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Enhancement of performance of heat sink by geometrical modification

Pradip Patil
pbp_mech@adcet.in
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra

Anil Shinde
abs_mech@adcet.in
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra

Shubham Raut
shubhamraut9c@gmail.com
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra

Siddheshwar Kumbhar
sidheshwarkumbhar7894@gmail.com
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra

Sharayu Kadam
kadamsharayu1@gmail.com
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra

Rutuja Shant
rhutujas798@gmail.com
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra

Abhijeet kadam
kadamabhijit544@gmail.com
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra

Pranav Shinde
pranav26r@gmail.com
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra

ABSTRACT

For efficient cooling of Microelectronic components, use of heat sink has emerged out to be one of the promising cooling techniques. Due to its exceptional features like good transfer heat coefficient, need of less coolant, compact size and higher surface area to volume ratio. It has gathered great attention especially in the recent two decades because of its outstanding advantages such as large heat transfer coefficient, low coolant requirements, small size, and high surface area-to-volume. Experimental, theoretical and numerical studies have been carried out to observe the heat sink performance. Firstly, a standard heat sink is chosen and its properties are noted. A similar heat sink is designed in CATIA and simulated over certain boundary conditions on COMSOL Multiphysics. After validation of both the results, different geometries of heat sink which are subjected to give better performance are designed and simulated. Simulations on modified geometry of interrupted wavy fin profile are conducted on COMSOL. The heat sink with greater performance is to be selected. It is observed that the heat sink with interrupted wavy fin profile design delivers better performance. It reduces the temperature of a 15* 15 mm heat sink by 3.75^{0}C provided the velocity of air is 1.5 m/sec. Due interrupted wavy fin profile there is formation of vortices which consequently results in increased air circulation. This leads to better cooling of heat sink.

Keywords— *Interrupted Fin, Wavy Design, Heat Transfer Coefficient, Thermal Management*

1. INTRODUCTION

Thermal management of electronic devices is a major challenge today. Due to large scale development in electronics and information technology, stacks of data are processed at an unbelievable speed. Consequently, it leads to increase in heat flux generation and increase in heat density per unit volume. The competitive market demand has resulted in miniaturization of electronic components creating an imbalanced distribution of power. Due to this, electronic devices deliver undesirable performances and are mostly prone to early failure. In order to cope up with this, heat sinks play a vital role in electronic devices/systems by achieving thermal cooling. A lot of researches have been carried out to increase the performance of heat sink for efficient cooling of electronic devices.

2. MODEL DESCRIPTION

The electronic component which is present in an electronic circuit which is responsible for dissipating heat from components like transistors into the surrounding air is called as heat sink.it improves the reliability and performance of components.it also prevents the premature damage of electronic components. It takes the help of cooling fan to dissipate the heat.

3. HEAT SINK PRINCIPLE

Fourier's law of heat conduction states that if temperature gradient is present in a body, then the heat will transfer from a high-temperature region to low- temperature region. And, this can be achieved in three different ways, such as convention, radiation and conduction. Heat sink is known for transferring of thermal energy from a higher temperature region to lower temperature region. Usually, the lower temperature region is taken as air.

4. APPLICATION
To decide the application for which the heat sink is to be designed, various electronic components/sub components were studied in details. Microprocessors, transistors and chips were prominent amongst the electronic components that were observed. A chip used in computer system is prone to premature failure very early as compared to microprocessor. The reason is that Computer processors are designed to run at high temperatures and it's completely normal for a CPU to heat up and to actually get very warm .As electricity passes through the CPU or gets blocked inside, it gets turned into heat energy thereby affecting the chip. So the application selected was – CHIP. It was a challenging application due to its small size.

5. HEAT SINK SELECTION
As per the chip requirement , an aluminum alloy 6063 heat sink with base 15*15 mm and height 10 mm was selected. It composed of 8*8 Fins.AL6063 has thermal conductivity of 201 -218

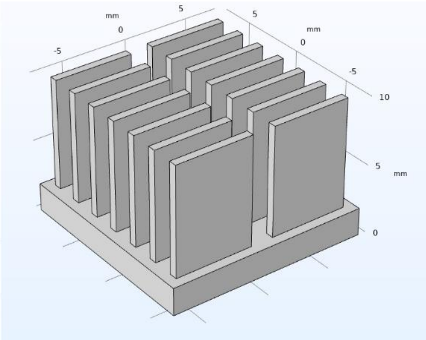

Fig. 1: Standard heat sink for comparison

As per simulation conducted on COMSOL multi-physics software for the above standard heat sink the following results are listed in the table .

