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Thermal Analysis of Heat Sink in CPU with Varying Fin Designs

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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. This is done by attaching fins to the device which aid in rapid heat removal to the surroundings. Heat sinks using thermal contact absorb and disperse heat. Heat sinks function efficiently by transferring thermal energy from an object at a relatively high temperature to another object at a lower temperature with greater heat capacity. This rapid transfer of thermal energy quickly makes both the object at equilibrium state by lowering the temperature of the first object, fulfilling the heat sink's role as a cooling device. A computer system's components produce large amounts of heat during their operation. Integrated circuits include CPUs, chipset and graphics cards along with hard drives produce large amount of heat. In order to keep these components in safe condition, heat generated must be dissipated. This is done mainly using heat sinks to increase the surface area which dissipates heat. For this task Finite Element Tool ANSYS is used to determine the thermal gradient and maximum value of temperature in heat sink. With these results from ANSYS an optimum area is added to increase the heat dissipation rate and also sharp points are designed in top edge of fins to increase the rate of heat transfer.

Keywords: Heat Sink, CPU, Thermal Analysis.

I. INTRODUCTION

A component designed to lower the temperature of an electronic device by dissipating heat into the surrounding air. All modern CPUs require a heat sink. Few CPUs may also require a fan. A heat sink without a fan is called a passive heat sink; a heat sink with a fan is called an active heat sink. Heat sinks are generally made of an aluminium alloy and often have fins.

There are a numerous factors which makes a good heat sink are high heat sink surface, good aerodynamics, good thermal transfer, perfect flatness and good mounting methods. Heat sink materials are commonly used are Aluminium, Copper and silver. The production of Heat sinks involve various manufacturing methods such as extrusion, Die-cast heat sinks, cold forging, milled/cut heat sinks, bonded fin/folded fin.

II. METHODS AND MATERIAL

A. Literature Review

The radiant heat performance of heat sink was increased with increasing the height of fin and the width of fin pitch [1,2]. The thermal resistance of a heat and examples are provided to illustrate the effect on the cooling performance of a heat sink under various design conditions [3,4]. An analytical simulation model has been developed for predicting and optimizing thermal performance of bidirectional fin heat sinks in a partially confined configuration by [5,6]. The thermal behaviour of high power semiconductor laser arrays by means of the finite element method (FEM) is tested by comparing it with analytical solutions [7].

B. Thermal Compounds

i. Applied process

Before installing, a very thin (paper thin) layer is applied on the heat sink by fingers. Thinner the layer gives better performance. The contact area between CPU and heat sink has to be covered entirely else leads to formation of hot spots. The heat sink is then pressed firmly on the CPU. Thermal compound is not hard, it will stay sticky for years. It may dry over the years based on the solvents used in making of the compound.

ii. Composition of compound

Mostly, the thermal compound consists of silicone since it doesn't have a high thermal conductivity. High-End thermal compounds are usually silicone-free, and use metal-based additives such as aluminum oxide or nitride, or even pulverized silver, instead of Zinc Oxide.

iii. Performance of thermal compound

The performance of thermal compound is measured in W/mK. Standard silicon/zinc oxide thermal compound has thermal conductivities between 0.7 and 0.9 W/mK, high end compound can have thermal conductivities of around 2 - 3 W/mK or more. But not only has the thermal conductivity mattered. The compound should also be very smooth - if it is too grainy or too hard, then it is hard to apply on a thin layer. CPU never be hotter after applying thermal compound. A hotter heat sink will have better thermal conductivity between the CPU and the heat sink. The CPU itself will be cooler.

C. Functional flow of Heat Sink Analysis

The steps to be followed in analyzing the heat generated by using the thermal compounds are shown in Fig.1.

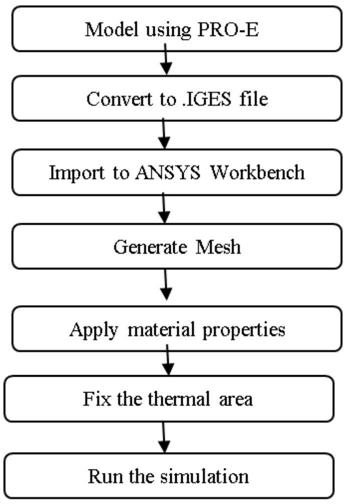


Figure 1 : Functional flow of Thermal Analysis

Modeling of the component using PRO_E has been shown in the Fig.2. The modeled component is converted to the required file format and then imported to ANSYS which is shown in Fig.3.

