International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018

Analytical Invistigation of Fin Heat Sinks by Natural Convection in a Closed Enclosure

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ABSTRACT

A heat sink is designed to increase the surface area in contact with the cooling medium surrounding it, such as the air. Approach air velocity, choice of material, fin (or other Protrusion) design and surface treatment are some of the factors which affect the thermal performance of a heat sink.

In this thesis CFD analysis is conducted on the rectangular fin arrays by laminar and turbulentflow conditions. Different sizesare considered for fins. Parameters varied in this work are height of the fins. Rectangular pin fin and hexagonal pin fins are compared for better heat transfer rate.

3D modeling software Catiais used for 3D models of fin arrays. CFD analysis is done in Ansys

INTRODUCTION

Now- a- days the microelectronics and micro-electromechanical systems plays a vital role in development of technological fields. By use of MEMS we can determine the temperature and pressure of micro particles by using sensors. The recent technology involves the demands for greater speed, more power, and less volume and mass have become more and more urgent in most of the forms and n products of the science and technology. The urgency in this operation is due to the changes in the operation of elevated temperatures which is an undesirable consequence. Since the systems tend tooperate at higher energy levels, requirements are also emerging for thedevelopment of new devices that can remove the greater amounts of thermal energy and can dissipate the higher heat fluxes. The need for greater efficienciesand improved life cycles, which are combined with less thermal stresses,Accelerated creep, and fatigue behaviours, is growing too.

Microprocessor microelectronics and gas turbine industries are the two most concerned industries in mechanical stream. The former one is very peculiar with its concentratedefforts on dramatically reducing the size and increasing the speed of its attainments. This resulted in higher functional temperatures, which created asevere operational condition with the significant effect of limiting the life span of the devices. Due to the criticality in the heat removal process in the practical version, it made the interest in micro heatexchangers which is most essential.

The current methods of heat transfer characteristics of a block with

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
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specified hole or without hole till now we saw the research on this experimentation only. Our motivation is to draw the heat transfer characteristics, velocity and temperature distribution of an aluminium block with tapered circular and hexagonal holes with specified dimensions.

BASICS OF HEAT TRANSFER

In the simplest of terms, the discipline of heat transfer is concerned with only two things: temperature and flow of heat. Temperature represents the amount of thermal energy available, whereas heat flow represents the movement of thermal energy from place to place. On a microscopic scale, thermal energy is related to the kinetic energy of molecules. The greater a material's temperature, the greater the thermal agitation of its constituent molecules (manifested both in linear motion and vibration modes). It is natural for regions containing greater molecular kinetic energy to pass this energy to regions with less kinetic energy.

Several material properties serve to modulate the heat transferred between two regions at different temperatures. Examples include thermal conductivities, specific heats, material densities, fluid velocities, fluid viscosities, surface emissivity's, and more. Taken together, these properties serve to make the solution of many heat transfer problems an involved process.

HEAT TRANSFER MECHANISMS

The three modes of Heat Transfer are: Conduction, Convection, and Radiation. Conduction is concerned with the transfer of thermal energy through a material without bulk motion of the material. This phenomenon is fundamentally a diffusion process that occurs at the microscopic level. Convection is concerned with the transfer of thermal energy in a moving fluid (liquid or gas). Convection is characterized by two physical principles, conduction (diffusion) and bulk fluid motion (advection). The bulk fluid motion can be caused by an external force, for example, a fan, or may be due to buoyancy effects. Finally, Radiation is the transfer of thermal energy through electro-magnetic waves (or photons). It is interesting to note that Radiation requires no medium.

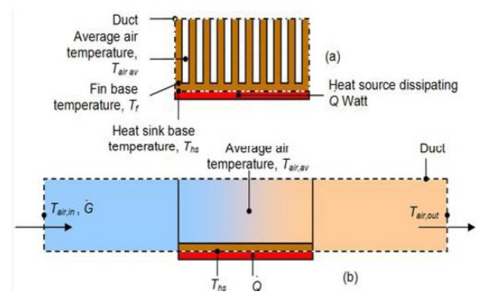
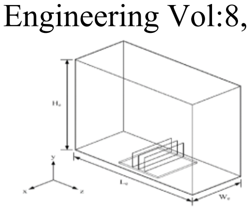


Fig. Sketch of a heat sink in a duct

LITERATURE SURVEY

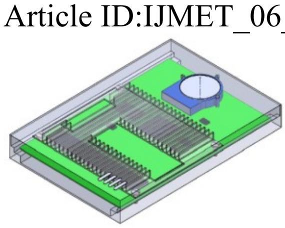
1. Estimation of Natural Convection Heat Transfer from Plate-Fin Heat Sinks in a Closed Enclosure by Han-Taw Chen, Chung-Hou Lai, Tzu-Hsiang Lin, Ge-Jang He..,World Academy of Science, Engineering and Technology International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:8, No:8, 2014.



