Thermal Analysis of Aluminium- Graphite Heatsink

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Abstract:- **A heat sink is used in electronic systems as a passive component that cools a device by dissipating heat into the surrounding air. Heat sinks are used to cool electronic components such as high-power semiconductor devices, and optoelectronic devices such as higher-power lasers and light emitting diodes. Heat sinks are may be of different sizes shapes and materials. The most common heat sink materials are aluminium alloys. Aluminium alloys 6061 and 6063 are also commonly used, with thermal conductivity values of 166 and 201 W/m-K, respectively. Heat dissipation from electronic devices is more and inefficient due to their relatively low thermal conductivity. Therefore there arises a need to suggest a heat sink material that can achieve a higher rate of thermal removal than other materials. In this work, the objective is to use of aluminium-graphite composites as a heatsink. Aluminium-graphite composite thermal conductivity values are determined experimentally. Using Ansys software, heat sink made up of aluminium-graphite composite are analysed and the suitability of the material as a heat sink are checked.**

Keywords: Heatsink, Al-Graphite, thermal conductivity, CTE, Thermo- Mechanical Analyser

1. INTRODUCTION:

Several methods exist for the reduction of temperature through heat removal from active devices [1–3]. Thermal management of electronic equipment is an active area of research considering the fact that heat dissipation in electronic components has gone up many fold with every new design. The heat generated by electronic circuitry must be dissipated to prevent immediate failure and improve long term reliability. The increasing heat generation rate also add to potential reliability concerns, as failure of these systems typically results in device failures. Techniques for heat dissipation include air cooling, immersion cooling, thermoelectric cooling, heat pipes and so on. Mobile phones, digital cameras, note-books and personal digital assistants (PDA) are now available with increased functionality and compactness. The compactness is achieved at the expense of the surface area, which is critical for heat rejection. Application of active cooling techniques is limited because of additional design and power requirements resulting in higher operating costs. Increased device size and weight are also matters of concern. The limited capability of the traditional air cooling techniques in the arising complex thermal management scenario has necessitated the development of new technologies.

phase change material cooling is a very promising passive cooling technique, considering the advantages such as high specific heat, high latent heat of fusion, small volume change during phase change, availability of PCMs at convenient melting temperatures and chemical properties such as non-toxicity, inertness and non-corrosiveness. Paraffins and non-paraffins are organic PCMs, while salt hydrates and metallics are inorganic phase change materials. PCMs can be used in industrial waste heat recovery, solar thermal applications [4–6], air conditioning systems [7,8], passive heating of buildings [9–11], textile industry [12], etc. PCMs can withstand a large number of cycles and are thus ideally suited for repeated use. PCMs are selected based on their heat of fusion and melting temperatures for different applications. The PCM melting temperature should be below the maximum operating temperature of the equipment. Even so, phase change materials usually have a very low thermal conductivity, which makes charging and discharging slow during PCM melting. Using high thermal conductivity materials with fins of different geometry in conjunction with PCMs can tackle this challenge. Heat sinks can be made from extrusion or casting. Usually these are fabricated from copper or aluminium.

Many methods are available to enhance the heat transfer in a latent heat thermal storage. Alawadhi and Amon [13], investigated thermal energy management issues associated with portable elec-tronic equipment. The performance of the PCM based thermal control unit was analysed for both constant and variable power operations. Tan and Tso [14], found that the effectiveness of heat

storage unit depends on the amount of PCM that is being used, when they conducted experiments using four heaters placed on the top of the heat storage unit filled with PCM. Yin et al. [15], pre-pared a composite PCM by absorbing the paraffin into expanded graphite. In this case, the thermal conductivity improved one order of magnitude compared to pure paraffin. Zhou and Zhao [16], experimentally investigated heat transfer in PCMs embedded in porous materials.

Even though several investigations have been carried out to study the performance of finned heat sinks for thermal storage, the performance of heat sinks with fin geometry in portable electronic equipment from the view point of stretching the operating time of the heat sink has not been explored in detail till date. The aim of the present work is to use of aluminium-graphite composites as a heatsink. Aluminium-graphite composite thermal conductivity values are determined experimentally

2. EXPERIMENTAL METHODS

Experimental tests are one of the more popular ways to determine the heat sink thermal performance. In order to determine the heat sink thermal resistance, the flow rate, input power, inlet air temperature and heat sink base temperature need to be known. Figure 1 shows a heat sink application. Vendor-supplied data is commonly provided for ducted test results given in table.1. However, the results are optimistic and can give misleading data when heat sinks are used in an unducted application.

