Analysis and Optimization of Heat Sink Which Used For Electronics Component Cooling – Review

Y Nandakishora[1], Nandyala Maheswra Reddy[2], Bathula Anjaiah[3], Gujarlamudi Prakash[4], Shaik Apsar[5], Kaja Venkata Radhakrishna[6]
Department of Mechanical Engineering
[1]Faculty, QIS College of Engineering and Technology, Ongole, Andhra Pradesh, India
[2,3,4,5,6] Students,QIS College of Engineering and Technology, Ongole, Andhra Pradesh, India

Abstract-*Due to the passage of current, the electronic components generate heat during the course of their operation. The main objective is to cool the electronic component by removing the heat generated in order to ensure the optimal working of the component heat sink is necessary. Therefore new heat sinks with large surfaces exposed to heat transfer and highly conductive materials are used to reduce the hot spots. In this paper is explains importance of some design factors while designing of heat such that thermal conductivity of fin material, ratio of the perimeter to the cross-sectional area of the fin, shape of the fine, length of the fine, area exposed to convection heat transfer, velocity of air, quantity of air (mass flow around the fines), low pressure drop, high heat transfer coefficient, lowest maximum temperature attained and ambient temperature. Out of six different shapes of fins, namely rectangle, trapezoidal, rectangular interrupted, square, circular inline and staggered, maximum heat transfer occurred in circular pin fin because Nusslet number is also maximum for circular pin fin design.*

Keywords-heat sink, convection heat transfer, heat flux and Nusselt number

I. INTRODUCTION

All electronic equipment performs is relies on the flow of and control of electrical current. When electrical current flows through electronics components heat is generated due to resistance. Concerning the suitable operation of the electronics heat dissipation is most important to get the good performance of the components and also reduce the power consumption. The designing of heat dissipation system is one of the most critical aspects to be considered when designing an electronic enclosure. Heat generation is an irreversible process and heat must be removed in order to maintain good performance of components and to continuous operation. Normally pure conduction, natural convection or radiation cool the components to some extend whereas today electronic devices need more powerful cooling system to obtain improved performance[2]. Extended surfaces or fins are commonly found on electronic components ranging from power supplies to transformers. The dissipation and subsequent rejection of potentially destructive self-produced heat is an important aspect of electronic equipment design. The dissipation of heat is necessary for its proper function. The heat is generated by the resistance encountered by electric current. Unless proper cooling arrangement is designed, the operating temperature exceeds permissible limit [11]. As a consequence, chances of failure get increased. In order to design an effective heat sink, some criterions such as a large heat transfer rate, a low pressure drop, high heat transfer coefficient, lowest maximum temperature attained, high surface Nusselt number, low thermal resistance, an easier manufacturing, a simpler structure, a reasonable cost and so on should be considered. Aluminum is also cheap to produce and is lightweight. When a heat sink is attached, its weight puts a certain level of stress on the motherboard, which the motherboard is designed to accommodate. Yet the lightweight make up of aluminum is beneficial because it adds little weight and stress to the motherboard [5]. The function of heat sink to dissipates heat from another object using thermal contact (either direct or radiant). Heat sinks are used in a wide range of applications wherever efficient heat dissipation is required, major examples include refrigeration, heat engines, cooling electronic devices and lasers. Heat sink performance (including free convection, forced convection, liquid cooled, and any combination thereof) is a function of material, geometry, and overall surface heat transfer coefficient. Generally in forced convection heat sinks thermal performance is improved by increasing the thermal conductivity of the heat sink materials, increasing the surface area (usually by adding extended surfaces, such as fins or foam metal) and by increasing the overall area heat transfer coefficient (usually by increase fluid velocity, such as adding fans, pumps, etc.[3].