There are three steps for the process of generating a mesh of nodes and elements such as

- A set consists of Element attributes.
- Mesh controls are set (optional). Large number of mesh controls can be generated by ANSYS, from which needs can be chosen.
- Finally the model is meshed.

Mesh controls are not set always sometimes the default mesh controls gives suitable for many models. If controls are not specified, then default settings will be taken by the program to produce a free mesh. Alternatively, the Smart Size feature will be used to make a better quality free mesh.

Fig.4 shows the mesh generation for the component modeled.

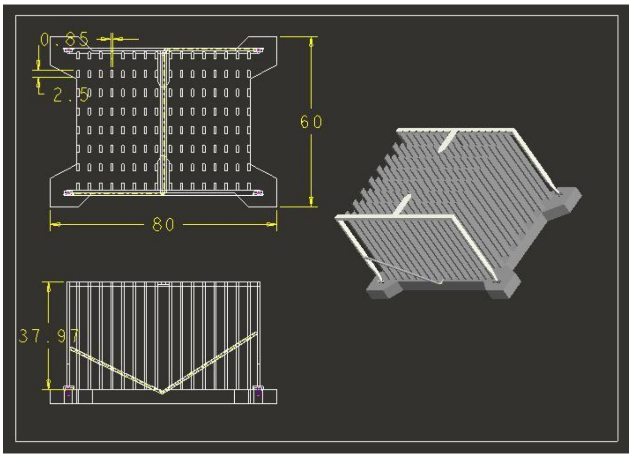


Figure 2 : Component Modeling using PRO-E

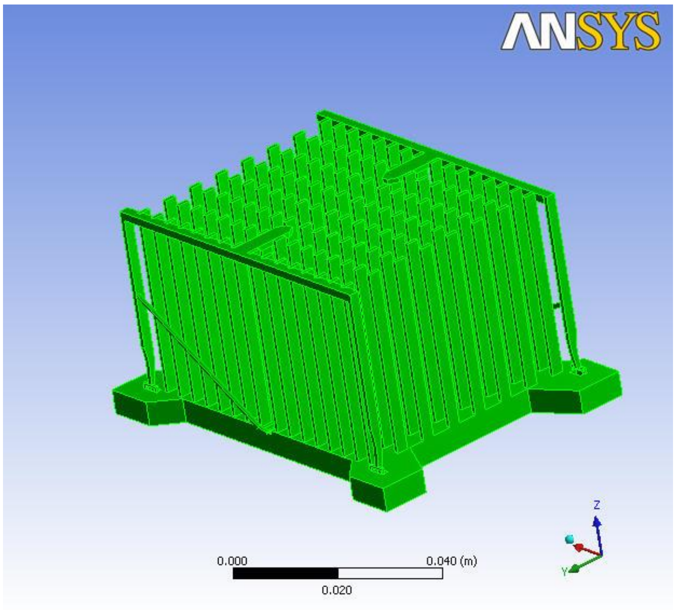


Figure 3 : Importing to ANSYS Workbench

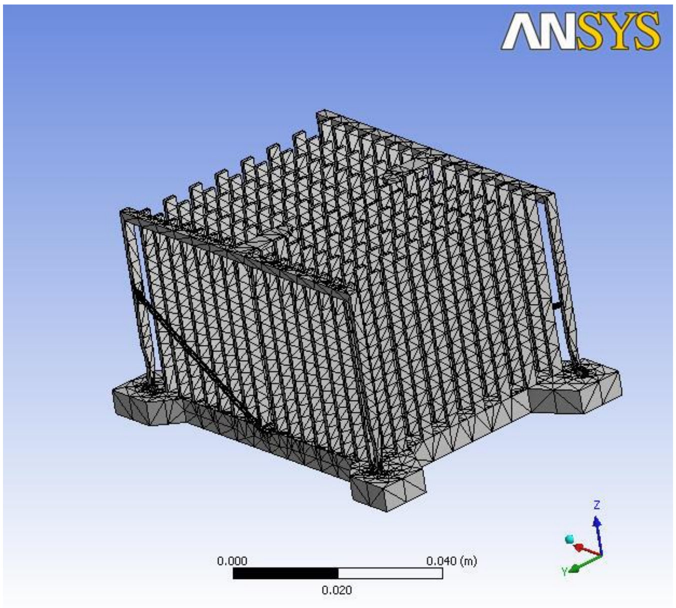


Figure 4 : Mesh generation

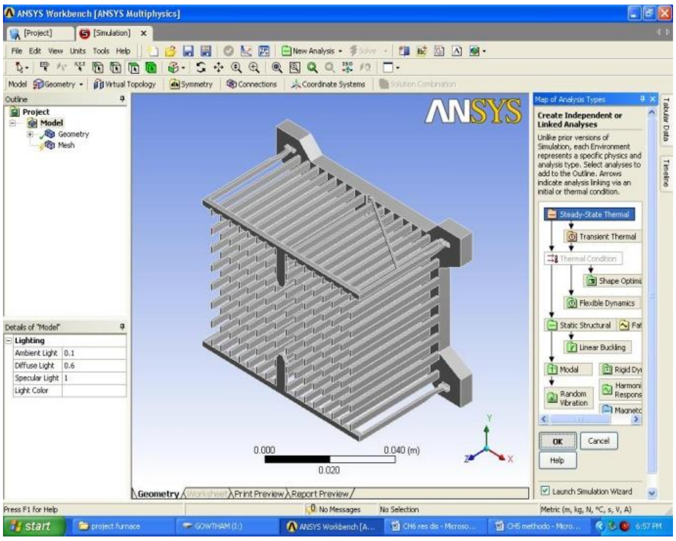


Figure 5

After generating meshing, the required material properties will be applied which is shown in Fig.5.

Then the thermal area will be fixed. It is fixed at bottom, side, Top and Edge. Bottom of the base has 55°C, the component obtained for this temperature is shown in Fig.6. Side of the base has 53°C, the component obtained for this temperature is shown in

Fig.7. Top side of the base has 52°C, the component obtained for this temperature is shown in Fig.8. The temperature of the fins are set to 49°C, the output of this is shown in Fig.9. Edge of the fins has 47°C which is shown in Fig.10. Finally the convention temperature is set to 11°C, the output of this is shown in Fg.11.

