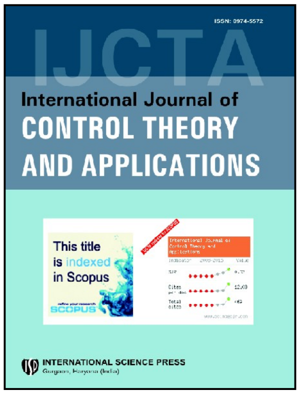

International Journal of Control Theory and Applications

ISSN : 0974-5572

© International Science Press

Volume 10 • Number 21 • 2017

Thermal Analysis on Electronic Devices Cooling heat sinks using Icepak software

B Nageswara Rao[1], Vedulla Manoj Kumar[2], D. Vinay Kumar[3], Sk. Farooq[3] and K. S. Raghavan[3]

[1] Department of Mechanical Engineering, Associate Professor, VFSTR University, Guntur-522213, AP, India
[2] PhD Scholar,Department of Mechanical Engineering Yuan Ze University, Taoyuan- 32003, Taiwan
[3] Department of Mechanical Engineering, VFSTR University, Guntur-522213, AP, India
Correspondence author E-mail: nag4mech@gmail.com

Abstract: Heat sink constitutes geometrically simple structure but to find out the accurate fluid flow path pose enormous difficulty to attempt to perform thermal analysis. These are used in a wide range of applications wherever efficient heat dissipation is required, major examples are Cooling electronic devices like microprocessors, DSPs, GSPs, Refrigeration, and lasers. This work is concerned with the comparative study of taper pin fins heat sink with Rectangular pin fins heat sink using the commercial CFD software Icepack. The heat sink is made from aluminum and air is used as the cooling fluid and a constant heat flux of 100 W/cm^{2}from bottom and flow velocity of 2m/s. The observed results are satisfactorily good.

Keywords: Heat sink, Thermal Analysis, Icepack, Taper pin fins, Rectangular pin fins.

1. INTRODUCTION

The performance of heat sink includes various modes of heat dissipation (i.e convection mode, cooling by liquids or combination mode). This has great relationship with the type of material, physical shape and combined heat transfer constant. Normally in artificial convection, the heat sink performance can be improved with an increase of heat conductivity, addition of extended surfaces, also by improving the combined heat transfer constant and increasing flow velocity using fans or blowers.

In realistic electronic applications the metallic plate brought in touch with the hot surface of electronic device. Even though the majority applications are designed in such a way that the negligible thickness diathermic established in between two surfaces. Mostly semiconductors and microprocessors needs a thermal sink to decrease the temperature need a heat sink to reduce their temperature and increases the heat energy or dissipation of heat quantity (i.e including all the three modes of heat transfer) against Reynolds number. Colban et.al [2] performed the simulations and compared heat removal performance of staggered type and inline arrangement. Authors noticed that for a given flow velocity, inline scattered configuration resulted lesser convection coefficients and friction coefficients than staggered. But in it's performance , no such considerable variation was observed between inline scattered configuration and staggered arrangement. The comparison was made based on either steady flow of drop in pressure or power in put however the channel shape and element were not changed. Therefore the influence of those parameters in their results not reported. Satyamurty *et al.* [3] focused on Staggered arrangement and inline scattered configurations in both analytical and experimentation methods. The authors found that a good coincidence between experimentation results and analytical results. It was examined for different flow velocities and power inputs and reported that staggered geometry results are much better than flat fin geometry. For the cost of extra pressure drop, the improvement in the performance of heat dissipation was observed. Ozturk and Tari (2008) have investigated inside of the chasis about the temperature and flow fields and also they analyzed the commercial heat sink designs of it's three kinds using CFD. The obstruction of flow in the chassis resulting air circulation that affect the temperature distribution of heat sink which are studied briefly [4].Vedulla Manoj Kumar et al. [5,6] presented review articles about electronic cooling i.e., how to eliminate heat from inside to ambient and the future needs in the field of electronics. Carlos A. Rubio-Jimenez et.al [7] has proposed a distinct micro fin heat sink geometry with variable density of pin fin .This configuration suggests an optimal cooling system which is capable of removal of high heat fluxes with a less drop in pressure and without altering the temperature at it's junction. After the analysis, in 2016 Vedulla Manoj Kumar et. al [8] addressed about different geometries of pin fin heat sinks, which reduces the heat resistance to a greater extent. Lot of research articles were available regarding the cooling of electronic chips, out of their analysis a few were numerical analysis remaining were experimental results. How ever the implementation is at elementary level. Understanding the fluid flow behavior and heat transfer characteristics of heat sins was a tough one to some extent there fore it has turned up as an obstacle for implementation. Therefore the knowledge of fluid flow analysis and het transfer behavior is very much important to establish a viable cooling heat sink. BarCohen et.al, [9-13] observed and reported regarding flat fin or pin fin geometries of suitable numerical design of forced convection heat sinks. They emphasized more on transition path and taken in to account of usage of energy at every stage including heat sink manufacturing, to arrive "optimization of less energy".