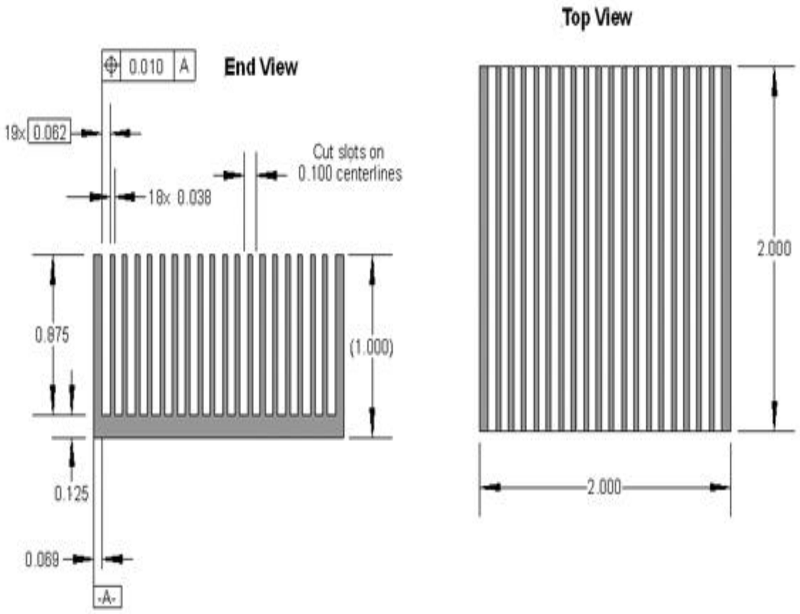

Figure 2.1 Heatsink details

Heat Sink Geometry	(in)	(mm)
Length	2	50.8
Width	2	50.8
Height	1	25.4
Base Thickness	0.125	3.18
Fin Thickness	0.038	0.97
Fin Spacing	0.1	2.54

Table.2.1 Heatsink geometry

3. DETERMINATION OF THERMAL CONDUCTIVITY AL-GRAPHITE.

The thermal expansion of Aluminium-graphite is tested with the use of a thermo-mechanical analyser. Thermo-mechanical analysis (TMA) is a technique used in thermal analysis, to study the properties of materials as they change with temperature using fig.3.1.

Fig.3.1 Thermal Mechanical Analyser

For a temperature range of 30°c to 400°c, the co-efficient of thermal expansion of aluminium graphite material is determined. The experimental setup supplies a pre-determined range of temperature to the specimen. The expansion of the specimen is measured by means of a probe when it is in contact with the specimen. Finally, plotting a graph of temperature versus the expansion of specimen gives us a curve, the slope of which is determined and hence the coefficient of thermal expansion of the material is determined. This experimental setup needs a cylindrical specimen of length of 12mm and diameter of 10mm made of the material to be tested. This is incorporated by casting and machining operations.

4. FEA ANALYSIS

Finite Element Analysis (FEA) is a fairly recent discipline crossing the boundaries of mathematics, physics, engineering and computer science. The method has wide application and enjoys extensive utilization in the structural, thermal and fluid analysis areas. The finite element method is comprised of three major phases: (1) pre-processing, in which the analyst develops a finite element mesh to divide the subject geometry into sub-domains for mathematical analysis, and applies material properties and boundary conditions. (2) solution, during which the program derives the governing matrix equations from the model and solves for the primary quantities and (3) post-processing, in which the analyst checks the validity of the solution, examines the values of primary quantities (such as displacements and stresses), and derives and examines additional quantities (such as specialized stresses and error indicators).