PCB-Enclosure with Fan and Heat sink (Isometric view)

This study applies the inverse method and three dimensional. CFD commercial software in conjunction with the experimental temperature data to investigate the heat transfer and fluid flow characteristics of the plate-fin heat sink in a closed rectangular enclosure for various values of fin height. The inverse method with the finite difference method and the experimental temperature data is applied to determine the heat transfer coefficient. The k-ε turbulence model is used to obtain the heat transfer and fluid flow characteristics within the fins. To validate the accuracy of the results obtained, the comparison of the average heat transfer coefficient is made. The calculated temperature at selected measurement locations on the plate-fin is also compared with experimental data.

2.Thermal analysis of a heat sink for electronics cooling by M. Chandra Sekhar Reddy
Associate Professor, Department of Mechanical Engineering, UCE (A), Osmania University, Hyderabad – 500 007, India .., **International Journal of Mechanical Engineering and Technology (IJMET)** Volume 6, Issue 11, Nov 2015, pp. 145-153, Article ID:IJMET_06_11_017



PCB-Enclosure with Fan and Heat sink (Isome

Heat transfer is a discipline of thermal engineering that concern the generation, use, conversion and exchange of thermal energy, heat between physical systems. Heat transfer is classified in to various mechanisms such as heat conduction, convection, thermal radiation & transfer of energy by phase change. Most of the electronic equipment are low power and produce negligible amount of heat in their operation. Some devices, such as power transistors, CPU's, & power diodes produce a significant amount of heat. so sufficient measures are need to be taken so as to prolong their working life and reliability. Here, we deal with the design of a heat sink ofAluminum alloy for cooling of a PCB of dimension 233.3×160 with FPGA, fine pitch BGA package, which dissipates 19.5 watts of heat energy. The whole mode of heat transfer is carried out through forced convection with help of a cooling fan of specific velocity. Heat sinks are passive components that cool a device by dissipating heat into surrounding air. We need to introduce discontinuities in the fin surface to break up the boundary layer. This can be accomplished by cross cutting an extruded 'Al' heat sink to create a segmented fin. Heat sinks have a wide range of applications mainly in microprocessors, BGA's, PCB's, Airplanes, Satellites, Space vehicles & missiles.

3. **Modelling and Analysis Of Heat Sink With Rectangular Fins Having Through Holes**
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Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622

Heat indulgence techniques are the prime concern to remove the waste heat produced by Electronic Devices, to keep them within permitted operating temperature limits. Heat indulgence techniques include heat sinks, fans for air cooling, and other forms of cooling such as liquid cooling. Heat produced by electronic devices and circuitry must be self-indulgent to improve reliability and prevent premature failure. Integrated circuits such as CPUs, chipset, graphic cards, and hard disk drives are susceptible to temporary malfunction or permanent failure if overheated. As a result, efficient cooling of electronic devices remains a challenge in thermal engineering. The objective of this paper is to present a best possible Heat Sink for efficient cooling of electronic devices. The choice of an optimal heat sink depends on a number of geometric parameters such as fin height, fin length, fin thickness, number of fins, base plate thickness, space between fins, fin shape or profile, material etc. Therefore for an optimal heat sink design, initial studies on the fluid flow and heat transfer characteristics of standard continuous heat sinks of different designs have been carried through CFD simulations. It is observed from the results that optimum cooling is achieved by the heat sink design which contains interrupted fins with holes. These heat sink designs promises to keep electronic circuits cooler than standard heat sinks and reduction in cost due to reduction in material.

4. **A Thesis on Design Optimization of Heat Sink in Power Electronics**

P.Chennakesavarao1 P.Srihari2 M.E (Thermal Engg.) student, Aditya Institute of Technology and Management, Tekkali.Associate .professor, Aditya Institute of Technology and Management, Tekkali.Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 4, Issue 10(Part - 5), October 2014, pp.83-94.