2. METHODOLOGY

In pinfin heat sinks, pinfins are arranged in either inline or staggered way as represented in Figs. 1. The fins are attached to it's base and the geometry of the array is computized by the dimensions, number and arrangement of the fins. In this work, a total of 35 fins of height of 36mm for taper and plate pin fins heat sink is considered. Fig. 1 shows a figure of this heat sink.

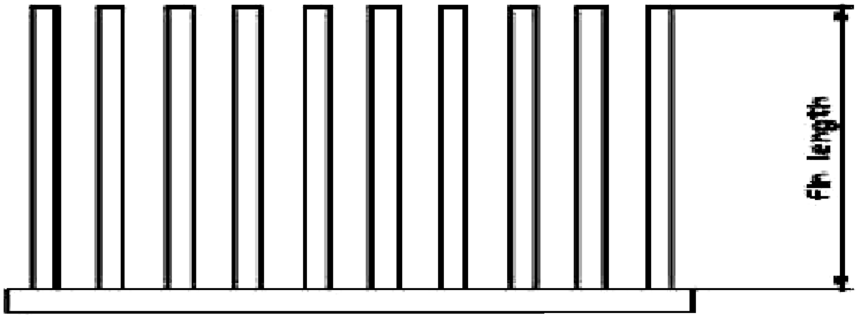

Figure 1: Schematic diagram of Rectangular pin fins heat sink

2.1. Generation of mesh and boundary condition

In the taken model the generated mesh was by consideration of uniform distribution with an approximation of half a million hexahedral elements, excluding the fin walls in section near to the base where a cell ratio of 1.025

was considered. The generated mesh is fitted to the fin shape. In order to obtain the suitable number of elements for realizing the good results, the optimal sensibility analysis was carried out.

The Boundary Conditions for the models were altered according to the interaction of the fluid with the surrounding environment. Velocity is given at the inlet section of the fluid modal i.e., 2m/s. At the bottom surface of the fin plate the fixed heat flux of $100 W/m^2$ applied on the base surface of the solid domain. at the fluid outlet section, the assumed static pressure is zero. For both the domains symmetry conditions are applied at the symmetry walls. The interface conditions set between the domains of the walls. The fins and upper wall channels set under adiabatic conditions.

3. USING CONVECTION RELATION

Innumerable ways to improve the performance of a heat sink. In the current work the emphasism made on parameters like temperature, Velocity and pressure distribution of both taper and rectangular plate fin heat sinks. The convective heat transfer coefficient mostly depends on Nusselt number. The relation between convective heat transfer coefficient and Nusselt number indicates as follows

$h - Nu K_{air} / L$ Where

L-is Characteristic length k_{fluid}-Thermal conductivity of the fluid, h-Convective heat transfer coefficient.

4. RESULTS ANALYSIS

After conducting innumerable simulation iterations by ice pack and the results were represented in order to know the thermal resistance, heat transfer coefficient, Nusselt number, Reynolds number and mass flow rate on the temperature distribution in the different geometriesofpin fin heatsinks.

