REVIEW OF HEAT TRANSFER ENHANCEMENT OF HEAT SINK USING PLATE AND PIN FINS

R. N. Mathul*, R. M. Kasekar**, N. P. Shevale**, S. R. Patil***
*Student of Mechanical Dept., PVPIT, Budhgaon
**Faculty of Mechanical Dept., RSIET, Pedhambe
*** Asst. Professor Mechanical Dept., PVPIT, Budhgaon

ABSTRACT

Heat sinks are widely employed in electronics industries for lowering the temperature to avoid any damage of integrated circuits and improve its overall performance. Fins play key role in heat sinks. The various geometrical aspects of the fin as well as material properties plays vital role in heat transfer rate. These properties should be optimized to obtain maximum possible thermal efficiency. Lot of researches are done by researchers to obtain the relation between various thermodynamic properties such as heat, temperature gradient due to ambient conditions. The heat transfer is enhanced by optimising the geometrical aspects of the heat sink. As the geometrical aspects have higher impact on overall results.

Keywords: *Heat sink, Fins, Aspect ratio, Material, Pressure drop, Direct and Indirect techniques, Convection.*

1. Introduction

The heat transfer through the heat sinks present in flow channel can be increased by employing modification in passive surfaces, such as extended surfaces with geometrical modifications. These techniques are having wide application such as cooling turbine aerofoil, electronic cooling systems, biomedical instruments, and heat exchangers. The pin fin technology is widely used in many applications such as computer mother board heat sink over microprocessor. In this study the pin fin is under consideration for enhancement of heat transfer rate.

Fig- 1 Heat exchanger used in INTEL microprocessor in computer

The heat transfer can be enhanced by following methods

I. Indirect techniques
II. Direct techniques

1.1 Indirect techniques

The passive technique mainly deals with surface modification by altering its geometries in flow passage to enhance the heat transfer by incorporating the inserts or fins. This modification alters the flow pattern over the geometry of surface to achieve maximum possible pressure drop for enhancing the heat transfer rate.

The passive techniques do not require any external power to enhance the heat transfer rate as of active techniques. The passive technique the extended surfaces are used to increase the heat transfer rate maintain maximum possible pressure gradient across the flow channel.

The extended surface mainly retards the flow rate of the fluid in channel and alters the flow pattern that ultimately leads to enhanced heat transfer rate. The direct techniques does not require any external agency to empower the heat transfer through the surface rather the surface alternation are done in various fashion such as geometrical modification, incorporating various inserts to alter the flow behaviour that leads to pressure drop across the channel for increasing the heat transfer. The following methods are employed for heat transfer by the means of indirect techniques:

I. Surface treatment: the alternation is made in the surface finish of the walls of heat exchanger such as heat sink. The surface are treated chemically or coated with another material in order to improve the heat transfer. This method is widely employed for boiling and condensing purposes.
II. Rough surface: these are the modification made on the surfaces to achieve turbulence in the flow near the surface of heat exchanger to improve heat transfer, without much increase in the surface area of contact between the fluid and the surface.
III. Extended surface: the modified development is going in surface to increase the fluid and wall contact area. This is achieved by adding more material to the surfaces known as fins, for enhancing the heat transfer.
IV. Displacement enhancement: for this method additional equipment are employed to increase the fluid flow rate over the surface in order to transport the heat energy from the heat exchanger surface at a rapid rate in order to enhance the heat transfer rate.
V. Swirl flow devices: these devices are employed to produce superimposed swirl flow on the axial flow of the channel. This type swirl flow is achieved by attaching inlet with helical strip, screw type tube insert, or twisted tapes.
VI. Coiled tube: this technique is used under space limitation, has compact size. The tube is arranged in helical coil shape. Due to its helical shape there is continuous change in the flow direction and increase in the flow friction near the wall, leading to higher pressure drop across the tube and hence the heat transfer coefficient increases.

