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Heat Optimisation of Processor Cooling by Varying casing Material

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ABSTRACT: Microprocessor is the soul of a computer device, a computer processor that incorporates the functions of a computer's CPU on a single Integrated Circuit (IC). It requires electrical energy to perform but unfortunately most of the power supplied is dissipated as heat energy, which affects its performance. In general, Heat Sink is employed in a processor to control its temperature, and the functioning of heat sink depends on parameters like heat sink material, fin thickness, number of fins, base plate thickness, casing material, etc. Number of fins& selection of casing material is the basis for improving performance. In this study, thermal analysis of the processor fins is proposed and an effort is made to decrease the maximum temperature of processor. Removal of heat generated in processor gets augmented by number of fins in it. Comparative study is presented by selecting particular material for casing, enclosing the copper processor rectangular in shape, and to which aluminum fins are attached. Modeling and Analysis is carried out by Finite Element Method (FEM) based software in ANSYS. Heat flows out from the processor to the surrounding through the casing and then to fins attached to it. Convective boundary conditions is applied to the casing and fins except the bottom, which is insulated. Increase in number of fins leads to decrease in maximum temperature and increase in heat flux of the processor proportionally. The results report the temperature distribution and heat flux contour for variation in number of fins& casing material. Conclusion is drawn from the results pertaining using the appropriate number of fins &material selection for the casing to be used to optimize the maximum temperature in process.

I. INTRODUCTION

Earlier, processors were able to operate completely without a heat sink. The low specifications allowed operation of first Intel processors without any heat removal mechanism. Later, as the processing speed increased, these processors required at least a passive heat sink (heat sinks used generally in natural convection systems) for smooth operation. However, over last few years, as the processors got more and more powerful, it became mandatory that a CPU require a multi-fin heat sink as well as a fan that ensure reasonable air flow through the cooling fins as the overheated processors exhibit a shorter maximum life span and often result in problems like system freezes or crashes.

A heat sink is a device used in computers to remove the large amount of heat generated by components, during their operation and keeps them under safe operating temperature. Fans are also used to speed up this process. It usually consists of a base with one or more flat surfaces and an array of fin like protrusions to increase the heat sink's surface area contacting the air, and thus increasing the heat dissipating rate.

A combination of a heat sink and a fan is widely used which maintains a larger temperature gradient by replacing warmed air more quickly. In electronic systems, a heat sink is a passive heat exchanger that cools a device by dissipating heat into the surrounding medium.

A. Heat transfer principal

The power supplies of electronics are not 100% efficient, so extra heat is produced that may be detrimental to the function of the device. As such, a heat sink is included in the design to disperse heat to improve efficient energy use. Fig. 1 shows how the heat sink looks. With the same image, principle of heat transfer can be understood.

To understand the principle of a heat sink, consider Fourier's law of heat conduction. Fourier's law of heat conduction, simplified to a one-dimensional form in the *x*-direction, shows that when there is a temperature gradient in a body, heat will be transferred from the higher temperature region to the lower temperature region. The rate at which heat is transferred by conduction, q_k , is proportional to the product of the temperature gradient and the cross-sectional area through which heat is transferred.

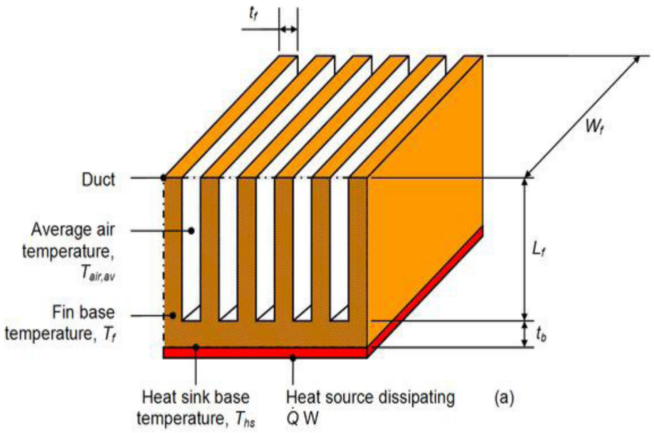

Fig. 1. Heat Transfer Principal.