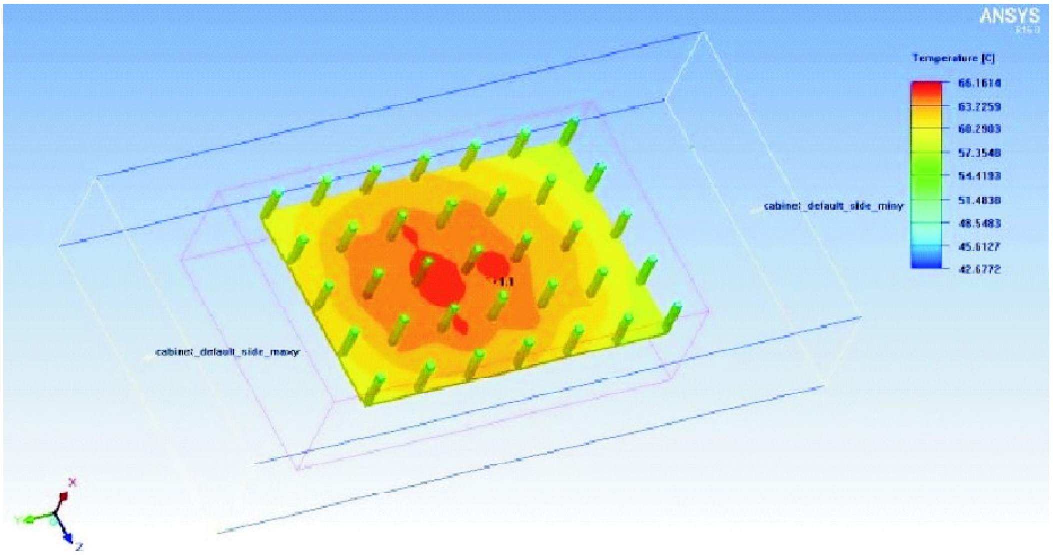

Figure 2: Temperature distribution of Rectangular pin fin heat sink

From figure 2 we have observed that the temperature distribution along the length of the Rectangular pin3 fins heat sink. The maximum temperature is occurred at center of heat sink and the minimum temperature is at edge of pin fin heat sink.

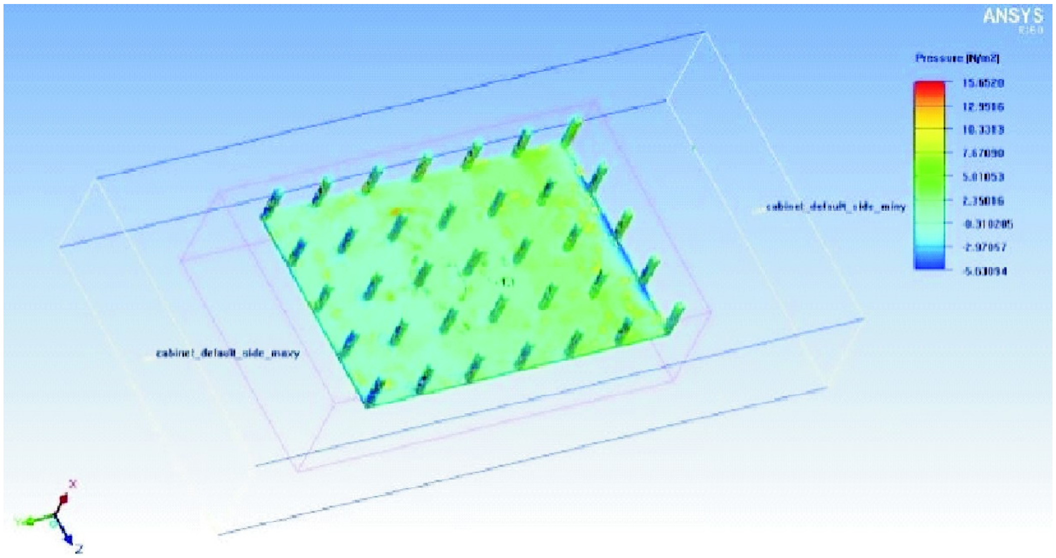

Figure 3: Pressure distribution of Rectangular pin fin heat sink

The pressure distribution of the Rectangular pin fins heat sink has maximum at inlet and minimum at outlet and the distribution of pressure we can see by giving boundary conditions and by clicking run solution.