1.2 Direct techniques

This technique is quit complicated as it requires external power input to achieve the desired modification in flow rate of fluid as well as the heat transfer rate. It is complicated to manufacture as well as design. It requires more space than indirect techniques due to various additional arrangements. As it require additional power so its implementation are limited.

This method can be implemented by any of the following methods:

I. Mechanical aids: additional instruments are used for stir the fluid or rotating the surface. This method includes rotating tube heat exchangers and mass exchanger.
II. Surface vibrations: this is employed to achieve higher heat transfer coefficient in single phase flow.
III. Fluid vibration: this is perhaps the most practical type of vibration enhancement technique. It is used for single phase fluid.
IV. Electrostatic fields: it is used in the heat exchanger involving di-electrical fluids.it can produce higher bulk mixing and induce forced convection or electro-magnetic pumping to increase the heat transfer in the heat exchanger.
V. Injection: in this method the heat transfer is increased by injecting the same fluid or another fluid in the main stream of flow depending upon the application. This can be done through porous heat transfer interface or up-steaming the heat transfer section.
VI. Suction: it is employed for the removal of vapour formed during the boiling through the porous heated interface in order to enhance the heat transfer. This method is employed to minimise the thermal resistance due formation of vapour near the heating surfaces.

2. Indirect techniques improved by different researchers.

Singh, B. Ubhi., et.al. [1], they have designed and analysed the heat transfer through fin extension in plate fins. They studied about various geometries such as rectangular, trapezium, triangular, and circular extensions in plate fins. The results showed that plate fin with extensions provided 5% to 13% more heat transfer than fin without extensions. The effectiveness of rectangular extension plate fin is more than the other types of extension.

S. R Pawar and R. B. Varasu [2], they have the heat transfer by natural convection from triangular notched fin array. They studied about different notch geometries such as fin without notch, fin with 20% notch with area compensation and fin with 40% notch with area compensation with respect to various parameters such as height, length, notch dimension, fin spacing and fin thickness. The studies showed that heat transfer coefficient is lower in notched fin as compared to without notch. There was 7% increase in heat transfer for 20% notched fin and 10% for 40% notch fin. The heat transfer increases with increase in notch size with area compensation.

U. S. Gawai, Mathew V. K. et.al. [3], they have done experimental investigation of heat transfer by pin fin. The results for single fin of aluminium and brass were studied for heat transfer. The results showed that the heat transfer coefficient and efficiency of aluminium fin was greater than the brass fin.

D. D. Palande and Walunj [4], they have done experimental analysis of incline narrow plate fins heat sink under natural convection. They have experimented on fins with respect to aspect ratio and different heater input wattage the result showed that natural convection heat transfer increases with heat input. The convective heat transfer increases with aspect ratio.

Hagote and Dahake [5], they have enhanced the natural convection heat transfer coefficient by using V- fin array. They analysed the V- fin using ANSYS CFX and experimentally. They used plate fins where the fins were arranged at an inclination of 60^o. The maximum convective heat transfer obtained was 600.

V. Karthikegn, Babu et.al. [6], they designed and analysed the natural convection heat transfer coefficient between rectangular fin array with extension and fin array without extension. The heat transfer through fin array with rectangular extension, circular extension, trapezoidal extension, triangular extension, 18mm perforation, 20 mm perforation, 22 mm perforation, 24 mm perforation were 27.32, 25.63, 25.62, 24.68, 23.82, 23.52, 22.97, 22.63 respectively. The fin array with rectangular extensions has minimum temperature at the end of fin array, when compared to fin array with rectangular extension, without extension and with perforation.

M. Reddy and G. Shivashankaran [7], they have done numerical simulation of forced convection heat transfer enhancement by porous pin fin in rectangular channel. They had studied about circular, long elliptical and short elliptical pin fin heat sink by varying inlet velocities i.e. 0.5m/s, 1m/s, 1.5m/s and 2m/s using ANSYS CFD fluent software. The result showed that the heat transfer efficiencies in porous pin fin are around 50% higher than solid pin fin.

