Fin-Set Analysis for Heat Removal Utilizing Ansys

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Abstract— Present paper discusses about heat transfer study of fin for electronics device cooling. All the electronic devices discharge heat during the work. That generated heat should be removed for proper working of the electronic device. Cooling of these heat generated devices can be done either by passive ways or active ways. Present paper emphasis on the passive (natural) ways which is fin to remove the discharge heat to the atmosphere. We assume that the electronic device is made of copper, fin is made of aluminium and the container which encloses the electronic device is made of steel. Convective conditions have been considered at the outer walls of the fin. Heat transfer coefficient of convection in the atmosphere has been considered around h=40 W/m2ºK and the ambient temperature is 27ºC.

Key words: Heat Removal, Fin-Set

I. Introduction

As we know that the every electronic equipment these days discharges heat that needs to be released. Fin serves this purpose very accurately. Fin increases the surface area and increase the amount of energy released to the atmosphere. One can observe the implementation of a fin from a two-wheeler engine to a microcontroller of small size.

II. Literature Review

Cheng et al1, studied design and analysis of LED using the finite element method for heat dissipation study. They focused their study towards the cooling of a heat Metal Core Printed Circuit Board (MCPCB) of a LED longer life. They have designed a multi-fin heat sink with MPPCB attached by fan. They have conducted the Finite Element Analysis (FEA) study of the study and talked about the LED life and temperature estimation of the chip.

Bahadur and Cohen2, conducted this study on orthotropic effect of thermal conductivity on cylindrical pin fin heat transfer. They targeted this study for polymer composites. They conducted the Finite Element Analysis (FEA) of the pin-fin and found and compared their results with conventional fins. Their study was based on the Biot number with increasing radial thermal conductivity. They studied the effect of thermal conductivity, fin height, conductivity ratio and effective conductivity of the solutions of pin-fin.

Bricault et al3, studied High power target developments at ISAC. TRIUMF, Canada’s national research facility for particle and nuclear physics is currently operating the ISAC facility. In Canada H-TRIUMF cyclotron is used to generate short-lived radioactive species in a thick target. A radioactive beam created by ion source, which into the ISAC beam lines and accelerator system. The ISAC facility in Canada has been designed to receive proton-beam-intensity up to 100μA at 500 MeV. Presently our targeted can sustains 40μA at max after target has to be cooled. A new target attached with fins has been designed which may sustain 100μA proton beams. Experiments have been conducted off-line and ANSYS has been used for thermal analysis.

Elnggar et al4, conducted experimental analysis and FEM simulation for desktop PC cooling using finned U-shape multi heat pipe. They have conducted the experiments for natural and forced convection considering heat input to be varying from 4W to 24W with velocity of air to be 1m/s to 4m/s. Effective thermal resistance and effective thermal conductivity have been calculated at the end of the run. They concluded that velocity of air and heat pipe deviate the results of the finned heat pipe by large amount and with increment in heat input and velocity of air thermal resistance decreases. They found minimum thermal resistance for 24W heat input and 3m/s velocity of air.

Galvis et al5, conducted numerical modelling of pin–fin micro heat exchanger (MHE). They studied various turbulent models by Finite Element Analysis (FEA) of a 3-D MHE. They varied the Reynolds number from 4×103 to 5×104. They found that overall heat transfer of a pin-fin heat exchanger surpasses the overall heat transfer of parallel and counter flow heat exchanger, it surpasses by 2.2 times for 8.5mm diameter pin-fin and 4 times for 0.5mm diameter pin-fin. They conducted the results for six different models SKE, RNG, NKE, GIRIMAJI, SZL and motzger and concluded that RNG gives the most accurate results compared to results obtained by other models.

Husain et al6, conducted optimization of a micro-channel heat sink with temperature dependent fluid properties. They have utilized surrogate analysis and evolution algorithm for optimization. They considered two variables based on micro-channel depth, width and fin width and set the ranges by 3D Navier-Stokes equation. They studied the heat transfer and drop in pressure and calculated resistance to thermal flow and pumping power of heat sink. They considered laminar flow in a micro-channel with temperature dependent thermal properties for water for calculation. After calculation they generate a polynomial function for the corresponding response.