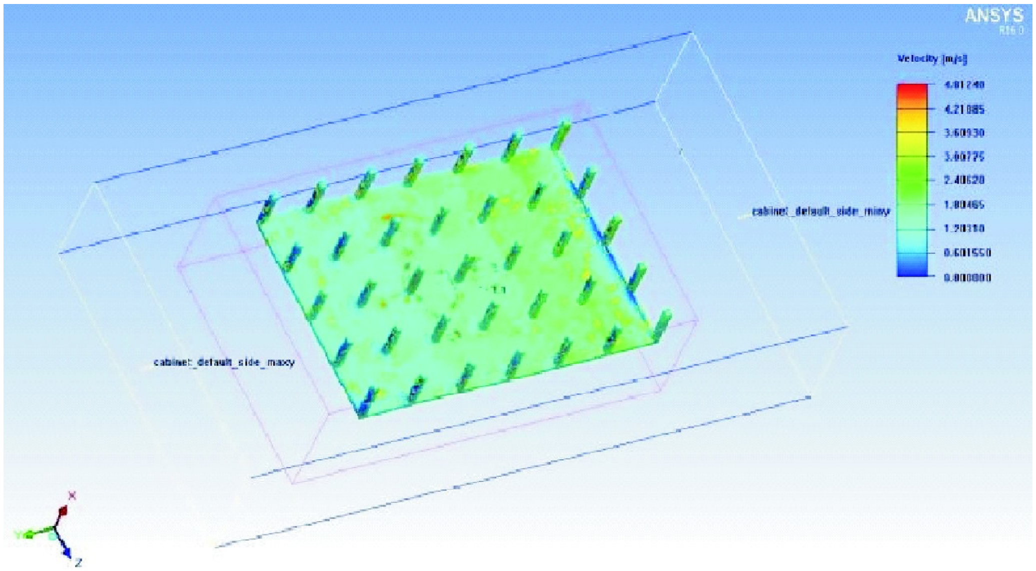

Figure 4: Velocity distribution of Rectangular pin fin heat sink

The typical figure of pin fins heat sink shows us velocity distribution from inlet section to outlet section, Here the flow is taking place from one side to other side with more uniform distribution and this velocity is maximum at entry position and minimum at exit position which is shown by red and blue colors respectively.