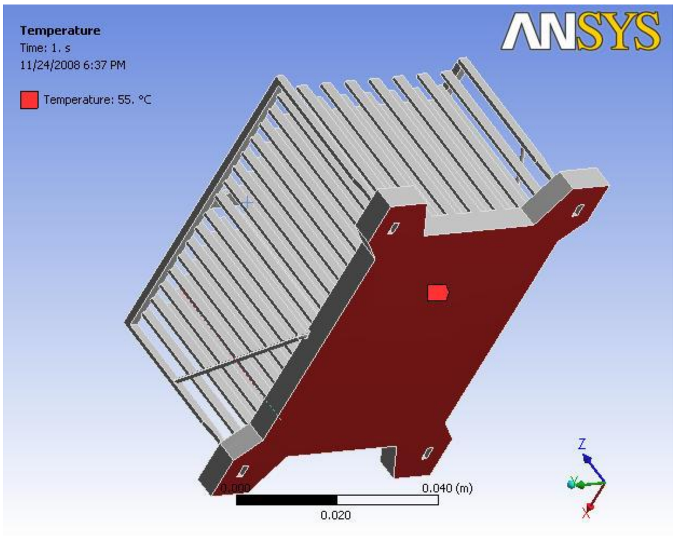


Figure 6 : Bottom of the base 55°C

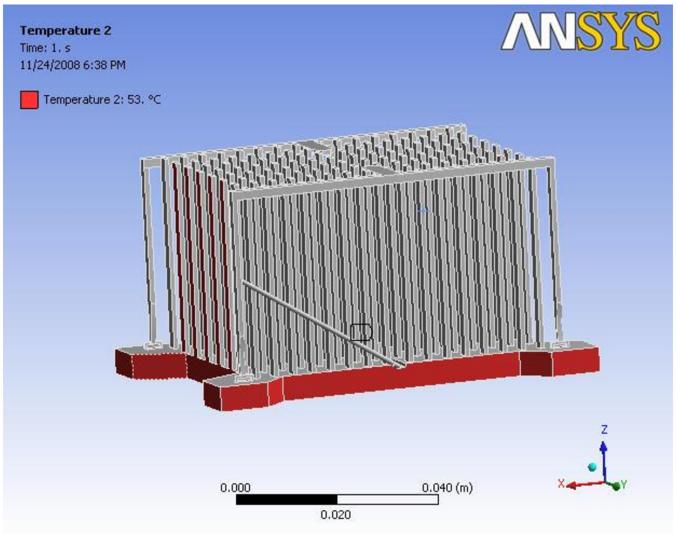


Figure 7 : Side of the base 53ºC

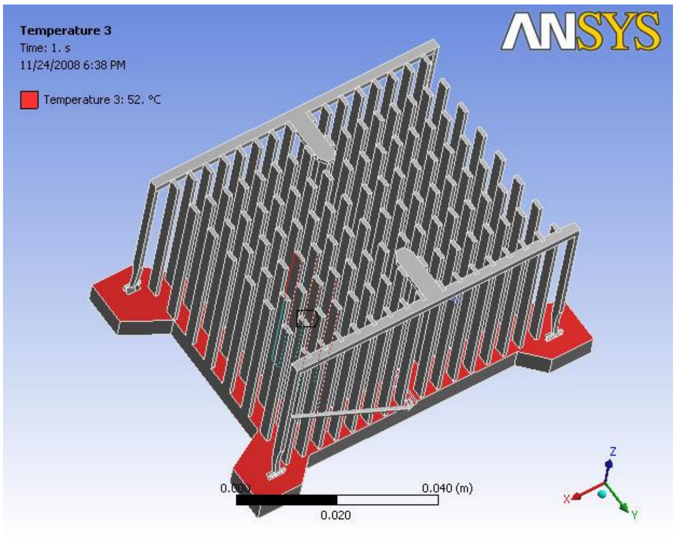


Figure 8 : Top side of the base 52ºC

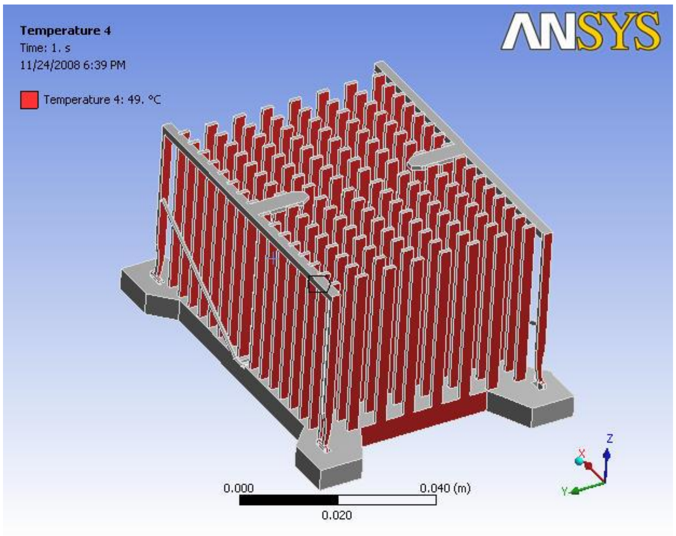


Figure 9 : Fins temperature 49ºC

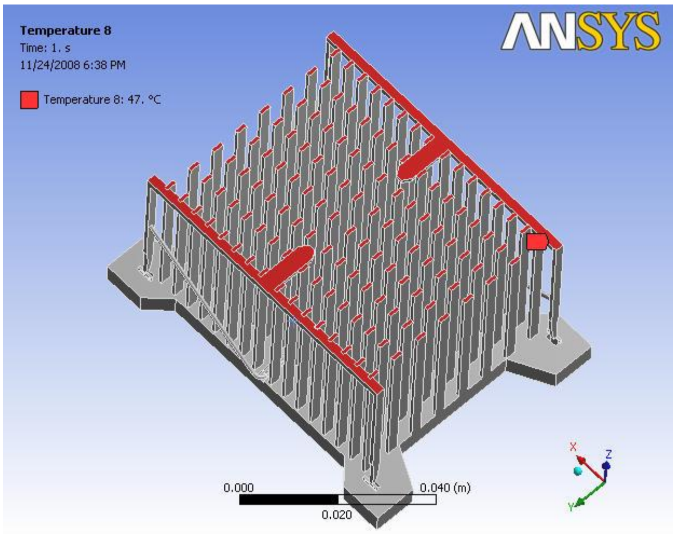


