PERFORMANCE ANALYSIS OF PARALLEL UNIFORM RECTANGULAR FIN AND CYLINDRICAL PIN FINS FOR HEAT SINK APPLICATION

[1] Yogesh G Joshi, [2] Dr. D. R. Zanwar
[1]Department of Mechanical Engineering
Shri Ramdeobaba College of Engg. And Management Nagpur – 440013
Corresponding Author: -yogesh.joshi54@yahoo.in

ABSTRACT

The paper involves steady state heat transfer analysis of parallel uniform plate and cylindrical pin for the heat sink application. Both comparative study has been done by using aluminium alloy and copper alloy. Both heat sink with their material allow to produce constant heat flux from the base as 50 Watt. Temperature distribution and total directional heat flux for each material has been mentioned with their magnitude. At 50 Watts of power obtaining from the base copper alloy shows the better results as compared to the aluminum alloy. Study also shows the advantage of parallel uniform rectangular heat sink over the cylindrical pin fin heat sink.

KEYWORDS- Heat sink, Al alloy, Cu Alloy.

1. INTRODUCTION

Heat sink is widely used for transferring the heat from the electrical device such as microprocessor, heavy electrical duties ICs, motherboard cooling etc. It involved convection mode of heat transfer through the fins. The convection mode of heat transfer generally involves using of various types of fins for improving the heat transfer rate. The following figure shows the schematic diagram of heat sink which has been taken from literature 1.

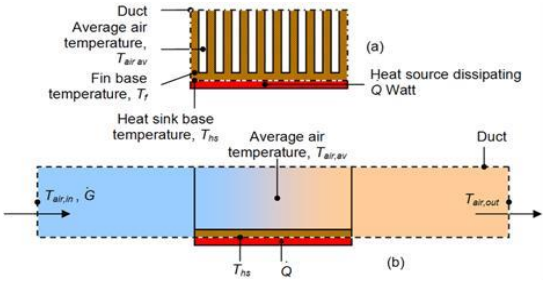

Fig. 1Parallel unform rectangular heat sink

Likewise in earlier days cylindrical pin fin heat sink were used. Such kind of heat transfer through pin enable the system to remove or transfer the heat in greater heat flux. [1].The following shows the schematic figure of cylindrical pin fin heat sink.

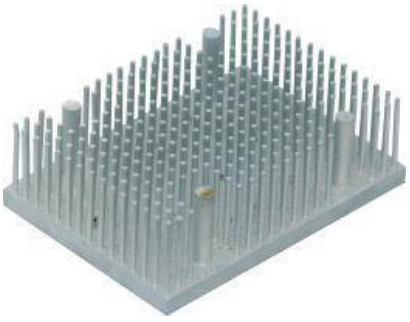

Fig. 2 Cylindrical pin fin heat sink

2. PROCESS METHODOLOGY

The analysis has been carried in this paper by using ANSYS steady state heat transfer analysis. Both kind of heat sink were simultaneously analyzed by using the Al alloy and copper alloy. The material properties of both the material has given below.

- Aluminum Alloy (6061A)

TABLE 1: MATERIAL PROPERTY OF AL ALLOY

Properties	Values
Density	2711 kg/m^3
Specific heat	387 J/Kg.K
Thermal Conductivity	237 w/mk

- Copper Alloy

TABLE 2: MATERIAL PROPERTY OF CU ALLOY

Properties	Values
Density	2672 kg/m^3
Specific heat	450 J/Kg.K
Thermal Conductivity	325 w/mk

The above material property has been standard for the heat sink using by the core dual microprocessor motherboard, the geometry and the other part of this heat sink were designed by using the ANSYS.