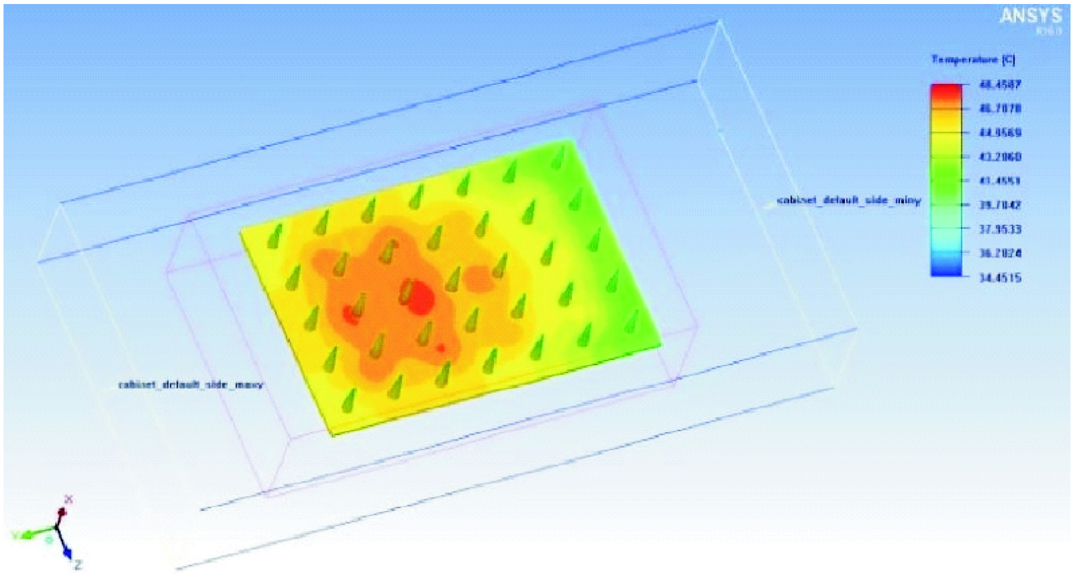

Figure 5: Temperature distribution of taper pin fin heat sink

From figure (5) we have observed that the temperature distribution along the length of the taper pin fins heat sink. The maximum temperature is occurred at center of heat sink and the minimum temperature is at edge of plate pin fin heat sink

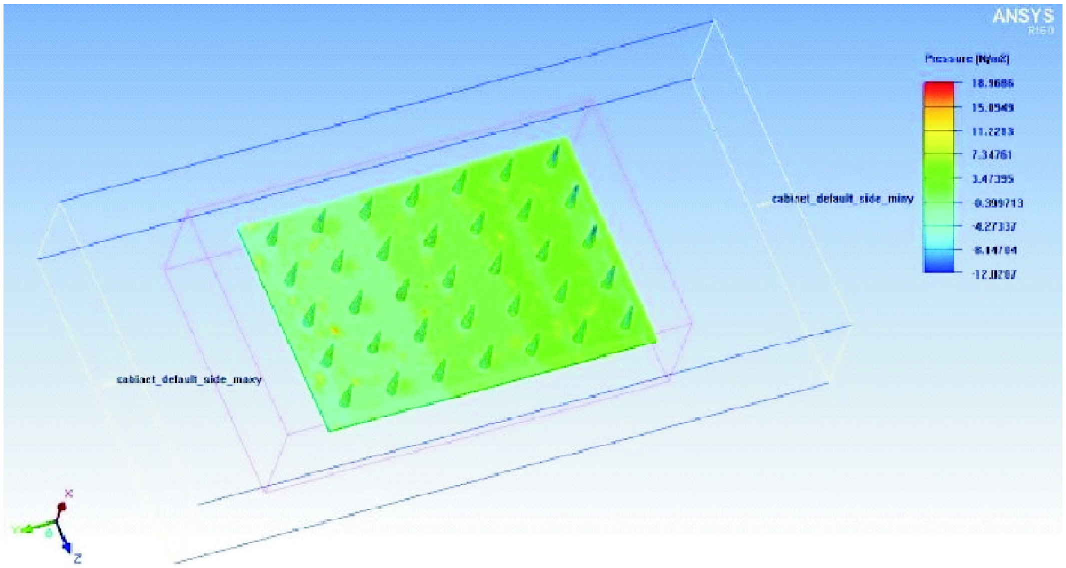

Figure 6: Pr essure distribution of taper pin fin heat sink

The pressure distribution of tap er pin fins heat sink is shown in above figure which is maximum and minimum positions at inlet and outlet respectively . In electronics we are trying to reduce the pressure drop so that uniformity had been taken place.