$$q_k = -kA\frac{dT}{dx}$$

Consider a heat sink in a duct, where air flows through the duct, as shown in Figure 1. It is assumed that the heat sink base is higher in temperature than the air. Applying the conservation of energy, for steady-state conditions, and Newton's law of cooling to the temperature nodes gives the following set of equations –

$$\dot{Q} = \dot{m}c_{p,in}\left(T_{air,out} - T_{air,in}\right) \quad (1)$$

$$\dot{Q} = \frac{T_{hs} - T_{air,av}}{R_{hs}} \quad (2)$$

Knight et al. (1992) extended previous analysis of micro channel heat sinks for turbulent as well as laminar flow. They demonstrated improvement of previous studies by relaxing constraints on fin thickness/ pitch ratio and allowing turbulent flow.

Copeland (1995) modified previous analyses for developing flow and calculated optimum fin thickness and pitch for silicon heat sinks cooled by fluorocarbon liquids.

Lee (1995) analysed flow through parallel fin heat sinks in fully ducted and partially ducted flows. Unlike a fully ducted configuration, in partially ducted configuration at a fixed approach velocity, an optimum size of fin existed; thermal performance improves monotonically as fin pitch is decreased.

Aranyosi et al. (1997) showed isocurves of pressure drop and fan power at fixed thermal resistance in addition to isocurves of thermal resistance at fixed pressure drop and fan power. As pressure drop or fan/blower power increased, optimum fan thickness and pitch decreased, resulting in reduced thermal resistance. In addition to analysis, experimental and numerical studies were performed.

Tasaka *et al.* (1997) performed experimental studies of compact heat sinks with fin thickness and pitch as small as 0.34mm and 0.70 mm. Results co-related well with results from compact heat exchanger data. This compactness factor, defined as thermal conductance per unit volume, was three to seven times that of standard heat sinks.

II. PROBLEM SPECIFICATION

Processor is made of copper with thermal conductivity of 386 W/m-K and it generates heat at the rate of 1 W. The enclosing container (casing) is made of steel with thermal conductivity of 17 W/m-K. The fins are made of aluminium with thermal conductivity of 180 W/m-K. There is convection along all the boundaries except the bottom, which is insulated. The film (convection) coefficient is h=50 W/m^2-K and the ambient temperature is 20°C. An attempt is done to decrease the maximum temperature and increase the heat flux in the electronic component by varying the number of fins to ensure the optimal working of the component. Comparative study is also done by taking copper as a material for casing.

