Heat Transfer Enhancement Techniques in Heat Sink: a Review.

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Abstract

All engineering systems under operations generates heat. If this heat is not removed periodically the system will fail due to overheating of components. Hence, extended surface or fin are used to remove the heat from the system. In this report experimental study on aluminium rectangular fins with inline array and perforations are made under forced convection mode with different voltages, air velocities and fin spacing of 8 mm. Reynolds number varies from 4000 to 18000 in step of 4000 and heatinputat50W, 80W, 100W, 125W.Results will be compared with solid perforated fins of same spacing's cross fin-array with and without perforation.
Keywords: fins, forced convection, heat transfer coefficient, perforated fins.

I. INTRODUCTION

Heat transfer enhancement is an active and important field of engineering research as increase in the effectiveness of heat exchangers through suitable heat transfer augmentation techniques can result in considerable technical advantages and savings of costs. Compactness of devices causes inadequate cooling; the fin provides surplus area for heat exchange, results in faster rate of heat transfer and cooling of device. The fins with various configurations and arrangements can be implemented to enhance the heat transfer rate. It finds application in various industries especially the refrigeration, automotive, chemical process industries and electronics. Considerable enhancement is demonstrated in the present work by using rectangular plates on sink surface. A partly quantitative theoretical treatment of the proposed method is presented. It uses simple relationships for the conductive and convective heat transfer to derive an equation that shows which parameters permit the achievement of heat transfer enhancements. It is shown that the suggested method of heat transfer enhancements is much more effective than existing methods, since it results in an increase in heat transfer area(like fins)and also increase in the heat transfer coefficient. Plate fin heat sinks (PFHSs) are widely used in electronic equipment cooling because of their many advantages, such as easy machining, simple structure, and low cost. Various forms of PFHSs are manufactured and supplied to markets in large quantity, and they can achieve excellent solutions for many thermal issues in electronic equipment's. Many publications studied the optimization of the PFHS and attempted to define general rules for optimizing it. All these researches focused on optimization of design parameters and the operating condition of a cooling system. However, there exists an intrinsic shortcoming in structures of PFHSs, i.e. parallel plate fins make airflows passing through heat sinks smoother. This is undesirable for enhancing heat transfer performances of heat sinks. Sometimes the existing PFHSs cannot satisfy cooling requirements of some electronic products in small quantity, and it will take some trouble for the users to find proper PFHSs. In this case, it will be helpful to reduce the cost of the total electronic device, if users can modify the heat sink structure and improve heat transfer performance of it by them.

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Limitation of Heat sinks is the poor heat transfer coefficient at the heat transfer surface. When a moving fluid comes in contact with the stationary surface, a thin boundary layer is developed adjacent to the wall and in this layer there is no relative velocity with respect to the surface. In heat transfer process, the near surface layer is called laminar sub layer, viscous sub layer or stagnant film and the heat flow in this layer is covered with by both conduction and convection process, since thermal conductivity of air is low, the heat flow from the wall is mainly due to convection which is also low due to less velocity near the wall. The convective heat transfer coefficient can be increased by providing additional heat transfer surface called fins in the path of flow of medium of heat transferring surface. Due to which boundary layer breaks, this reduces the thermal resistance and promotes the turbulence on the heat transferring surface and heat transfer rate increases. The purpose of providing fins on the heat transfer surface is to increase heat transfer rate and keeping pressure drop penalties in limits. These fins induce flow separation and reattachment with pairs of vortices. The areas of high heat transfer include the areas of flow reattachment on the flat surface immediately downstream of the fins. Increase in surface area due to the use of rectangular fins in the passage of plate fins are another important reason for heat transfer enhancement. Numbers of investigations for several geometries were performed for natural and forced convection heat transfer rate from fin arrays.

The present work includes Numerical study of heat sink (Plate fin array) on verticalbasewithdifferentfingeometrieslikeRectangular,TrapezoidalandInverted trapezoidal plate fin arrays and comparison of performance at different Reynolds no., heat inputs, fin spacing, ratio of Tip width to base with in case of TPFA and ITPFA. This work also includes study of Perorated Inverted Trapezoidal plate fin array with circular perforations which consists of diameter of perforations, Area ratios, perforations centre to centre distance at different Re , calculation of Heat transfer coefficient, Avg. Nusselt No. Pressure drop pumping power and comparison of results with different configurations. Experiment is carried out using flat plate,

ITPFA and PITPFA of optimum dimensions. So heat transfer analysis has been done on Rectangular Plate Fin Array (RPFA), Trapezoidal plate fin array (TPFA), Inverted Trapezoidal Plate Fin Array (ITPFA) Perforated Inverted Trapezoidal Plate Fins Array (PITPFA) Numerically. And experiments has been performed using ITPFA PITPFA. So present work is aimed to “find out the heat transfer experimentally and numerically in a heat sink with Inverted trapezoidal plate fin array with without perforations under forced convection.