M. Ali, Tabassum et.al. [8], they have performed thermal and hydraulic analysis of rectangular fin arrays with different perforation size and number. They have done experiment study by taking base area 1088 mm^2. They varied perforation from 0 to 2, and varied perforation diameter form 0mm to 3mm. The results showed that heat transfer and pressure drop increased with increase in Reynolds number for all fins. With experiments it was found that with more or larger perforations the efficiency and effectiveness increased, whereas the thermal resistance and pressure drop decreased.

K. Kumar, Vinay et.al. [9], they performed thermal and structural analysis of tree shaped fin array. They had taken tree shaped fin with slots and tree shaped fin without slots for their analysis. They also studied the effect of material on the results for the same geometries by taking aluminium alloy, structural steel and copper alloy for the same. The results obtained showed that the capabilities of the slotted tree fins are better than without slotted tree fins. According to material the copper fins with slots was best for heat transfer among all the fins. The aluminium slotted fin was found most effective as it has effective heat transfer without deformation among all the fins taken for the study.

V. Kumar and Bartaria [10], they have done experimental and CFD analysis of an elliptical pin fin heat sink using Ansys Fluent v.12.1. They have done the study by varying the dimension of elliptical pin fin i.e. by varying the cross-section area. The results showed that for all the velocities 2mm minor axis elliptical pin fin had better thermal resistance and pressure drop.

K. Dhanawade and Sunnapwar et.al. [11], they have done the thermal analysis of square and circular perforated fin array by forced convection. They have varied the size of perforation for the analysis i.e. 10mm square, 8mm square, and 6mm square and for circular perforation 10mm, 8mm, 6mm diameter. The result obtained showed that the Nusselt numbers increased with increase in Reynolds number, thermal friction increased with increase in perforation and use of perforated fin increase the heat transfer and also there is reduction in weight, saving of material that ultimately decreases the expenditure on fin material.

P. Chaitanya and G. Rao [12], they have done the transient thermal analysis of drop shaped pin fin array using CFD. They have done the comparative study between circular shape pin fin and drop shaped pin fin. The results showed that the heat transfer increased due to increase in contact surface area between fluid and the fin. There was increase in the pressure drop for drop shaped pin fins compared to circular pin fins.

H. Dange and Patil [13], they have done the experimental and CFD analysis for heat transfer on elliptical fin by forced convection. They have done the analysis by varying the velocity. The results showed that the heat transfer coefficient increases with increase in velocity of fluid.

Junaidi, Ansari et.al. [14], they have done thermal analysis of splayed pin fin heat sink. They have done CFD analysis using ANSYS Fluent 12.1 with different angle (i.e. 4 degree, 5 degree, 6 degree and 7 degree) of inclination of pin fin with respect to base plate. The heat transfer during natural convection is more in splayed pin fin structure. The splayed pin fin provides better air turbulence.

Dhumne and Farkade [15], they have done heat transfer analysis of cylindrical perforated fins in staggered arrangement. The perforated fins of different sizes were used for the analysis. The results showed that nusselt number increases with decrease in clearance ratio and inter fin spacing. The friction factor increases with decrease in inter fin spacing.

3. Conclusion

From the literature survey following conclusions are made:-

1. The orientation and geometry of the fin plays vital role in enhancement of heat transfer rate in heat exchanger.
2. The heat transfer can be enhanced by improving the fluid to fin contact area. The efficiency of heat exchanger can be improved by increasing the contact surface area.
3. The space between the fins in array should be optimized for enhancing the heat transfer rate.
4. The thermal conductivity of the fin material and convective coefficient of fluid should be as better for enhancement of heat transfer.
5. The Reynolds number of the flowing fluid is directly proportional to the rate of heat transfer source (fin) to the sink (fluid).
6. The heat transfer rate increases with increase in fluid turbulence over the fin.
7. The heat transfer increases with increase in pressure drop across the channel of fluid flow over the fin.