Islamoglu7, conducted Numerical analysis of the influence of a circular fin with different profiles on the thermal characteristics in a ceramic tube of heat transfer equipment. Silicon carbide tube with circular fin for steady state heat transfer and thermal stress has been considered. They used the Finite Element Method (FEM) for conducting present work and determined the thermal and stress fields. They considered material to be homogeneous and isotropic means thermal conductivity remains constant with variation of the temperature. They considered convective heat transfer coefficient to be 1000W/m2 to100W/m2. They concluded that temperature at the centre line for triangular section is higher compared to the rectangular section. They concluded that temperature profile decreases with ratio of outer to inner diameter.

Kolluri et al8, conducted modelling and analysis of self-heating in fin-FET devices for improved circuit and

EOS/ESD performance. They developed an analytical model for steady state and transient condition for preheating of fin-FET. They conducted 3D electro-thermal simulation. The model they developed has been conducted for wide variety of fin-FET configurations and to improve the performance of circuit and reliability of EOS/ESD. Thermal time constant of these devices has been has been calculated by these models. They verified their results with Finite Element Analysis (FEA) results.

Zhang et al9, conducted temperature analysis of continuous-flow micro-PCR based on FEA. They conducted the study for two-kinds of flow pattern of continuous-flow micro-PCR. They used glass-glass-bonding cheap and silicon-glass-bonding cheap configuration for Finite Element Analysis (FEA). They calculated the temperature gradient and temperature uniformity on the chip surface and developed a method. Coolers by means of cycle water and one heater can realize three temperature zones for PCR reaction.

Li et al10, designed a decoupled flexure-based XY parallel micromanipulator. They conducted the dynamic and kinematic analysis of the manipulator. Using matrix method they conducted the stiffness analysis and validated it with FEA results. They conducted the dimensions optimization by means of particle swarm optimization.

III. Problem Definition

Geometry of the electronic equipment which generates heat with a set of number of fins has been drawn on the Mechanical APDL as shown in figure 1 and 2. The device which generates heat is made of copper attached to electronic device which is made of steel. Fins have been considered to be made of aluminium. Convective boundary conditions have been considered at the walls shown in figure 3, while bottom boundary is considered to be insulated.

IV. Physical Domain

Physical domain consist three parts. One part is “heat generating device” cyan blue colour, the second part is “electronic device” the sky blue colour and the third part is “fin” red colour.

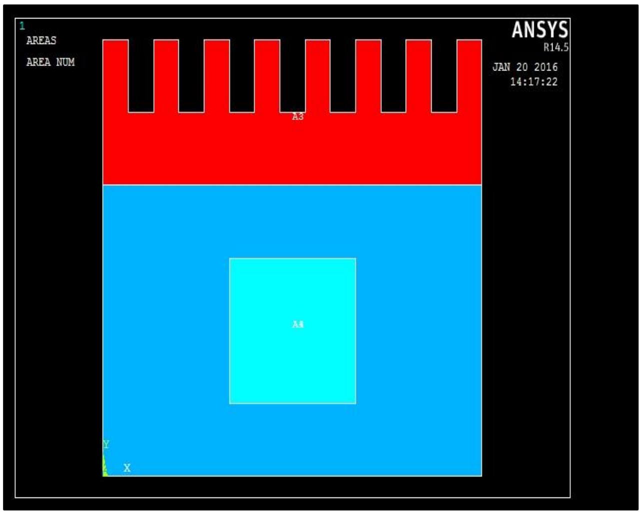

Fig. 1: Assembly of the electronic device with fin

V. Material Properties

Part	Material	Thermal Conductivity (W/m-K)
Electronic device	Copper	386
Heat generating device	Steel	20
Fin	Aluminium	180

Table.1

VI. Boundary Condition

Convective boundary has been considered at the walls of the electronic device. As convective boundary represent the actual physical scenario of the problem. Bottom wall considered to be insulated which represents no transfer of heat from the wall. One can also notice that the lines has been divided into number of parts which represents the meshing has been done for the three parts considered in the present study.