Fig.: Rectangular Cross Plate Heat Sink.

Heat Transfer Augmentation Techniques:

Heat transfer augmentation is one of challenging problems faced by the heat transfer engineers in industry. Heat transfer augmentation techniques find application mainly in the design of the more compact heat exchangers. Various industries especially the refrigeration, automotive and chemical process industries are becoming strong users of this technology. These techniques are generally classified as follows:

- Passive Techniques
- Active Techniques
- Compound Techniques

1. Passive Techniques: Thesetechniquesgenerallyusesurfaceorgeometricalmodificationstotheflow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behaviour (except for extended surfaces) which also leads to increase in the pressure drop. In case of extended surfaces, effective heat transfer area on the side of the extended surface is increased. Passive techniques hold the advantage over the active techniques as they do not require any direct input of external power. Heat transfer augmentation by these techniques can be achieved by using:

(a) Treated Surfaces:
This technique involves pits, cavities or scratches like alteration in the surfaces of the heat transfer area which may be continuous or discontinuous. They are primarily used for boiling and condensing fluid.

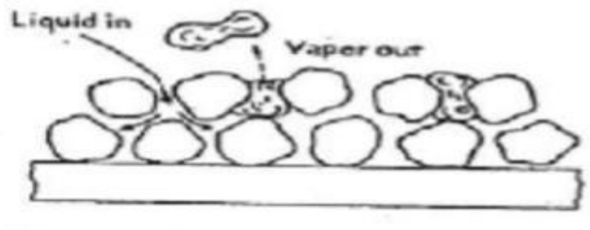

Fig.: Treated Surface.

(b) Rough Surfaces:
These surface modifications particularly create the disturbance in the viscous sub layer region. These techniques are applicable primarily in single phase turbulent flows.

(c) Extended Surfaces:
Plain fins are one of the earliest types of extended surfaces used extensively in many heat exchangers. Finned surfaces have become very popular now days owing to their ability to disturb the flow field apart from increasing heat transfer area

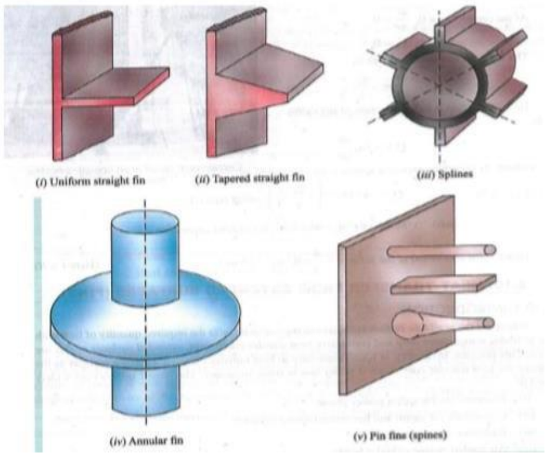

Fig.: Various fin types.

(d) Displaced Enhancement Devices:

These inserts are used primarily in confined forced convection. They improve heat transfer indirectly at the heat exchange surface by displacing the fluid from the heated or cooled surface of the duct with bulk fluid from the core flow.

(e) Swirl Flow Devices:

Swirl flow device include a number of geometric arrangements or tube inserts for forced flow that create rotating and/or secondary flow inside tube. Such devices include vortex generators, twisted tape inserts and axial core inserts screw type windings. The augmentation attributable to several effects increased path length of flow, secondary flow effects and in case of tapes, fin effects.

(f) Coiled Tubes:

In these devices secondary flows or vortices are generated due to curvature of the coils which promotes higher heat transfer coefficient in single phase flows and in most regions of boiling. This leads to relatively more compact heat exchangers.

(g) Surface Tension Devices:

These devices consists of relatively thick wicking material or grooved surfaces on heat transfer devices to direct the flow of liquid in boiling and condensing.

(h) Additives for Liquids:

Additives for gases are liquids droplets or solid partials, either dilute phase (gas-solid suspension) or dense phase (Fluidized beds).

2. Active Techniques:

From design point of view and application, these techniques are more complex, as the method requires some external power input to cause the desired flow modification and improvement in the rate of heat transfer. It finds limited application because of the need of external power in many practical applications. In comparison to the passive techniques, these techniques have not shownmuchpotentialasitisdifficulttoprovideexternalpowerinputinmany

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cases. Various active techniques are as follows:

(a) Mechanical Aids:
They stir the fluid by mechanical means or by rotating the surface or by surface scraping. Surface scraping is widely used for various liquids in the chemical process industry.

