with staggered fins will have higher values of Nusselt number.
2. Staggered arrangement enhances the heat transfer rate as compared with inline fins.
3. Staggered fins give better performance than standard fins in terms of heat transfer

3. EXPERIMENTAL SETUP

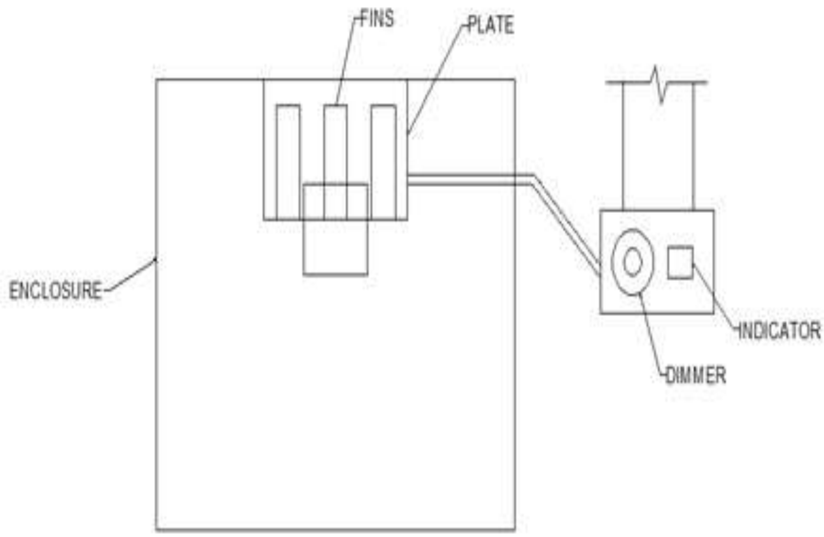

Fig. 1 Experimental setup

Percentage Staggering of Fins
For the proposed work 33.33 % and 50% lengthwise staggering is done. Then by performing an experiment, readings of 12 temperatures were recorded for four different heater inputs. From these readings Nusselt number for each array for given range of heater input is calculated. Conduction and radiation losses are also calculated. The arrays under study are compared.

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