4. References

1) P. Singh, H. Lal, B. S. Ubhi, "Design and Analysis for Heat Transfer Through Fin with Extensions", International Journal of Innovative Research in Science, Engineering and Technology, Vol.3, Issue 5, May 2014.
2) Sachin R. Pawar, R. Yadav, "Computational Analysis of Heat Transfer by Natural Convection from Triangular Notched Fin Array", IJST- International Journal of Science Technology & Engineering, Vol-1, Issue 10, April 2015.
3) U. S. Gawai, Mathew V. K., Murtuza S. D., "Experimental Investigation Of Heat Transfer By Pin Fin", International Journal Of Engineering And Innovative Technology (IJEIT), Vol-2, Issue 7, January 2013.
4) A. A. Walunj, D. D. Palande, "Experimental Analysis Of Inclined Narrow Plate- Fins Heat Sink Under Natural Convection", IPASJ International Journal Of Mechanical Engineering(IIJME), Vol. 2, Issue- 6, June 2014.
5) R. Hagote, S. K. Dahake, "Enhancement Of Natural Convection Heat Transfer Coefficient By Using V- Fin Array", International Journal Of Engineering Research And General Science, Vol-3, Issue-2, April 2015.
6) V. Karthikeyan, R. Suresh Babu, G. Vignesh Kumar, "Design and Analysis of Natural Convective Heat Transfer Coefficient Comparison between Rectangular Fin Array with Perforated and Fin Arrays with Extension", International Journal of Science, Engineering and Technology Research (IJSETR), Vol-4, Issue-2, February 2015.
7) M. Reddy, G. S. Shivanshankar, "Numerical Simulation of Forced Convection Heat Transfer Enhancement by Porous Pin Fins In Rectangular Channels", International Journal of Mechanical Engineering and Technology (IJMET), Vol-5, Issue- 7, July 2014.
8) M. Ehteshum, M. Ali, M. Tabassum, "Thermal and Hydraulic Performance Analysis of Rectangular Fin Arrays With Perforation Size and Number". 6th BSE International Conference On Thermal Engineering (ICTE 2014), Procedia Engineering

9) K. Kumar, P. Vinay, R. Siddhardha, “Thermal and Structural Analysis of Tree Shaped Fin Array”, Int. Journal of Engineering Research and Applications”, Vol-3, Issue- 6, Dec 2013.
10) V. Kumar, Dr. V. N. Bartaria, “CFD Analysis of an Elliptical Pin Fin Heat Sink Using Ansys Fluent V12.1”, International Journal of Modern Engineering Research (IJMER), Vol-3, Issue 2, April 2013.
11) K. Dhanawade, V. Sunnapwar, “Thermal Analysis of Square and Circular Perforated Fin Arrays by Forced Convection”, International Journal of Current Engineering and Technology, Special Issue-2, February 2014.
12) K. Chaitanya, G. V. Rao, “Transient Thermal Analysis Of Drop Shaped Pin Fin Array By Using CFD”, International Journal Of Mechanical Engineering And Computer Applications, Vol-2, Issue 6, Dec 2014.
13) R. Patil, H. M. Dange, “Experimental and Computational Fluid Dynamics Heat Transfer Analysis on Elliptical Fin by Forced Convection”, International Journal of Engineering Research & Technology (IJERT), Vol-2, Issue-8, August 2013.
14) Md. Abdul Reheem Junaidi, R. Rao, S. Sadaq, M. Ansari, Thermal Analysis Of Splayed Pin Fin Heat Sink, International Journal Of Modern Communication Technology & Research (IJMCTR), Vol-4, Issue-4, April 2014.
15) Amol Dhummne, H. Farkade, Heat Transfer Analysis Of Cylindrical Perforated Fins In Staggered Arrangement, International Journal Of Innovative Technology And Exploring Engineering (IJITEE), Vol-2, Issue-5, April 2013.