(b) Surface Vibration:
It is at either low or high frequency has been used primarily to improve single phase heat transfer. E.g. boiling and condensing.

(c) Fluid Vibration:
It the most practical type of vibration enhancement, given the mass of most heat exchangers. The vibration range from pulsation of about 1Hzto ultrasound. Single phase fluids are primary concern. E.g. Single phase flow, boiling and condensing.

(d) Electrostatic Fields

Electrostatic field like electric or magnetic fields or a combination of the two from DC or AC sources are applied in many different ways to dielectrics to cause greater bulk mixing of fluid in the vicinity of heat transfer surface. An electric field and magnetic field may be combined to provide forced convection via electromagnetic pumping

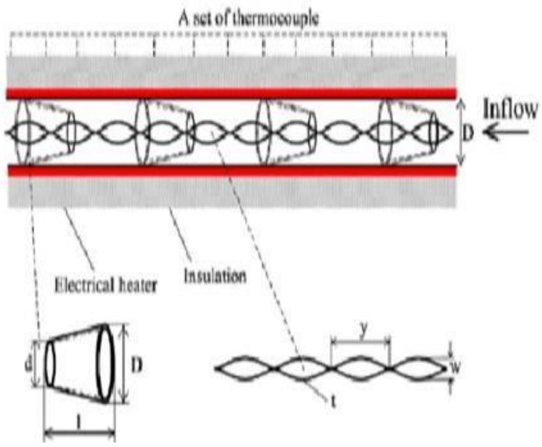

Fig.: Electrostatic fields.

(e) Injection:
It involves supplying gas to a flowing liquid through a porous heat transfer surface or injecting similar fluid upstream of the heat transfer section.

3. Compound Techniques:
A compound augmentation technique is the one where more than one of the above mentioned techniques is used in combination with the purpose of further improving the thermo-hydraulic performance of a heat exchanger.

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II. LITERATURE REVIEW

Ganesha BB GV, Naveen Prakash, In this paper experimental study on aluminium rectangular fins with triangular, rectangular and circular perforated fins are made under forced convection mode with different voltages, air velocities and fin spacing of 8 mm. Heat transfer rate can be increased by increasing the fin surface area, increasing the velocity of fluid . Because increasing the area of fins leads increase in total weight of the system. Duct of length 1500 mm and rectangular in cross section of 250 mm 200 mm, Ammeter, Voltmeter, digital temperature indicator are used for the investigation. For 8 mm fin spacing, under low voltages perforated fins gives almost same results as that of solid fins. Therefore solid fins can be replaced by perforated fins overall weight can be reduced. Results were compared with solid fins. Results showed that perforated fins give better results compared to solid fins for all velocities.
Muthuraja C S, Aravindkumar, Hanoca P, This study examined heat transfer enhancement from a vertical rectangular fin embedded with circular perforations under natural convection compared to the equivalent solid (non-perforated) fin. Fins as heat transfer enhancement devices have been quite common. The requirements of lightweight fins and economical, so the optimization of fin size is very important in fin’s design. Therefore, fins must be designed to achieve maximum heat removal with minimum material expenditure, taking into account experimental setup. Heat supplied: 20-220 W 2. Perforation shape: circular 3. Number of perforations: 52 (13 cross 4 array) 4. Diameter of perforation: 12mm 5. Length of heat sink and fin : 270mm 6. Width of the fin: 100mm 7. Diameter of heat sink: 50mm The 12 thermocouples were divided equally onto the 2 fins. The temperature drop along the length of the perforated fins was consistently higher than for the equivalent nonperforated fin. Heat transfer coefficient for circular perforated fin is higher than the non-perforated fin. It gives brief idea about heat transfer rate in perforated fins is greater as compared to non-perforated fins.
shangseng feng , meng shi , hongbinyan , shanyouning sun , feichen Li, tian jian Lu, This study for cross fin heat sink, the cold air is able to reach the entire short fin channel and formed an impinging flow towards channel end wall. Life, performance and reliability of electronic components decays sharply as the operation temperature is increased hence it is crucial to include appropriate thermal management solution in the electronic device from the above experimental analysis overall convective heat transfer coefficient increases, therefore rate of heat dissipation increases from the above experimental analysis overall convective heat transfer coefficient increases, therefore rate of heat dissipation increases.
Abbas J.Al Jessani, Hussein R.Al-Burgharbee, An experimental work is conducted for investigating the enhancement of heat transfer of cross fins with circular perforations. The heat transfer coefficient and temperature difference are obtained for different heat generations and at various perforation areas. An experimental and theoretical study of the thermal performance of finned heat sink is conducted. The heat transfer rates are assessed using different materials (i.e. aluminium, copper and mild steel) for the fins and at different perforations. The results show that having greater perforations enhanced the rate of heat transfer. The optimum total perforation area (i.e. number of perforation) was determined such that highest coefficient of heat transfer and lowest temperature differenceare obtained.