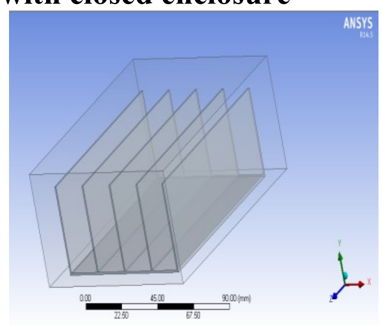
The heat sinks are used in electronic systems to remove heat from the chip and effectively transfer it to the ambient. The heat sink geometry is designed by the mechanical engineers with the primary aim of reducing the thermal resistance of the heat sink for better cooling in the electronic systems. Due to the proximity of the heat sink with the ICs, the RF fields created by RF currents in the ICs/PCBs gets coupled to heat sinks. Hence, the coupled RF current can cause radiated emission. This radiated noise from the device can couple and disturb the functioning of the nearby electronic systems. Also this radiated emission from the device poses a problem to the system compliance with respect to EMI/EMC regulations. The international EMI/EMC standards require the radiated emission from the electronic devices to be kept below the specified limits. As a result the design of Heat Sink is very important factor for the efficient operation of the electronic equipment. In this project design optimization of a Heat sink in a Power amplifier is performed to reduce the weight and size .Power amplifier is electronic equipment mounted in an army vehicle. The power modules inside the amplifier generates a heat of 1440 Watts and a temperature of 140 0c.Two Heat sinks are used to dissipate the heat generated inside the equipment and maintain a temperature of less than 850c. The existing heat sink which is being used is weighing around 10.3kgs and height of 51mm; as a result the unit is very robust. The objective of my project is To design & optimize the heat sink to reduce the weight and size. The optimized heat sink should also dissipate heat generated by power modules and maintain a temperature of less than 850c inside. To achieve the design a steady state thermal analysis will be performed on the heat sink and plot the Temperature distribution on the fins. Based on the above analysis results we will increase/decrease the number of fins, thickness of fins, and height of fins to reduce the weight of the heat sink. We will perform CFD analysis of the power amplifier by mounting the optimized heat sink and plot temperature, pressure and velocity distribution in the power amplifier enclosure. Efforts are made to optimize temperature, pressure and velocity distribution in the power amplifier enclosure by reorienting the power modules in the enclosure. UNIGRAPHICS software is used for 3D modeling SOLID WORKS FLOW SIMULATION software is used for thermal and CFD analysis.

5. Natural convection heat transfer from a radial heat sink with Horizontal rectangular fins. Mangesh D. Shende1, Dr. Ashish Mahalle2 1(SHREEYASH COE & T, Aurangabad/ BAMU, University Aurangabad/India) 2(LIT, Nagpur/RSTM University Nagpur/India)
International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Volume 1 Issue 8 (September 2014).
High heat flux of electronic devices, e.g. projector, LED, high power chip, etc., require efficient cooling methods for heat dissipation in a limited region. It means maintaining a small heat source at an acceptable temperature i.e. there is a continuous increase of the system power and the shrinkage of size. This resulted in inevitable challenges in the field of thermal management of electronics to maintain the desirable operating temperature. This paper presents the detailsstudy natural convection in a radial heat sink, composed of a horizontal circular base and rectangular fins. The general flow pattern is that of a chimney; i.e., cooler air entering from outside is heated as it passes between the fins, and then rises from the inner region of the heat sink. Experimental investigations are performed to compare the effects of three geometricparameters (fin length, fin height, and number of fins) and a single operating parameter (heat flux) on the thermal resistance and the average heat transfer coefficient for the heat sink array.

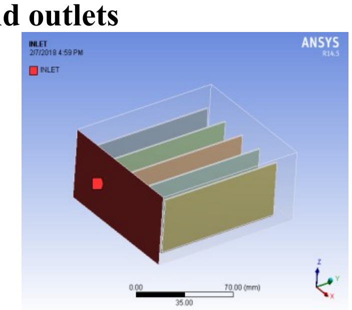
CFD ANALYSIS OF HEAT SINK WITH LAMINAR FLOW