A. Geometry (Parallel uniform rectangular fin)

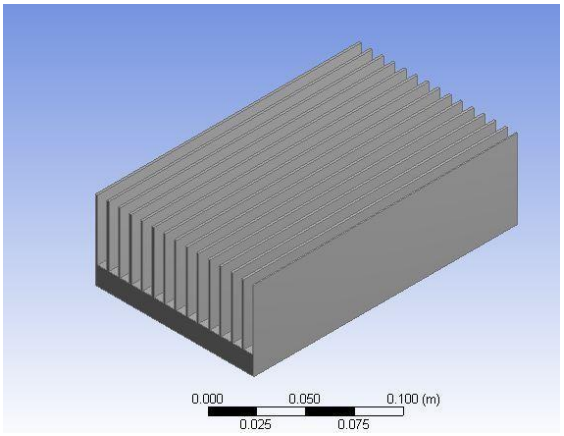

Fig. 3 Geometry for rectangular fin heat sink

Dimensions for the solid extruding has considered as follows:
Base plate size = 0.080 * 0.080 m
Base plate thickness = 9 mm
Rectangular fins thickness = 1mm (thickness)
Fin length = 3 cm
Fin longitudinal length = 85 mm
Heat flow from the base = 50 Watts
Ambient air temperature = 220C
Condition is steady state heat transfer with heat transfer type Convection.

B. Geometry Cylindrical pin fin*)*

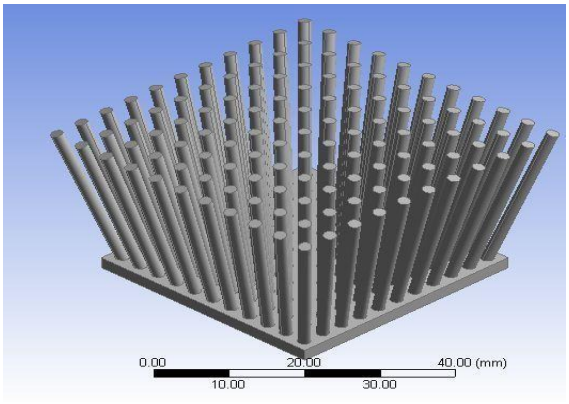

Fig. 4 Geometry for Cylindrical pin fin heat sink

Dimensions for the solid extruding has considered as follows:
Base plate size = 0.080 * 0.080 m
Base plate thickness = 9 mm
Cylindrical fins diameter = Fin spreading = Each 1.3 mm
Fin Height = 3.5 mm
Heat flow from the base = 50 Watts
Ambient air temperature = 220C
Condition is steady state heat transfer with heat transfer type Convection.

C. *Meshing*

Meshing of both the solids has been with the element size defining 0.1 mm. The fine meshing has been done to obtained soft flow of heat from the base of heat sink to the tip of the fin. The following figure shows the fine meshing for the both kind of heat sink.

