COMPUTATIONAL HEAT TRANSFER ANALYSIS OF ELECTRONIC EQUIPMENT

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ABSTRACT

The Research area of engineering of the electronic system cooling is having wide application nowadays. Therefore, in the present work, Aluminum is chosen as the material for the heat sink. In the present work effect of various shapes of cross sections of fins on the mother board is studied keeping the inlet air velocity, temperature of the ambient and the heat generation constant. The optimized shape of cross section is done to analyzing the effects of velocity and inlet air temperature, keeping the other parameters constant. The results are compared and optimum operational condition of that sink is found out. The optimized shape is proceeded to find a suitable sectional area which gives a minimum temperature.

Key words: Steady State Thermal Analysis, Finite Element analysis (FEA), Heat Sink, Fluid Flow, Rectangular Pin Fin, optimization, size and cost, thermal conductivity, temperature distribution, Heat Capacity


1. INTRODUCTION

Electronic equipment has made its way into practically every aspect of modern life, from toys and appliances like mobiles to high power computers. The reliability of the electronic of a system is a major factor in the overall reliability of the system. Electronic components depend on the passage of electric current to perform their duties, and they become potential sites for excessive heating, since the current flows through a resistance is accompanied by heat generation. Continued miniaturization of electronic system has resulted in a dramatic increase in the amount of heat generation per unit volume, comparable in magnitude to those
encountered as nuclear reactor and their surface of the sun. Unless properly designed and controlled, high rate of heat generation results in high operating temperatures for the electronic equipment, with jeopardizes its safety and reliability. With the increase in heat dissipation from microelectronics devices and the reduction in overall form factors, thermal management becomes a more important element of electronic product design. Heat sinks are devices that enhance heat dissipation from a hot surface, usually the case of a heat-generating component, to a cooler ambient, usually air which is assumed to be the cooling fluid. A heat sink lowers this barrier mainly by increasing the surface area that is in direct contact with the coolant. This allows more heat to be dissipated and/or lowers the device operating temperature. The primary purpose of a heat sink is to maintain the device temperature below the maximum allowable temperature specified by the device manufacturers. Both the performance reliability and life expectancy of electronic equipment are inversely related to the component temperature of the equipment. The relationship between the reliability and the operating temperature of a typical silicon semi-conductor device shows that a reduction in the temperature corresponds to an exponential increase in the reliability and life expectancy of the device. Thermal analysis refers to the variety of techniques developed and used in which any physical property of a given product / system is continuously measured as a function of temperature. Electronic circuits, engines and machines all generate heat while they are working.

Cellular phones, also known as mobile phones or wireless phones are hand-held phones. Unlike home phones, cellular phones can be carried from place to place with minimum fuss. Mobile phones were introduced in the mid -1980s and in the last two decades their ownership and use to increase dramatically. Cellular phones are vast improvement over the telecommunication technology of the past, and are daily becoming a fixture of modern life. Apart from all advantage, cellular phones have some limitations like over usage result in health hazards. But, no other product in the market has that much demand as a cellular phone. Mobile phone has become necessities for everyday life and attracted much attention due to its great market value. Manufacturers are integrating mobile phone with more and more functionalities while making it smaller and smaller. High consuming power and compact structure combine together and a great challenge comes for thermal management engineers. Mobile phone is unique in thermal characteristics because it has not only high-power density but also limited freedom for thermal enhancement. There is a vivid description, “A kind of device without heat sink”. This means it is rather difficult to add heat sink and fan because both need space. Therefore, much emphasis is put on system analysis and design, including system numerical simulation and system.

Overheating and excessive thermal stresses are some of the issues related to heat transfer that a thermal analyst has to consider. Thermal analysis can be executed to find temperature distribution, temperature gradient, and heat flowing in the model, as well as the heat exchanged between the model and its environment. Good thermal assessments require a combination of analytical calculations using thermal specifications, empirical analysis and thermal modelling. The art of thermal analysis involves using all available tools to support each other and validate their conclusions. Applying three different and sometimes complex thermal transport mechanisms to a complex thermal product creates a system that cannot be evaluated by simple and inexpensive tools. Often the only feasible approach is to model such a product with tools created for that purpose and validate that model with empirical testing.
2. LITERATURE SUMMARY
As heat loads continue to increase in electronic devices, designers seek out more powerful and effective heat sinks to cool their electronic equipment. In many cases, designers are turning to pin fin heat sinks, which are considered to be one of the most effective heat sink technologies available in present scenario. Due to various problems faced by the conventional fin heat sinks, increased weight, more heat generation, more time in heat dissipation and many more we have concluded to design a type of fin heat sink with hollow holes in its slots.