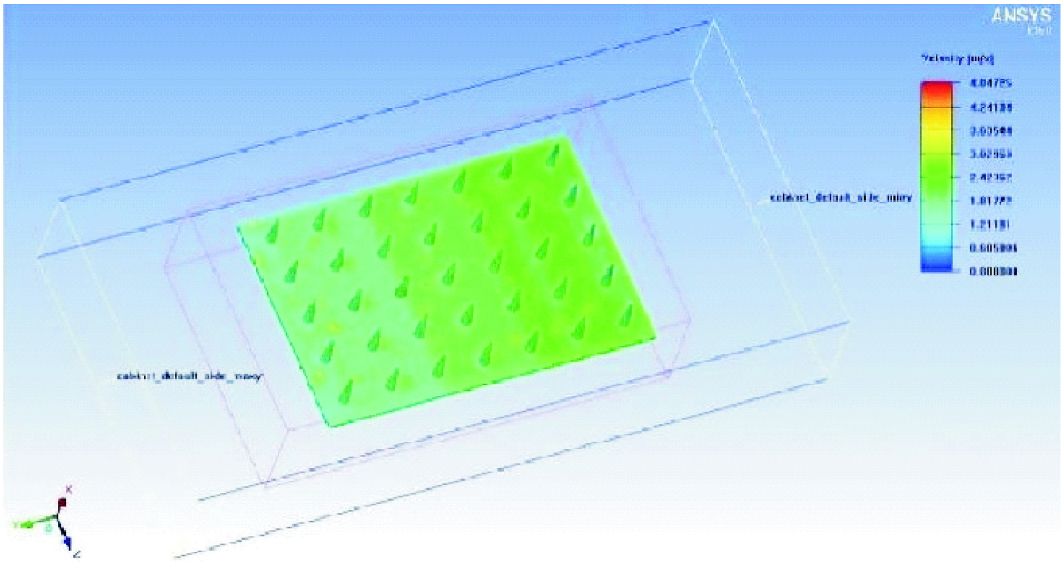

Figure 7: Velocity distribution of taper pin fin heat sink

From the figure (7) we observed that the velocity distribution and we can see how the flow of velocity will be taken place. To get the more amount of heat transfer per unit area we should concentrate about velocity configuration and fluid flow that has been shown in above figure.

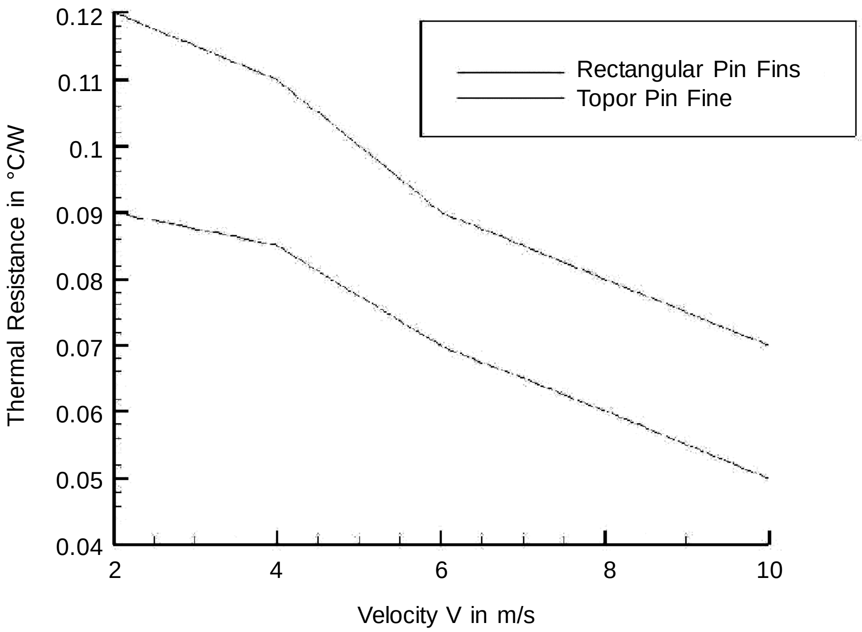

Figure 8: Graph between taper pin fin heat sink and Rectangular pin fin heat sink

The graph showed that the various types of pin fin geometries, this analysis investigated that the taper pin fins heat sink gives the better solution for electronics packaging compared with Rectangular pin fins because it has got very less temperature thermal resistance

5. CONCLUSION

The most of the electronic applications facing challenge about removal of excess heat generated. Here we considered different geometries of pin fins heat sink those are rectangular, cylindrical an d taper in both inline and staggered arrangements. A compariso n was made for different geometries of pin fins heat sink by using Ansys ice pack 16.0. From this analysis it is o bserved that for taper pin fins geometry performe d better than rectangular geometries with the thermal resistance is of 0.09^0C/W at 2 m/s velocity. From this analysis it is concluded that taper geometries performed better heat sink characteristics than rectangular geometries. Lastly, th is study clearly shows that the low thermal resistance and rectangu lar geometries of pin fin heat sink.