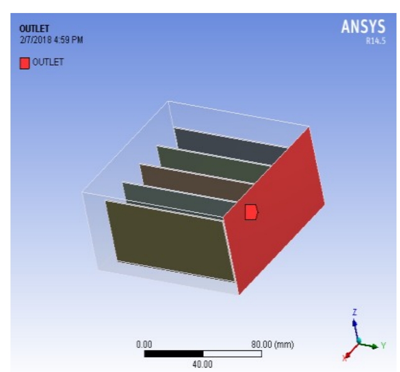
RECTANGULAR FIN

Model with closed enclosure



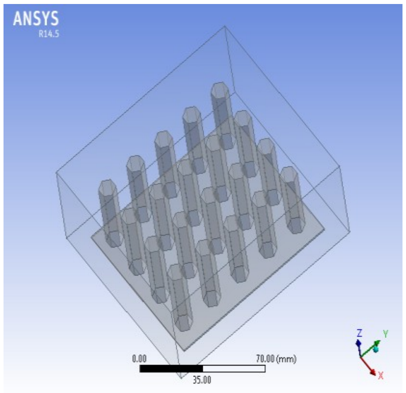
Inlet and outlets





HEXAGONAL FIN

Model with enclosure



RESULTS TABLE
CFD ANALYSIS RESULTS

Fin height 40 mm

	Laminar flow		Turbulent flow	
	Rectangular	**Hexagonal**	**Rectangular**	**Hexagonal**
Pressure(Pa)	0.3948	1.282	0.4038	1.215
Velocity(m/s)	0.7396	1.070	0.7311	1.061
Heat transfer co-fficient(w/m^2-K)	109	100	109	100
Heat transfer rate(w)	0.021	0.71	0.002	0.105
Mass flow rate(kg/s)	6.47e-7	0.67e-7	4.63e-7	3.09e-7

Fin height 60 mm

	Laminar flow		Turbulent flow	
	Rectangular	**Hexagonal**	**Rectangular**	**Hexagonal**
Pressure(Pa)	0.3768	1.321	0.4054	1.284
Velocity(m/s)	0.7326	1.106	0.7243	1.104

Heat transfer co-efficient (w/m^2-K)	96.8	102	96.8	128
Heat transfer rate(w)	0.018	0.34	0.018	0.139
Mass flow rate(kg/s)	6.74 e-7	0.99 e-7	6.74 e-7	0.89 e-7

CONCLUSION

In this thesis CFD analyses are conducted on the rectangular fin arrays by laminar and turbulent flow conditions. Different materials are considered for fins. Parameters varied in this work are height of the fins. Rectangular pin fin and hexagonal pin fins are compared for better heat transfer rate.

3D modeling software CATIA is used for 3D models of square fin arrays. CFD analysis is done in Ansys.

By observing CFD analysis results, the heat transfer rate and heat transfer coefficient is increasing the increase of fin height. By comparing the results for Rectangular and hexagonal, hexagonal has more values than rectangular. The values are more laminar flow than turbulent flow.

REFERENCES

[1] A 3D numerical study of heat transfer in a single-phase micro-channel heat sink using graphene, aluminum and silicon as substrates by Ahmed JassimShkarah, Mohd Yusuf Bin Sulaiman, MdRazali Bin HjAyob, Hussein Togun, International Communications in Heat and Mass Transfer 48 (2013) 108–115

[2] Experimental study on cooling performance of minichannel heat sink using water-based MEPCM particles by Ching-Jenq Ho, Wei-Chen Chen, Wei-Mon Yan, International Communications in Heat and Mass Transfer 48 (2013) 67–72

[3] Fluid flow and heat transfer investigations on enhanced microchannel heat sink using oblique fins with parametric study by Yong Jiun Lee, Pawan K. Singh, PohSeng Lee, International Journal of Heat and Mass Transfer 81 (2015) 325–336

[4] Analysis of three-dimensional heat transfer in micro-channel heat sinks by WeilinQu, IssamMudawar, International Journal of Heat and Mass Transfer 45 (2002) 3973–3985

[5] Experimental and numerical study of pressure drop and heat transfer in a single-phase micro-channel heat sink by WeilinQu, IssamMudawar, International Journal of Heat and Mass Transfer 45 (2002) 2549–2565

[6] Numerical Investigation of Flow Dynamics and Heat Transfer Characteristics in a Microchannel Heat Sink by Md. Emran, Mohammad Ariful Islam, International Conference on Mechanical Engineering, Volume 90, 2014, Pages 563–568

[7] Experimental investigation of heat transfer performance for a novel microchannel heat sink by Y Wang and G-F Ding, Journal of Micromechanics and Microengineering, 2008 *J. Micromech. Microeng.* 18 035021 doi:10.1088/0960-1317/18/3/035021

[8] Flow Boiling Heat Transfer in Micro-Channel Heat Sinks under Sub-Atmospheric Pressures by X. Hu, G. Lin, X. Bu, Y. Caia& D. Wen, A Journal of Thermal Energy Generation, Transport, Storage, and Conversion, pages 85-113

[9] Theoretical and Experimental Investigation of Heat Transfer Characteristics through a Rectangular Microchannel Heat Sink by Dr. B. S. Gawali , V. B. Swami , S. D. Thakre, International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 8, August 2014

[10] A numerical study of fluid flow and heat transfer in different microchannel heat sinks for electronic chip cooling by ShanglongXu, Guangxin Hu, Jie Qin, Yue Yang, Journal of Mechanical Science and Technology, April 2012, Volume 26, Issue 4, pp 1257-1263