At left wall (Convective boundary)

$$q = k\frac{\partial T}{\partial x} = h(T - T_\infty)$$

At right wall (Convective boundary)

$$q = k\frac{\partial T}{\partial x} = -h(T - T_\infty)$$

At top wall (Convective boundary)

$$q = k\frac{\partial T}{\partial y} = -h(T - T_\infty)$$

At bottom wall (Heat flux boundary)

$$q'' = 0$$

VII. Governing Equation

Governing equation will be two-dimensional heat conduction equation with heat generation. As no movement of the fluid particles takes place during the heat transfer of the fluid. Only conduction heat transfer will dominate over convection and radiation heat transfer in the present problem.

$$\rho C_p \frac{\partial T}{\partial t} = k\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right)$$

A simplified form of the above governing equation can also be written as.

$$\frac{\partial T}{\partial t} = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right)$$

Where: $\alpha = k/\rho C_p$ is thermal diffusivity in m^2/s, k is thermal conductivity in W/m-K, ρ is density in Kg/m^3, C_p is specific heat J/Kg-K, T is temperature in Kelvin (K), t is time in seconds.

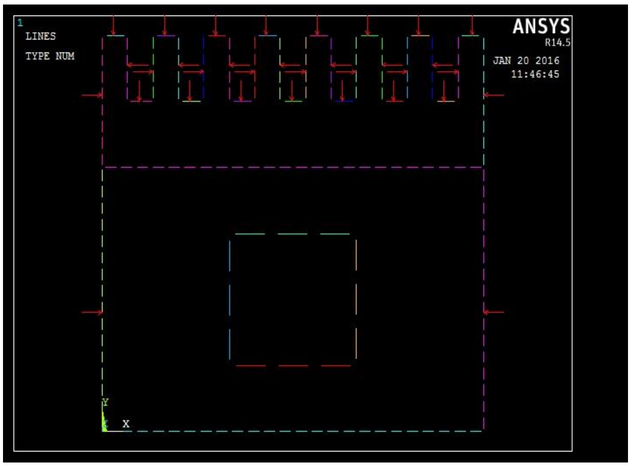

Fig. 2: Convective boundary condition on the walls

VIII. Results

Figure 3 represents the temperature distribution inside the electronic device. From the figure it can be noticed that the highest temperature is near to the centre of the electronic equipment which represents the heat generating device. It can be noticed that the lowest temperature is near the fins.

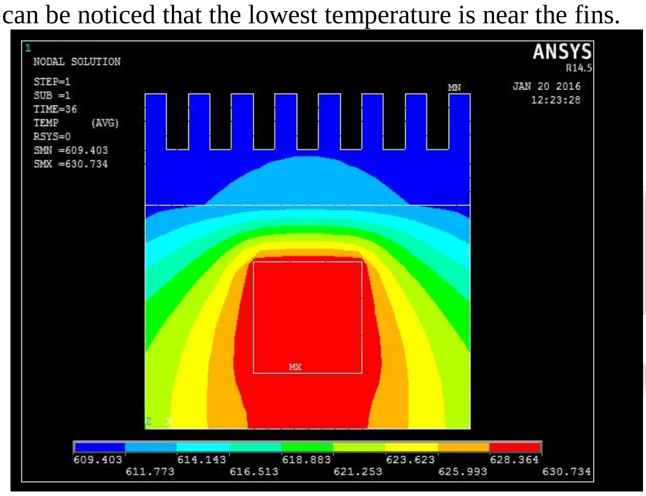

Fig. 3: Temperature distribution in the electronic device

IX. Conclusion

- Fin maximizes the heat transfer rate of the electronic device.
- Mechanical APDL can be used to study the electronic device environment.
- Effects of number of fins have been studied.
- There can be further scope of the present research.

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