II. LITERATURE REVIEW

MD. Safayet Hossain[4] is studied about temperature distribution and heat flux through various fin surfaces. In this steady state heat transfer was discussed and the sole purpose of this study is to analyze temperature distribution and heat flux of flared fin and rectangular fin profiles. Heat transfer distribution through rectangular and flared profiles was observed. In addition to that, heat flux distribution was also analyzed. The simulation was done by using finite element method based solver. Besides, for the meshing process, in order to conclude numerical analysis, ANSYS meshing utility has been used. From the simulation the following decision can be considered:

With the increase in thermal conductivity of fin material, temperature distribution is increased.The ratio of the perimeter to the cross-sectional area of the fin should be as high as possible to increase the heat transfer.

Jeehoon Choi[6] studied the performance of active CPU cooling heatsinks primarily depends on the forced air convection created by computer fans. Boosting the fan speed, however, results in noise, vibration problems, and increased power consumption. The active heatsink, therefore, should be optimized under the constraints of overall volume, cost, and noise level. In this paper, a new CPU cooler is proposed that provides a more efficient heat dissipation capacity from the CPU to a finned heat sink without adding more heat pipes at a low noise level of a small fan under the confined space constraints of a computer chassis. On the basis of the tunnel shape of the existing CPU cooler, the new cooler was designed to position the fan in the center of two finned heatsinks combined with heat pipes bent in an “U” shape. Airflow is then forced through the fins of one heatsink and exhausted from the fins of the other heatsink. On the basis of the CFD simulation results, it was expected that the CPU cooler employing this new design could effectively cool CPUs because all the heat pipes combined with the two finned heatsinks performed well. The new design satisfies all requirements, namely, enhanced cooling capacity, confined size, low cost, and low-noise level.

R.Mohan[12] worked on the CPU cooling performances of a computer chassis with rectangular, pin fin heat sinks with varying thickness and carbon composite heat sinks were investigated and the results were compared. The heat sink temperature difference results have been compared with an experimental result to find out best heat sink designs. The number of fins, the fin profiles, fin thickness and the base plate thickness were investigated for enhancing the heat dissipation rate from CPU, and some thermal improvements as well as space reduction and material savings were attained. In the current study, it is observed that stacking too many fins is not a solution for decreasing the hot spots on the heat sink since they may prevent the passage of air coming from the fan to the hottest Centre parts of the heat sink. It was shown that the improvements on heat sink designs are possible with the help of CFD. In this study, different thickness of heat sinks with base plates are selected and analyzed. From which the optimal design of heat sink is selected which gives more heat transfer rate. If base plate material is selected to be copper rather than aluminum, then the thermal resistance of the heat sink decreases as expected.

Piyush Laad[11] studied the effect of the pin-fin shapes on the overall performance of the heat sink with inline and staggered arrangement. Six different shapes of fins rectangle, trapezoidal, rectangular interrupted, square, circular inline and staggered are subjected to study in this paper.

The optimization processes are carried out using computer simulations performed using Ansys workbench 14.0. It is observed from the results that optimum cooling is achieved by the heat sink design which contains Circular pin fins. After the selection of proper heat sink by CFD simulations the steady state thermal performance is carried out at different fin height of circular pin fin heat sink. The result shows that the temperature is increasing by decreasing the fin height and the value of Nusslet number is also maximum for circular pin fin design MATERIAL SELECTED FOR HEAT SINK Aluminum alloy 6063 is a medium strength alloy commonly referred to as an architectural alloy. It is normally used in intricate extrusions.

P. Ravichandran[9] did experimental study of heat sink and also he plotted the temperature distribution over the heat sink. He studied two different types of model namely Flat edged fins and Limited length fins. Temperature and heat flux for the design having features such as sharp edged fins and increased length of. Thus the analysis is done for two different designs using ANSYS. From this analysis, as the area increases, the rate of heat dissipation increases. Also by future designing sharp points in heat sink future rate of heat dissipation increase. Thus an optimum design is obtained to increase the life of the mother board. Also by designing cooling tubes future heat dissipation also increase. Hence all these three features such as increasing the area of fins along length wise, design of sharp points, design of cooling tubes are combined. From the above results these conditions have been designed and analyzed and verified.