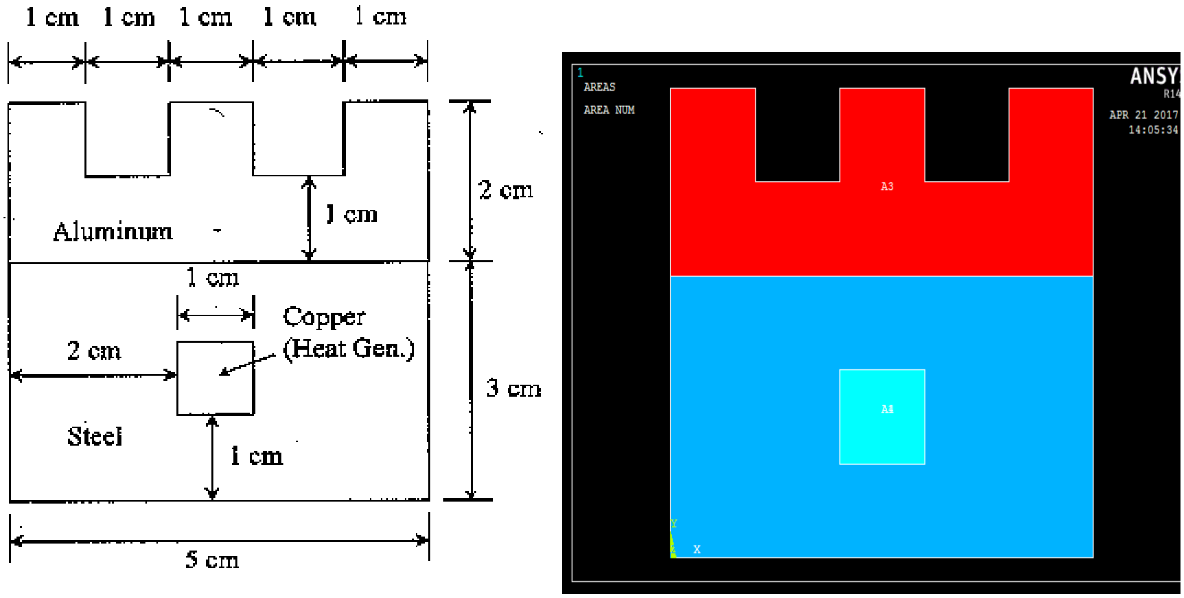

Fig. 2. Problem Specification.

III. RESULTS AND DISCUSSIONS

Two–dimensional thermal analysis of the solid model has been carried out in ANSYS APDL.

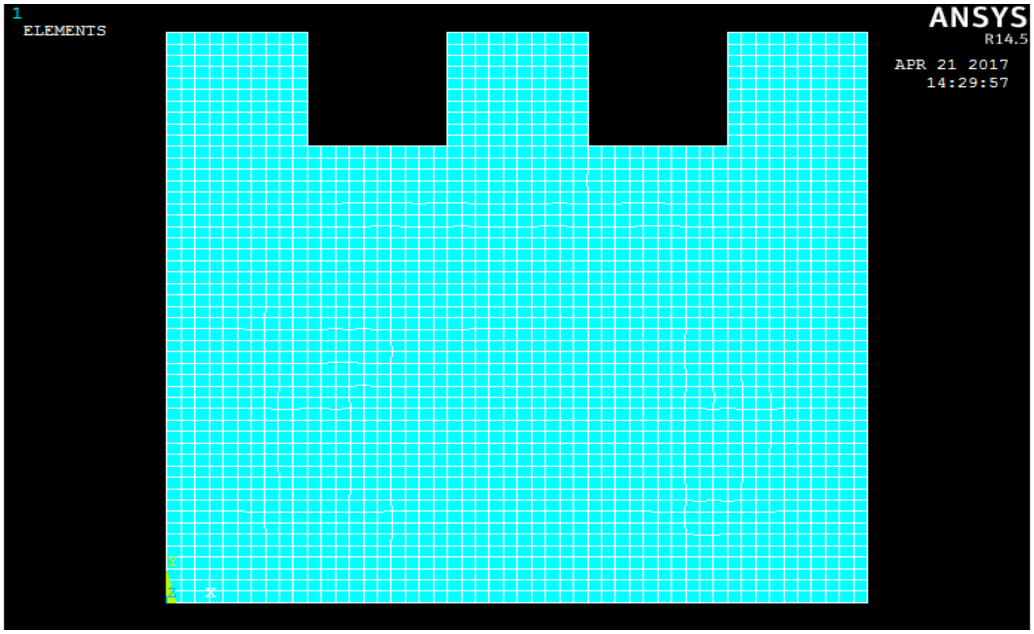

Fig. 3. Meshed area.

The temperature and heat flux contours have been obtained, for steel and copper casing with three fins. The contours obtained are shown in following figures –