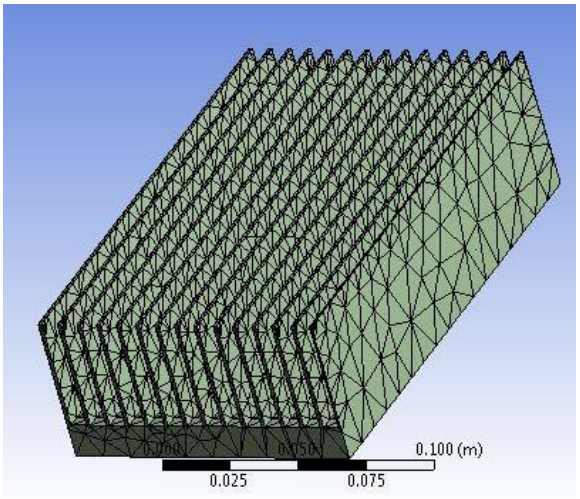

Fig. 5 Meshing of Geometry for rectangular fin heat sink

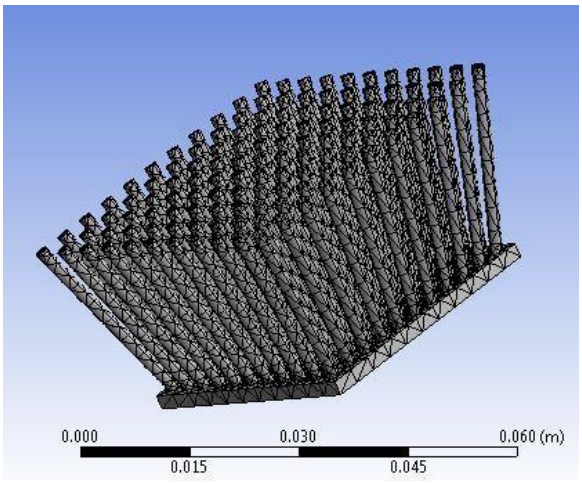

Fig. 6 Meshing of Geometry for Cylindrical pin fin heat sink

3. STEADY STATE HEAT TRANSFER ANALYSIS

SSHT analysis of parallel uniform rectangular fin Heat sink With Al Alloy

After applying the all thermal loads from the base of the heat sink, steady state heat transfer analysis has been done on parallel rectangular plate fin heat sink to obtain the temperature distribution profile and the directional total heat flux from the heat sink. The following figures show the SSHT analysis with Al alloy material.

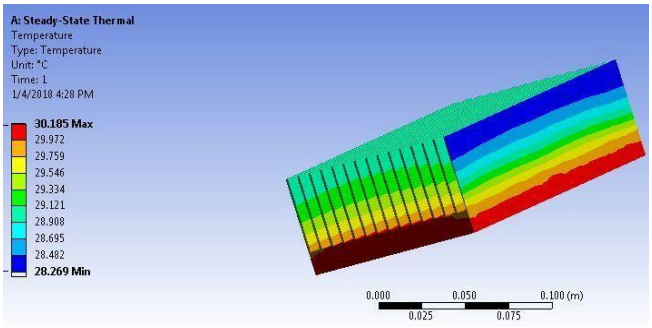

Fig.7 Temperature distribution for rectangular fin heat sink with Al Alloy

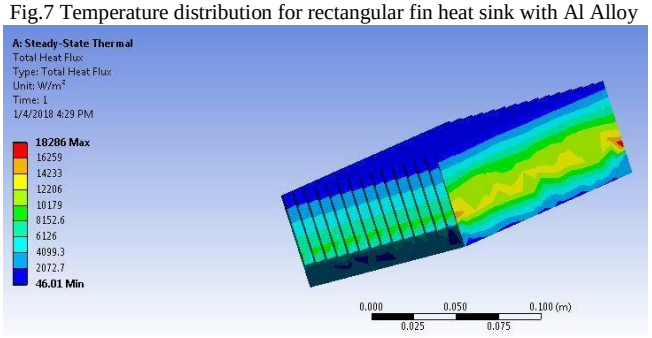

Fig. 8 Total heat flux for rectangular fin heat sink with Al Alloy

From the SSHT analysis it has been observed that by applying heat flow of 50 Watts to the base of the sink the maximum temp. is 300C and the minimum is 280C. The maximum heat flux is 18286 W/m2 to the minimum of 46.01 W/m2.

SSHT analysis of cylindrical pin fin Heat sink With Al Alloy

After applying the all thermal loads from the base of the heat sink, steady state heat transfer analysis has been done on cylindrical pin fin heat sink to obtain the temperature distribution profile and the directional total heat flux from the heat sink. The following figures show the SSHT analysis with Al alloy material.