Gaurav Kamde, et. al Have done an experimental and computational investigation of forced convection analysis of plate circular pin fin heat sinks over vertical base. In this analysis three different fin spacing are considered such as 20, 23, 28 mm diameter of pin fins such as 6, 10, 15 mm. Numerical computations of the plate circular pin-fin heat sink on vertical base and provides physical insight into the flow and heat transfer characteristics in forced convection. The parameters such as

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fin spacing, fin density, heat input and Reynolds number has been varied to observe the variation of thermal performance of PFHS and PPFHS on vertical base. Limited experimentation is carried out to validate the numerical model. Numerical analysis is carried out to compare thermal performance of plate fin and plate pin fin heat sink under the condition of equal temperature difference between mean sink temperature and the ambient temperature. The effect of fin spacing, pin fin diameter and temperature difference between fin and surroundings on the forced convection heat transfer from vertical fin arrays were studied. The analysis have been carried out for the two type of heat sinks with three different spacing, three different pin diameters and five temperature differences.

Harshal Patil et. al, Have done experimental and numerical investigation of forced convection heat transfer in heat sink with rectangular plates on vertical base. The main objective of this experimental study is to evaluate and compare the rate of forced convection heat transfer enhancement of rectangular fin at different inclinations (0–60 with x-axis) with respect to different ranges of Re and heat flux. The variables for this study of forced convection are orientations of fins with various inclinations, heat fluxes and Re. Reynolds no varies from 4000 to 18000 in step of 4000 and heat in put at 50W, 80 W, 100 W and 125 W. The heat transfer coefficient increases with the rise of air velocity for all the configurations. The increase in the heat transfer coefficient is achieved at the fin inclination 30 for inline and 0 for staggered arrangement.

Kavita H. Dhanawade et. Al, Made an attempt of Thermal Analysis of Square and Circular Perforated Fin Arrays by Forced Convection. In this study, the effect of the various parameters like geometry, Reynolds number and friction factor on the heat transfer for the rectangular fins with square and circular perforation are investigated experimentally. The effects of perforation and Reynolds number on the heat transfer characteristics were determined. It is found that the most important parameter affecting the heat transfer is Reynolds number and secondly and geometry of perforation. The result shows that the Nusselt numbers of perforated fin arrays as well as solid fin arrays increases with increase in Reynolds number. And it is found that percentage improvement in Nu of Perforated fin arrays over solid fin array is found.

Pooja P. Shirjose, Worked on numerical investigation of elliptical and triangular perforated fins under forced convection. The size of the perforation for this work was considered as 6 mm. These fins were studied for different flow conditions characterized by Reynolds Number (Re = 21,000 to Re = 87,000). The numerical results were validated against the existing experimental data for the solid fins without any perforations, fins with square perforations and fins with circular perforations. Further, fins with elliptical and triangular perforations were investigated for the identical flow conditions. Based on the results comparison, in terms of Nusselt Number, the elliptical perforations on the fins provide better heat transfer rate. It is found that elliptical perforations give better performance and Nu of which is approx. equal to 200 and with circular perforations approx. = 185.

III. RELEVANCE

1. Results were compared with solid fins. Results showed that perforated fins give better results compared to solid fins for all velocities.
2. It gives brief idea about heat transfer rate in perforated fins is greater as compared to non-perforated fins.
3. From the above experimental analysis overall convective heat transfer coefficient increases, therefore rate of heat dissipation increases.
4. It gives brief idea about heat transfer rate in perforated fins is greater as compared to non-perforated fins.

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IV. MOTIVE

Longevity, performance and reliability of electronic components decays sharply as the operational temperature increases. Hence it is crucial to include approximate thermal management solution in the device .That's why our moto of the project is to increase the heat transfer rate, which can be done by using fins.so we are using cross arrangement of fins along with perforation to enhance the heat transfer rate and to increase the performance of the system i.e. effectiveness of the system.

V. CONCLUSION

The thermal analysis of solid and perforated rectangular cross plate heat sink is experimentally investigated in this study. In these study, the focus is more on increasing thermal performance of the traditional solid heat sink and study the effect of perforation on rectangular cross plate fin heat sink. In cross plate heat sink arrangement we got a proper temperature distribution among the plate and therefore we can achieve minimum temperature along the surface. It also gives smaller pressure drop along the heat sink in case of cross arrangement, which will increases the thermal performance of the system.

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