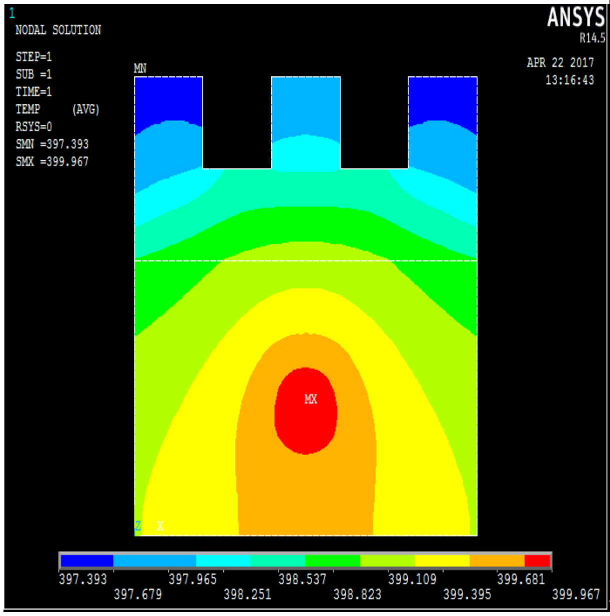

Fig. 4(a) Temperature contour for copper.

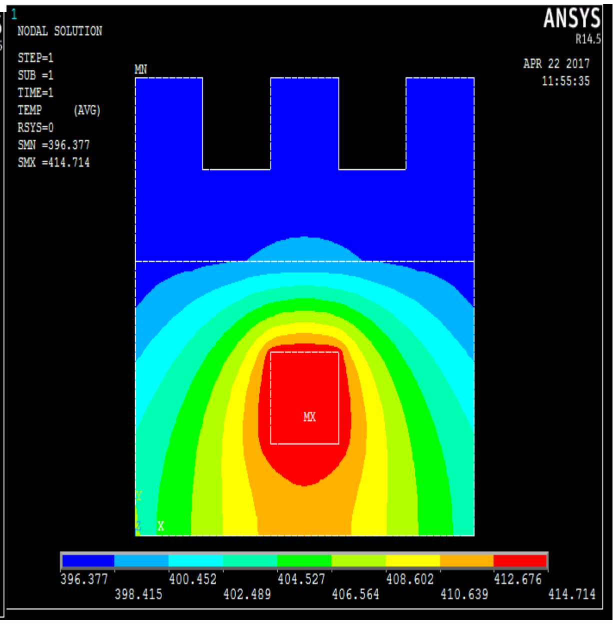

Fig. 4(b) Temperature contour for steel.

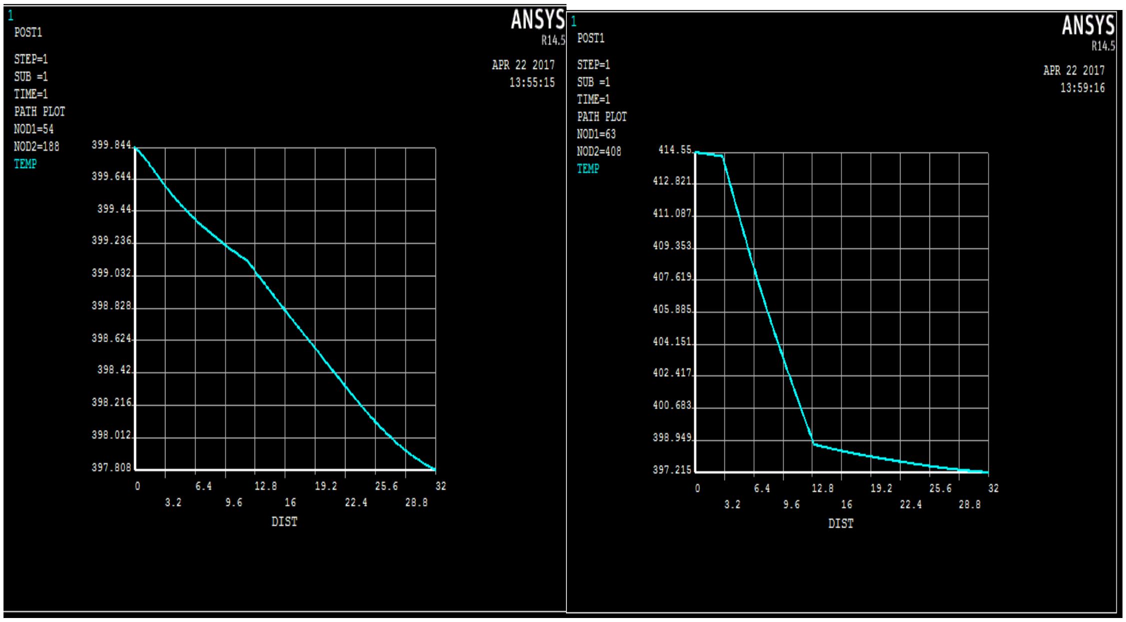

Fig. 5(a). Copper casing.