Figure 10 : Edge of the fin 47ºC

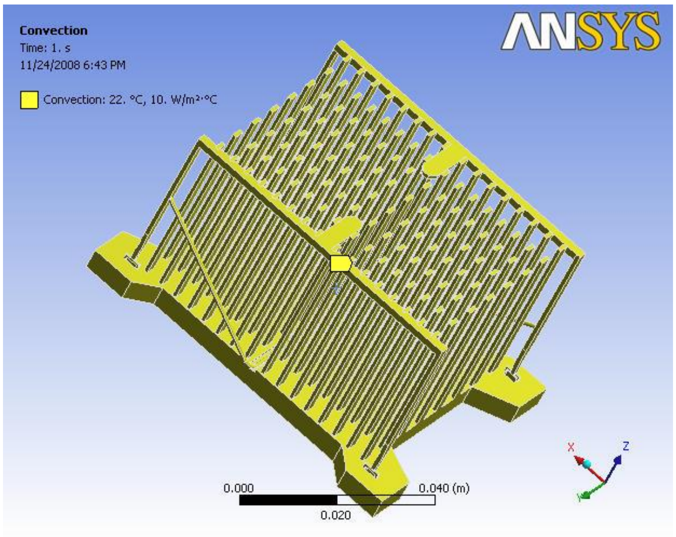


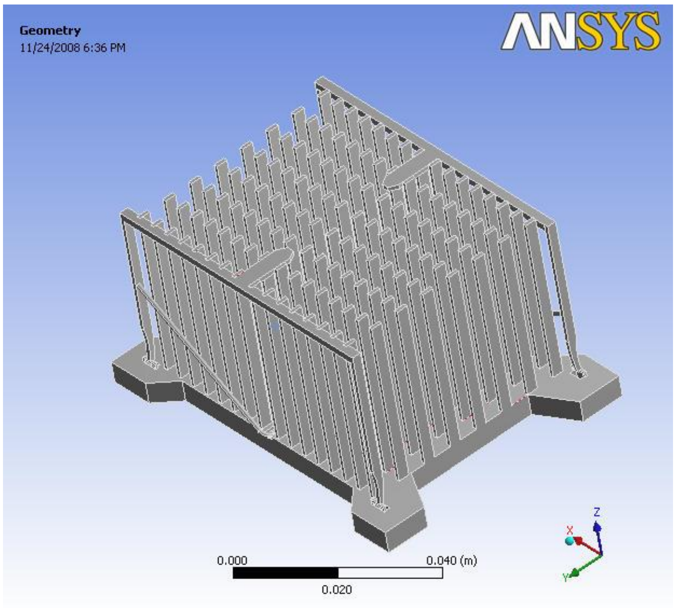
Figure 11 : Convection temperature 22ºC

III. RESULTS AND DISCUSSION

Experimental Results

Two models are analyzed and are described as below. *Model 1:* Initially, the heat sink design composed of following features, the designed model is shown in Fig.12.