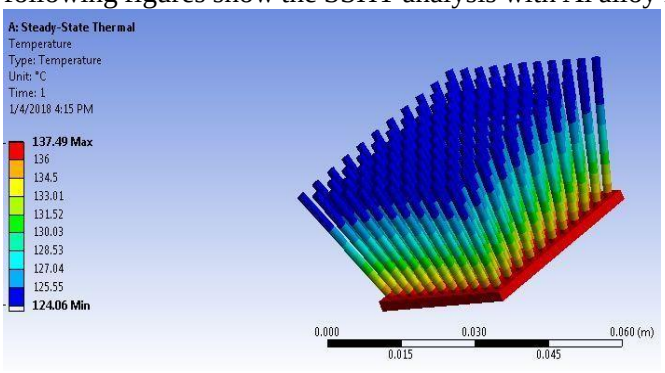

Fig 9: Temperature distribution for Cylindrical pin fin heat sink With Al Alloy

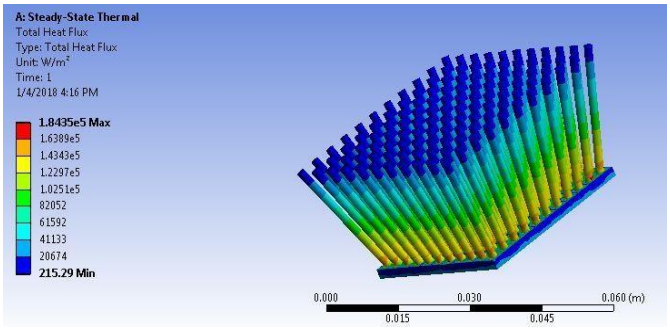

Fig 10: Total heat flux for Cylindrical pin fin heat sink with Al Alloy

From the SSHT analysis it has been observed that by applying heat flow of 50 Watts to the base of the sink the maximum temp. is 137^0C and the minimum is 1240C. The maximum heat flux is 1.823E5 W/m2 to the minimum of 215.29 W/m2. Which makes it a poor heat sink for the electrical devices?

SSHT analysis of parallel uniform rectangular fin Heat sink With Cu Alloy

By applying the all thermal loads from the base of the heat sink, steady state heat transfer analysis has been done on parallel rectangular plate fin heat sink to obtain the temperature distribution profile and the directional total heat flux from the heat sink. The following figures show the SSHT analysis with Cu alloy material.

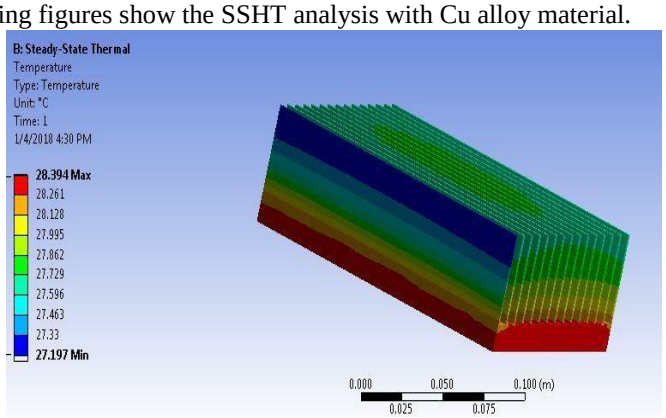

Fig.11 Temperature distribution for rectangular fin heat sink with Cu Alloy

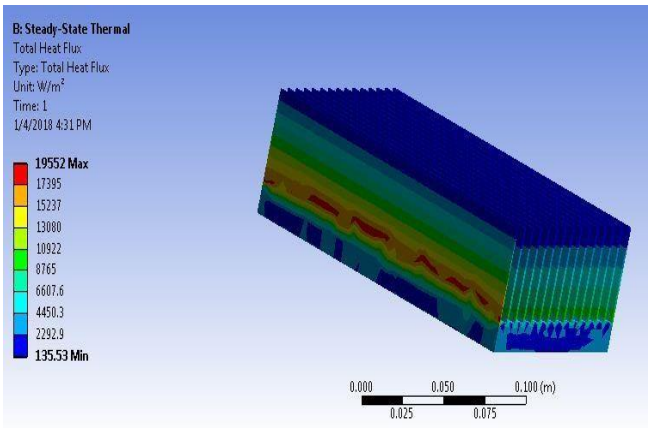

Fig. 12 Total heat flux for rectangular fin heat sink with Cu Alloy

From the SSHT analysis it has been observed that by applying heat flow of 50 Watts to the base of the sink the maximum temp. is 28.39^{0}C and the minimum is 27.19^{0}C. The maximum heat flux is 19552 W/m^2 to the minimum of 135.53 W/m^2.

SSHT analysis of cylindrical pin fin Heat sink With Cu Alloy

After applying the all thermal loads from the base of the heat sink, steady state heat transfer analysis has been done on cylindrical pin fin heat sink to obtain the temperature distribution profile and the directional total heat flux from the heat sink. The following figures show the SSHT analysis with Cu alloy material.