Velocity m/s	$TR_{STD\ W/^oC}$	TMax ^{0}C
1	9.2	123.65
1.5	8	100.3

Calculated by,

Thermal resistance = (Tmax -amb temp) / heat rate

By conducting simulation on 15*15 heat sink and observing the values mentioned in above table. It is found that the value of thermal resistance is provided in the data sheet. Thermal resistance is calculated with help of simulation within 10%.Within 10% error in the results indicate that the values and physics used for simulation are correctly conducted. So, the further geometrical modifications are done on the 15*15 heat sink by considering same physics used for simulation.

6. GEOMETRICAL MODIFICATIONS OF HEAT SINK
From the literature survey, number of modifications having potential to increase the performance of considered heat sink was noted. First step in modification of heat sink is the selection of proper material for the heat sink. the material that is to be selected should have high thermal conductivity , copper has higher thermal conductivity 398 W/mK. However, it is very expensive to use . so, Al 6063 with thermal conductivity of 201W/mK is selected for modification. The interrupted wavy fin profile was designed and re-modified by changing width, height, number of fins and other geometrical parameters. The CATIA designs of the modifications and simulation are described below.

6.1 Modification of wavy interrupted fin design
Horizontal straight fins are modified in horizontal wavy fin so that the surface area of the fins increases without increasing length of the fin. The angle between two wavy fin is 150 degrees with 7 fins having 14mm length. The spacing between two fin is 1.55 mm .In horizontal wavy fin two interruption are provided to convenient flow of air.

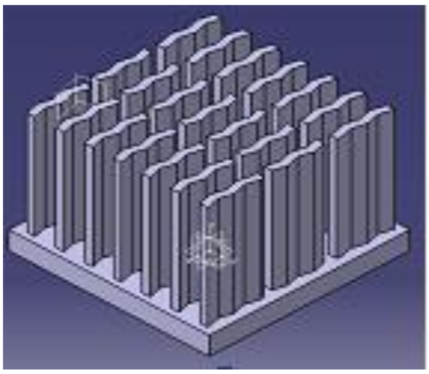

Fig. 2: Wavy Interrupted fin design

7. ANALYSIS OF WAVY INTERRUPTED FIN

Following are the reults of modified heat sink

Table: Results of wavy interrupted fin

Velocity [m\s]	Heat source [W]	Tmax [degC]	TRc [DegC\watt]
1	10	119.90	9.64
1.5	10	97.30	7.63

8. RESULT AND DISCUSSION

With the help of comsol mutiphysics , simulations are conducted by changing the air velocity. Value of the temperature and thermal resistance is given below. After simulation we got minimum results than standard results

8.1 Results deliberation for wavy interrupted fin heat sink

The following table shows the comparison of result between standard heat sink and wavy interrupted fin. The temperature is lowered by 3.75^0C than standard company heat sink.

Table: Comparison of standard heat & wavy interrupted fin

Velocity [m\s]	Heat source [W]	Heat flux [W\m^2]	Tmax [degC]	TRc [DegC\watt]	Tmax std [DegC]	Tmax- Tmax std[DegC]
1	10	10	119.90	9.64	123.65	3.75
1.5	10	10	97.30	7.63	100.3	2.7

9. CONCLUSION

By performing modifications on wavy interrupted heat sink substantial difference in temperature was observed. The following conclusions were drawn out -

(a) Due to the wavy interrupted fin geometry ,better air circulation was observed reducing the pressure drop. Due to better air circulation and increased surface area due to a greater number of fins, better cooling of the heat sink body was observed. Heat transfer coefficient was observed to be high.
(b) Increase in the number of fins, increases the surface area of heat sink and thereby the Nusselt number increases.
(c) In case of wavy interrupted fin heat sink, 3.75 ^{0}C reduction in temperature as compared to standard heat sink was obtained. This ensures better cooling of electronic system with use of wavy interrupted heat sink.

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