1. Flat edged fins
2. Limited length fins



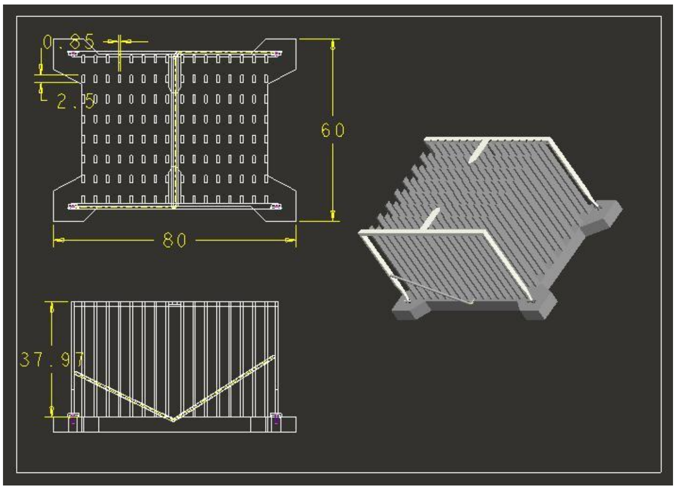
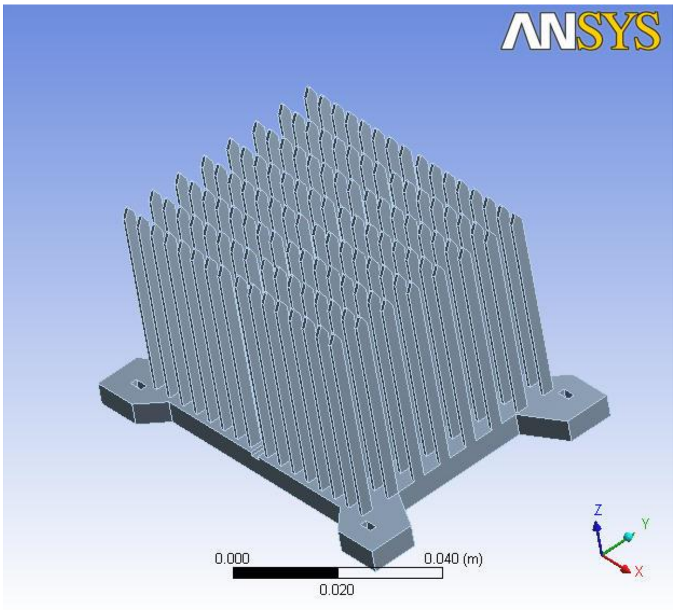