Fig. 5(b). Steel casing.

Fig. 5. Temperature vs distance graph for copper & steel casing.

As is observed from the Fig. 4 that the temperature difference in copper casing is less compared to that in steel casing. Therefore, the cooling will be better in case of copper casing as it is unable to hold heat& expel it out because of its high conductivity. The graphs shown in fig.5 also verify the results that there is a gradual decrease in temperature in copper casing compared to that in steel casing.

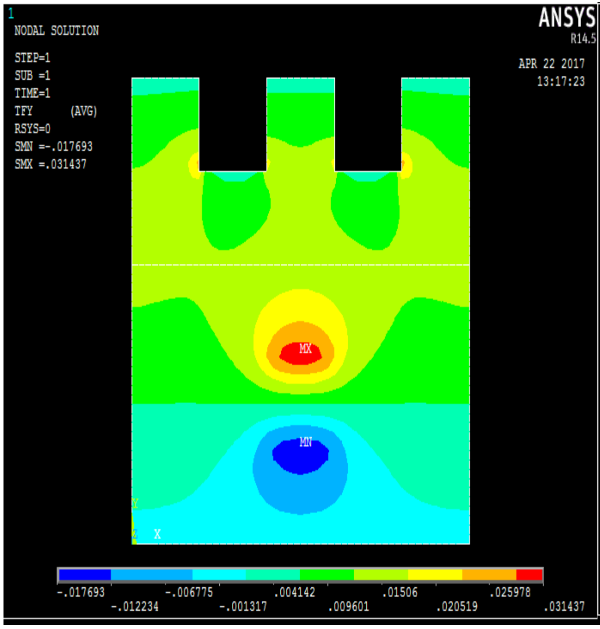

Fig. 6(a). Heat flux contour for copper.

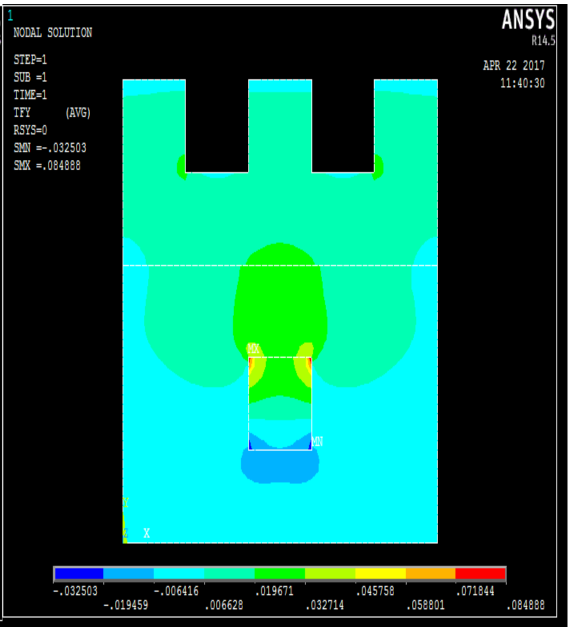

Fig. 6(b) Heat flux contour for steel Casing casing.

IV. CONCLUSION

Thermal analysis of processor is done for ensuring its optimal working. Rectangular fins of aluminum are attached to the casing enclosing the copper processor. The results have been obtained by varying the casing material (copper & steel) & a comparative study has been carried out. The temperature distribution and heat flux contours for different casing material are obtained. It is observed that the temperature difference in copper casing is less as compared to that in steel. This implies that the cooling will be better in case of copper casing as copper will be unable to hold heat & expel it out rapidly due to its high thermal conductivity. Also, the gradual decrease of temperature (with distance) in copper compared to the decrease in steel concludes the same. Thus, copper turns out to be a better alternative of steel for heat optimization of cooling of processor.

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