Heat sinks with hollow profile would be providing a cost-effective heat sink solution with rectangular geometry for high and medium volume applications in like CPU motherboards, amplifiers, and many more due to reduced waste of raw material, weight reduction and low combined machining charges. Rectangular fin heat sinks with hollow geometry can be employed at minimal cost and will provide the necessary thermal heat dissipation and performance to drive a design process, high – efficiency hollow fin heat sinks will be providing efficient thermal performance with minimum cost with the versatility to get fit into variety of electronic equipment as well as other devices where effective heat sink is imperative. In this we are defining various process parameters like thermal conductivity, material type, density of fin material, film coefficient, ambient air temperature and specific heat of the selected material of the fin. [1-14]


3. MODELLING AND ANALYSIS
The dimensions of the base plate are L × W × H, where L is the length in the base plate , W is the width, and H is the height, the air flow would be from direction U (velocity of the air) . The direction of the air flow would be parallel to the x-axis. The base plate is kept at constant heat flux and the top surface of the fins is adiabatic. The heat source is idealized as a constant heat flux boundary condition at the bottom surface of the base plate. It is assumed that the heat sink is fully shrouded and the heat source is situated at the centre of the base plate. It is
assumed that the fluid temperature is averaged over the height of the heat sink, so the fluid temperature \( T \) is the mean fluid temperature. Fully developed heat and fluid flow are assumed in the analysis, and the thermal physical properties are taken to be temperature independent.

Thermal steady state, commercial software based on the finite volume method (FEM) and provided by ANSYS, Inc., is used as the simulation tool. The Geometry modeling of continuous rectangular fin heat sink, rectangular heat sink with holes and further designs of are designed in “Creo 2.0”.

For the numerical analysis, the following assumptions are assessed:

- The flow is steady and three dimensional.
- The Boussinesq approximation is used for natural convection flows.
- The direction of the gravitational acceleration is the negative \( x \)-direction.

The governing equations are as above: For the fluid phase, Continuity equation, momentum equation, energy equation given in (i),(ii) and (iii)

![Figure 3.1 Hollow rectangular fin heat sink With chip](image)

![Figure 3.2 Discontinues fin heat sink](image)

**Calculations**

To form an appropriate model for calculations, the following assumptions are made.

- The contact resistance between the heat sink and base plate would be nominal when using a high quality thermal heat sink paste.
- The average temperature of the air flowing through the heat sink would be 297 K.

Heat transfer coefficient (\( h \)) [W/m²K] over flat base plate:

Reynolds’s number \( (\text{Re}_L) = (\rho v L)/\mu \) (1) \( \text{Nu} = 0.331 \text{Re}_L^{0.5} \text{Pr}^{0.331} \) (2)

\[ \text{Nu} = \frac{h_1 L}{k} \] (3) \[ h_1 = \text{Nu} k/L \] (4)
CFD Simulation
We carried out the Simulation in ANSYS FLUENT 17.0 WORKBENCH code. The simulation procedure was started with pre-processing. Material selected was aluminum 6061, which is mainly used for manufacturing of fins. The computational mesh was generated using tetrahedral elements. In order to accurately resolve the solution fields in the high gradient regions, the grid was stretched. The discretization procedure was first order upwind scheme. A basic algorithm was utilized. For the simulations presented by us, depending on the geometry used, fine meshing was selected. The flow field and heat transfer were determined by iteratively solving the governing momentum and energy equations. The under relaxation factors were first set at low values to stabilize the calculation process, and were increased to speed up the confluence.

**Figure 3.4** Temperature contour of regular rectangular continuous fin heat sink with 2.1 m/s velocity, $T_{\text{max}} = 89.70^0C$
**Figure 3.5** Temperature contour of rectangular discontinuous fin heat sink with 2.1 m/s velocity, $T_{max} = 89.70^\circ C$

4. CONCLUSION AND FUTURE SCOPE

The results obtained from FEA simulation method as shown as above illustrates that the heat transfer rate is increasing in the discontinuous rectangular fins with holes in comparison to continuous rectangular fins heat sink and Reduction in material also results in reduction of overall weight.

The highly increased rate of heat conduction gives us the option of thermal management of electronic circuits. This thermal management is very important to control the fatigue & thermal failure of every component as the electronic circuits are being compact& the components have to place within control volume rate of heat generation, highly increased that’s way thermal management of electric circuits are important.

In this present paper Thermal FEA analysis of heat sinks which comprises of regular continuous rectangular fins, discontinuous rectangular fins and geometry with through holes for electronic cooling are examined and studied. Based on the result obtained it can conclude that in the sense of junction temperature interrupted fins are efficient than continuous. It also found that through holes for the interrupted fins has better performance than interrupted rectangular fins of heat sinks and reduction in the overall weight due to more material removal from the standard available Rectangular fin heat sinks.

In the near future, Due to the advancement in the technology this work may be preceded based on Size Optimization, Material Optimization, and Cost Optimization. Mobile Phone system can be designed and analyzed using Finite Element Analysis (FEA). In modelling and simulation works different boundary conditions can be applied with few assumptions. Due to assumptions in boundary conditions considerable scope is available to continue the research in the field of Electronics and Heat transfer.

Simulation engineering is adding value to improve its durability, reliability and robustness. By the thermal Analysis of Electronic Equipment we can Determine various thermal parameters, like heat transfer rate, Temperature distribution, Steady-state Temperatures, Thermal coefficient, cooling rate, heat flux, etc. With increasing integration of advanced functionality, mobile device power consumption is rapidly increasing. Therefore, temperature is also rapidly increasing. This method may be used to reduce the design cost, reliability since we can determine Time Vs temperature graph, Time versus flux Comparison.
flow of Heat Flux between materials by which we can design a better device with efficient cooling with miniaturization in the near future, which will be in Demand as per the present scenario.

REFERENCES


Computational Heat Transfer Analysis of Electronic Equipment