Figure 12 : Designed Model 1



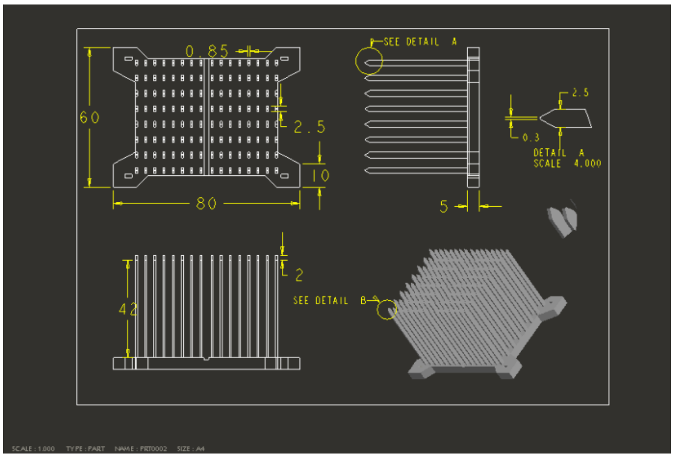


Figure 13 : Designed Model 2

A. Temperature and Heat Flux

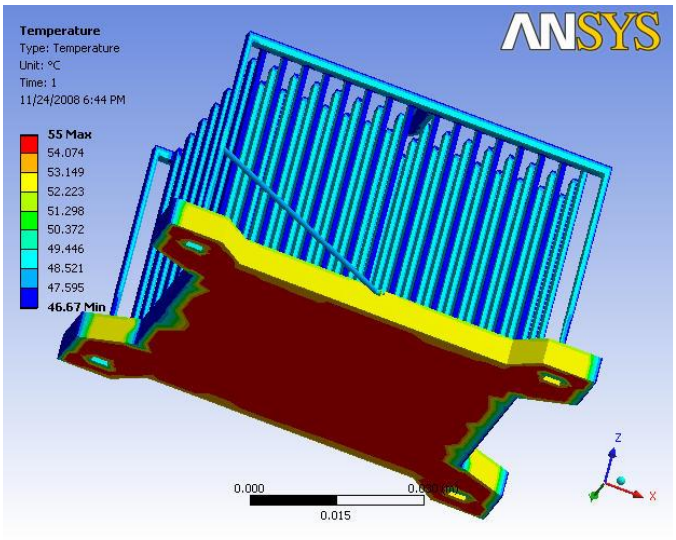


Figure 14.a : Temperature

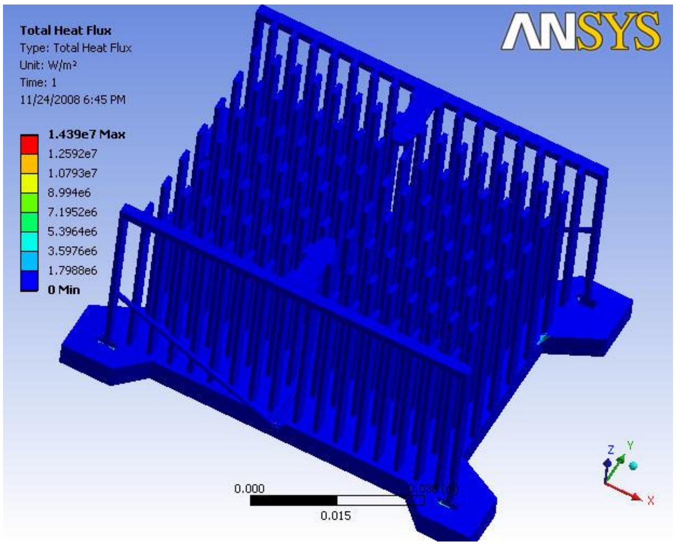


Figure 14.b : Heat flux

Heat flux is also called as thermal flux. Temperature and heat flux for the design having features such as Flat edged fins and Limited length fins is shown in Fig.14.a and b. Similarly the Temperature and heat flux for the design having features such as sharp edged fins and increased length of fins is shown in Fig15.a and b.