Deepak Gupta [8] studied the heat transfer in the CPU which includes PCB, Heat Source and Heat Sink such as cylindrical pin fins i.e. 100 pin fins. This geometry was created in catia and then imported to ANSYS-Fluent in its format. From his study, he conclude that total Heat Transfer rate of rectangular plates fins is greater than cylindrical pin fins with applying same dimensions and boundaries condition.

Ambeprasad.S.Kushwaha [5] studied about heat sink having fins of various profiles namely Rectangular, Trapezoidal and Parabolic as heat sinks are the commonly used devices for enhancing heat transfer in electronic components. For the purpose of study heat sink is modeled by using the optimal geometric parameter such as fin height, fin thickness, base height, fin pitch as 48 mm, 1.6 mm, 8mm, 2mm and after that simulation is done at different heat load of 50W, 75W, 100W and with a air flow at 15CFM and air inlet temperature is taken as 295 K. The simulation is carried out with a commercial package provided by fluent incorporation. Heat transfer coefficient and surface Nusselt number is Maximum in Trapezoidal heat sink for all the fin pitch and for different heat loads of 50W, 75W, 100W. As per the criterion for the selection of heat sink, the heat sink should have lowest thermal resistance and maximum heat transfer coefficient. The Trapezoidal Heat sink shows the lowest thermal resistance and the maximum heat transfer coefficient. From the calculated values we can find that the best configuration for this type of convective heat transfer of a heated sink is a heat sink with TRAPEZOIDAL fin with a fin pitch of 2mm as they have the highest total heat transfer rate as it has the lowest maximum temperature attained compared to other, lowest thermal resistance best surface Nusselt number along with highest surface heat transfer coefficient for a given heat load of 50W, 75W, 100W.Power S P [3] was worked on design of a heat sink using metal device with many fins. The high thermal conductivity of the metal combined with its large surface area (fins). The fins result in the rapid transfer of thermal energy to the surrounding cooler air. This cools the heat sink and whatever it is in direct thermal contact with. Use of fluids (for example coolants in refrigeration) and thermal interface material (in cooling electronic devices) ensures good transfer of thermal energy to the heat sink. Similarly a fan may improve the transfer of thermal energy from the heat sink to the air by moving cooler air between the fins.

S rangadinesh[1] designed and developed a shoe-brush-shaped fin, it consisting of a single bunch of splayed metal wires of circular cross-section from copper base plate. The fin was fabricated and its heat transfer characteristics were studied through experiments and numerical simulation. Fabrication was done through sand casting and the product was machined for required dimensions and surface finish. Numerical studies were done using ANSYS Fluent 3D. It can be inferred from the experiments and numerical studies that the fabricated fin maintains a lower base plate temperature than the rectangular flat fin and cylindrical pin fin for the same heat transfer rate, material and exposed area.

III. CONCLUSION

From the above study can conclude that to improve the performance of the electronics device also to save the energy consumption, controlling of heat rising is necessary. Fin is the commonly used to dissipate heat from the devices and heat is transfer by conduction, convection (free or forced) and by radiation. Forced convection is more popularly used in the electronics device to increase the heat transfer. Fin performance can be varied under various circumstances like, length of fin profile, coefficient of thermal conductivity, ambient temperature etc. But in general fin performance depends upon the length of the cross-sectional area of selected fin profile. In case of flared fins, it was observed that, different temperatures were obtained at different tips. From the above study it will clear that area exposed to convection heat transfer is increased, effectiveness of fines also increases. Heat transfer is mostly depends on thermal conductivity of fin material and the ratio of the perimeter to the cross-sectional area of the fin should be as high as possible to increase the heat transfer. The number of fins, the fin profiles, fin thickness and the base plate thickness were investigated for enhancing the heat dissipation rate from CPU. Out of six different shapes of fins, namely rectangle, trapezoidal, rectangular interrupted, square, circular inline and staggered, maximum heat transfer occurred in circular pin fin because Nusslet number is also maximum for circular pin fin design. Compared with circular and Trapezoidal fin with a fin pitch of 2mm, Trapezoidal fin have the highest total heat transfer rate as it has the lowest maximum temperature attained compared. By analyzing shoe-brush-shaped fin it consisting of a single bunch of splayed metal wires of circular cross-section, this will increase the area exposed to convection heat transfer but at the base of brush temperature is more and it having small area to conduction.