A 3D Mathematical model developed u sing Navier stokes equations of motion which is capa ble of predicting correctly the fluid flow and heat transfer characteristics in the heat sink. The developed model was v alidated while taking into the consideration of available literature reports.

At the end, the ultimate interest in the pin fin heat sinks, which were evident by the d ata available after series of studies, eventually it leads to conclu ded that research in this area will give us optimized solution in this decade for cooling of electronic devices.

ACKNOWLEDGMENT

We would like to thank the Department of Applied and Mechanical Engineering of VFSTR University and Computation Plasma Research Group, Yuan Ze University, Taoyuan County, Taiwan for their valuable support.

REFERENCES

[1] A. Bejan and A. M. Morega, “Optimal Arrays of Pin Fins and Plate Fins in Laminar Forced Convection,” Transactions of the ASME, Journal of Heat Transfer, Vol. 115, pp. 75-81, February 1993.

[2] R. A. Wirtz and D. M. Colban, “Comparison of the Cooling Performance of Staggered and In- Line Arrays of Electronic Packages,” Transactions of the ASME, Journal of Electronic Packaging, Vol. 118, No. 1, pp. 27-30, March 1996.

[3] P. Sathyamurthy, P.W. Runstadler, and S. Lee, “Numerical and Experimental Evaluation of Planar and Staggered Hear Sinks,” Proceedings of the Fifth InterSociety Conference on Thermal Phenomena in Electronic Packaging (Itherm), Orlando, Florida, May 28 – June 1, pp. 132-139, 1996.

[4] Emre Ozturk and Ilker Tari, 2008. “Forced air cooling of CPUs with heat sinks” IEEE Transactions on components and packaging Technology” 31: 650-660.

[5] Vedulla Manoj Kumar, B. Nageswara Rao, Sk. Farooq, “A Detailed Review on Pin Fin Heat Sink”, World Academy of Science, Engineering and Technology International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:10, No:5, 2016, pp.966-975.

[6] Vedulla Manoj Kumar, Sk. Farooq, B Nageswara Rao, “A Review of Microchannel Hear sink”, Australian Journal of Basic and Applied Sciences, 10(9) May 2016, pp. 230-238.

[7] Carlos A. Rubio-Jimenez, Satish G. Kandlikar and Abel Hernandez-Guerrero, “Numerical Analysis of Novel Micro Pin Fin Heat Sink With Variable Fin Density” , IEEE transactions on components, packaging and manufacturing technology, Volume 2 ,Issue no 5, Year 2012,pp 825- 833.

[8] Vedulla Manoj Kumar, B Nageswara Rao, Sk. Farooq, “A Comparative Study of Cylindrical and Tapered Pin fins heat sink using CFD Analysis”, National Conference on “Emerging Trends in Power, Energy and Control” (ETPEC’16) October 14-15, 2016.

[9] A.Bar-Cohen and M. Iyengar, “Design and optimization of air-cooled heat sinks for sustainable development,” IEEE Trans. Compon. and Packag. Technol., vol. 25,Year 2002, pp 584-591.

[10] A.Bar-Cohen and M. Iyengar, “Least-energy optimization of air-cooled heat sinks for sustainable development,” IEEE Trans. Compon. and Packag. Technol., vol. 26, pp. 16-25, 2003.

[11] M. Iyengar and A. Bar-Cohen, "Least-energy optimization of forced convection plate-fin heat sinks," IEEE Trans. Compon. and Packag. Technol., vol. 26, Year 2003, pp 62-70.

[12] N. Afgan, M. G. Carvalho, S. Prstic and A. Bar-Cohen, "Sustainability assessment of aluminum heat sink design," Heat Transfer Engineering, vol. 24, Year 2003, pp 39-48.

[13] W. B. Krueger, and A. Bar-Cohen, "Optimal numerical design of forced convection heat sinks," IEEE Trans. Compon. and Packag. Technol., vol. 27, Year 2004, pp 417-425.