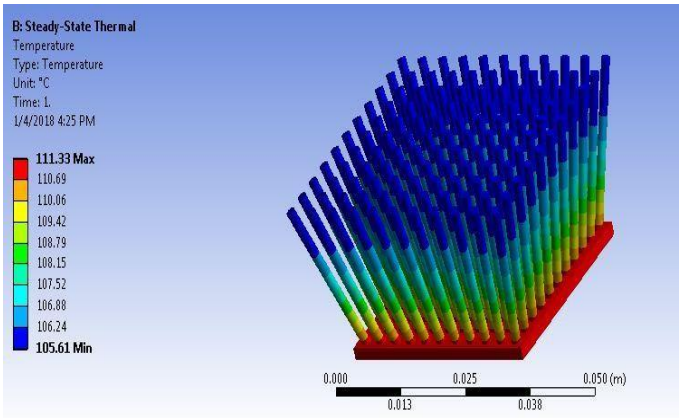

Fig 12: Temperature distribution for Cylindrical pin fin heat sink With Cu Alloy

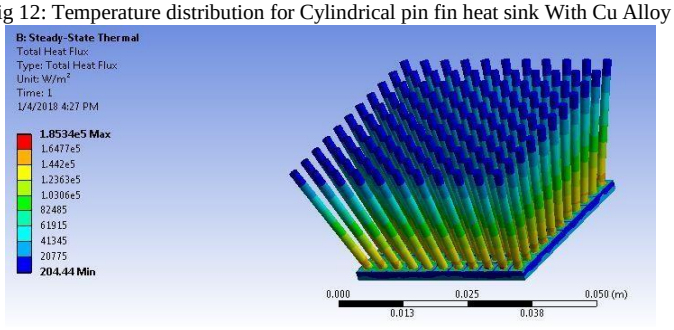

Fig 13: Total heat flux for Cylindrical pin fin heat sink with Al Alloy

From the SSHT analysis it has been observed that by applying heat flow of 50 Watts to the base of the sink the maximum temp. is 111.33^{0}C and the minimum is 105.1^{0}C. The maximum heat flux is 1.823E5 W/m^2 to the minimum of 204.85 W/m^2.

4. RESULT AND DISCUSSION

During the analysis it has been found the cylindrical heat sink performance is much poor than the rectangular plate heat sink. Even in this case by changing the material from Al alloy to copper alloy, it shows the significant improvement. The following clarified the performance analysis of the both kind of heat sink with Al alloy and Cu alloy.

TABLE III: RESULT AND DISCUSSION

Heat sink	Material	Temp. (0C)		Heat Flux(W/m2)	
		Max	Min	Max	Min
Parallel rectangular uniform plate heat sink	Al Alloy	30	28	18286	46.01
	Cu Alloy	28.39	27.19	19552	135.53
Cylindrical pin find heat sink	Al Alloy	137.49	124.06	1.82E5	215.29
	Cu Alloy	111.3	105.1	1.82E5	204.85

5. REFERENCES

[1] Y. Joshi and Dr. D. Ikhar, on " steady state heat transfer analysis of aluminium microprocessor, IEEE xplore 8226232 Dec 2017.
[2] Yogesh Joshi , Dhananjay Ikhar (2015), "A Literature Review on Design and Performance analysis of Graphite metal as Heat sink for Microprocessor in CPU", (ISSN: 2321-5747) International Journal on Mechanical Engineering and Robotics (IJMER)
[3] R.Mohan and Dr.P.Govindarajan. ―Thermal analysis of CPU with composite pin fin heat sinks ‖,International Journal of Engineering Science and Technology ,Vol. 2(9), 2010, 4051-4062.
[4] Konstantinos-Stefanos P. NIKAS* and Andreas D.Panagiotou.―Numerical Investigation of Conjugate Heat Transfer in a Computer Chassis‖ Columbia International Publishing Journal of Advanced Mechanical Engineering (2013) 1: 40-57 doi:10.7726/jame.2013.1004.
[5] Y. Wang and K. Vafai, ―An experimental investigation of the thermal performance of an asymmetrical flat plate heat pipe, Int. J. Heat Mass Transfer‖, 43 (2000) 2657-2668