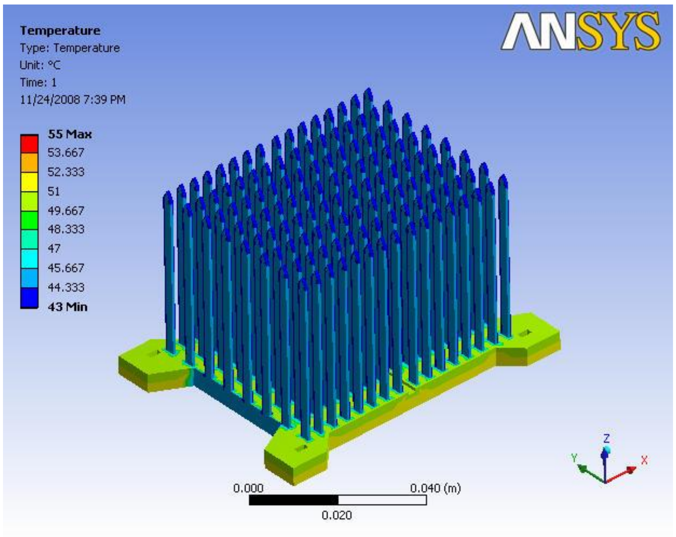


Figure 15.a : Temperature

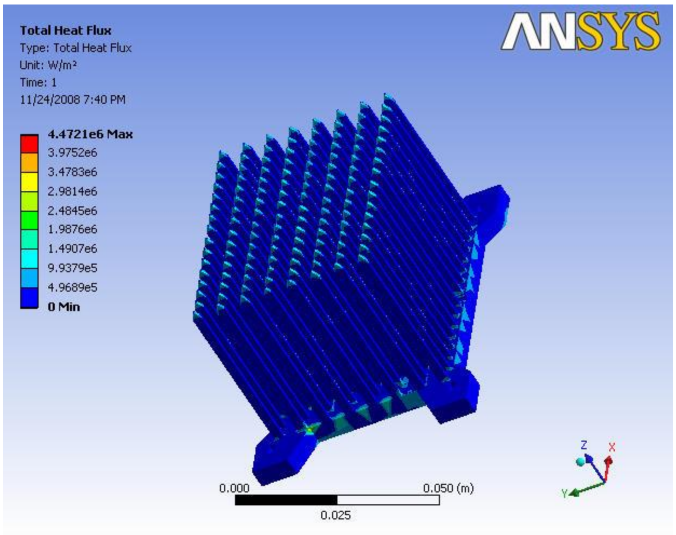


Figure 15.b : Heat flux

The assigned values of temperature are shown in Table.1.

Table.1. Assigned values of temperature

TEMP°C	Bottom of base	Side of base	Top of base	I side of Fins	II side of Fins	Edge of the fins	Convection
Design-I	55	53	52	49	48	47	22
Design-II	55	51	50	45	44	43	22

IV. CONCLUSION

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 analysed and verified.

V. REFERENCES

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