REFERENCES

[1] S. Rangadinesh, M. Rajasekar, S. Arunkumar and M. Venkatesan " Experimental and numerical analysis on heat transfer characteristics of shoe brush-shaped fins" current science, vol. 106, no. 1414 10, 25 May 2014.

[2] Prashant Rathod , Hanoca P " Numerical Analysis Of Heat Dissipation Of Rectangular Heat Sink Under Natural Convection With Orientation Effects" International Journal of Advance Research In Science And Engineering IJARSE, Vol. No.4, Special Issue (01), April 2015

[3] Pawar S P, Prof. Ghuge N C, Palande D D " Review-Design and Analysis of Heat Sink Optimization and its Comparison with Commercially Available Heat Sink" International Journal of Application or Innovation in Engineering & Management Volume 4, Issue 8, August 2015

[4] M D Safayet Hossain , Muhammad Ferdous Raiyan , Samantha Sayeed , J U Ahamed "Analysis of Thermal Characteristics of Flared and Rectangular Fin Profiles by Using Finite Element Method" IOSR Journal of Mechanical and Civil Engineering, Volume 12, Issue 5 Ver. II (Sep. - Oct. 2015), PP 58-67

[5] Ambeprasad S Kushwaha , Ravindra Kirar "Comparative Study of Rectangular, Trapezoidal and Parabolic Shaped Finned Heat sink" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Volume 5, Issue 6 (Mar. - Apr. 2013), PP 01-07

[6] Jeehoon Choi, Minjoong Jeong , Junghyun Yoo , Minwhan Seo " A new CPU cooler design based on an active cooling heatsink combined with heat pipes" Applied Thermal Engineering 44 (2012) 50-56

[7] Prasad P.Kadam Sanjay H. Godse Ravikiran S. Patil Priyanka M. Patil Priyanka P Shendage and Prasad D. Kulkarni "numerical analysis and simulation of conjugate heat transfer study of electronic circuit board" novateur publications International journal of innovations in engineering research and technology volume 2, issue 5, may-2015

[8] Deepak Gupta, Vignesh Venkataraman, Rakesh Nimje "CFD and Thermal analysis of heat sink and its application in CPU" International Journal of Emerging Technology and Advanced Engineering,Volume 4, Issue 8, August 2014)

[9] P Ravichandran , L C Gokul "Thermal Analysis of Heat Sink in CPU with Varying Fin Designs" Engineering and Technology 2016 Volume 2.

[10] C H Liang , S. Zeng , Z. X. Li , D. G. Yang and S. A. Sherif "Optimal Design of Plate-Fin Heat Sink under Natural Convection Using a Particle Swarm Optimization Algorithm" international journal of heat and technology Vol. 34, No. 2, June 2016, pp. 275-280.

[11] Piyush Laad, Bhushan Akhare, Praveen Chaurasia "thermal analysis of heat sink with fins of different configuration using ansys workbench 14.0" International journal of engineering sciences & research technology 5.(6): June, 2016

[12] R.Mohan and Dr.P.Govindarajan" Thermal Analysis of CPU with variable Heat Sink Base Plate Thickness using CFD" International Journal of the Computer, the Internet and Management, Vol. 18 No.1 (January-April, 2010), pp 27-36