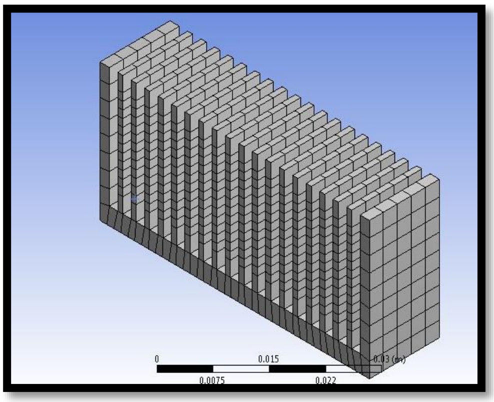

Fig.4.1 Model of heat sink

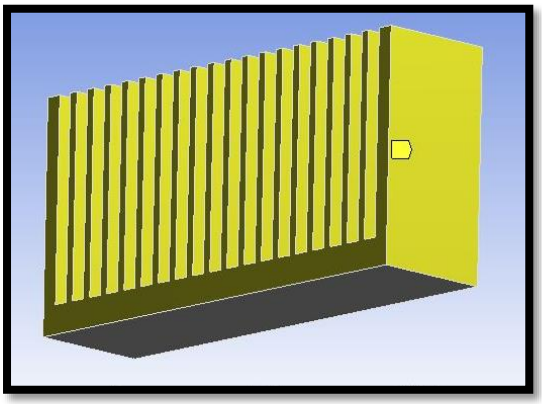

Fig.4. 2 Conduction on heatsink

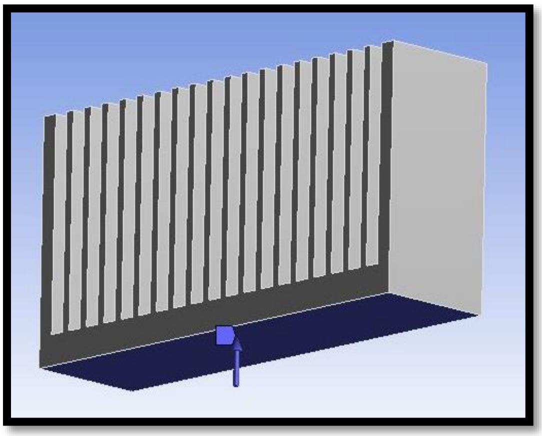

Fig.4.3 Heat flux on heatsink

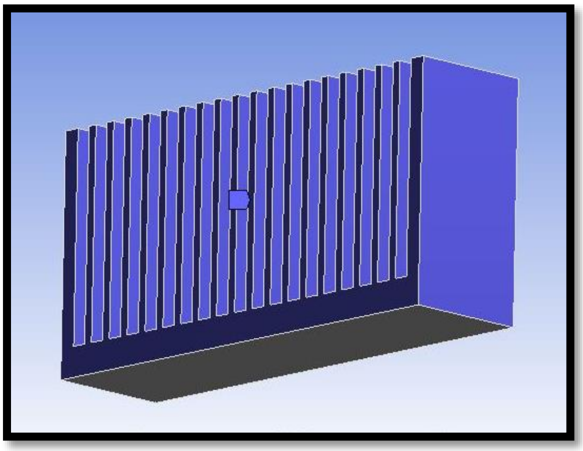

Fig.4.4 Radiation on Heatsink

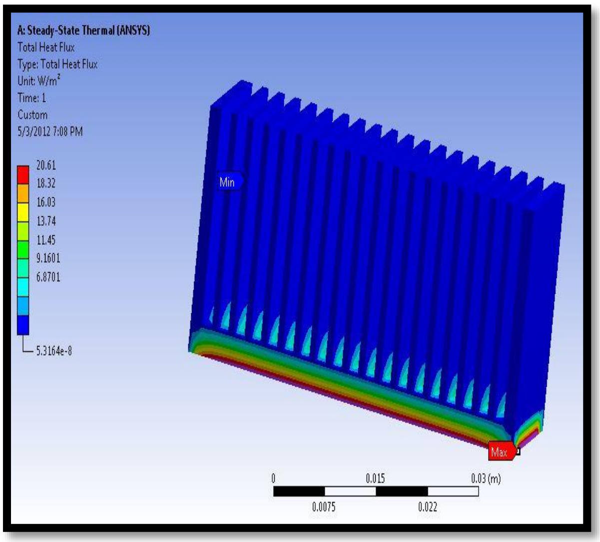

Fig.4.5 Simulation of heatsink

For the given model in fig.4.1, conduction, convection & radiation is applied to different faces of heatsink as shown in fig.4.2, fig.4.3, & fig.4.4. From the test results obtained, CTE & thermal conductivity values are used as input values for analysis. Compared to topfin surface, heat removal is fast. Heat is removed at faster rate from the base compared to fin surface.

5. CONCLUSION

For a given heat flux of 15 W/m^2 , better heat flow is possible. CTE of Al-Graphite is found to be less. Thermal conductivity obtained is higher when compared to Al-Graphite. Fins dimension can be reduced for the heatsink to be effective. The experimental results obtained holds good for the application of heat sink used in printed circuit boards.

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