"STEADY STATE THERMAL ANALYSIS ON HEAT SINKS HAVING DIFFERENT TYPES OF RECTANGULAR FINS USING CFD"

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ABSTRACT

This paper introduces the way of heat extraction from heated sink by using different shapes of fins under natural convection. Finned heats sinks are used to cool power electronic Components. The shape which is used is of Hollow Rectangular Fins with Different perforations such as rectangular, square, circular and elliptical. The heat sink i.e. base is of dimension (l×b×h) 70×60×10 mm and height of the fin is 70 mm. As per industrial demand there are numerous of research are going on to enhance the thermal t ransmission from the surface of the he at sink through fins and this is done by increasing the contact surface area. The Perforations on the hollow fins are done to achieve the maximum contact surface area. This results in improved rate of heat dissipation from the surface of the fin. All the fins are designed using CATIA V5 and the thermal properties are analyzed by using ANSYS R13 Workbench. The main aim of this research is to observe variation of thermal properties such as temperature distribution, total heat flux and direction heat flux over the different shapes of fins having different perforations. Here aluminum is selected as fin material as it is lighter in weight as well as good thermal conductor.In this study, a literature review was first conducted in order to better understand the subject and shed light on the continuation of the study.Heat sink used with solid type of fins but construction of fins in different holes and taper size, it will increase the heat transfer area. So in present thesis different fins with different holes and taper in nature are introduced with fillet and analysis is done for the same.

1.INTRODUCTION

In present scenario of technology, thermal management of electrical and electronics devices or in mechanical systems are most important component during its working. As far as the electronics devices, the heat dissipation and temperature distribution is important for proper working of device. In present era heat sinks are widespread component for managing the heat of circuit or chip of electronics devices.

By definition heat sink is basically a heat sink is a part which enhances the heat distribution of part as well as enhances the heat flow away from the hot component. This is done by either enhancing the heat flow surface area or increasing the flow of the fluid or both of it as per the requirement of the part. As per the device installation type the heat sink is designed as per the requirement of the devices. Heat sink basically used to increases the heat flow of component and reduces the temperature of installed component by increasing surface area. A heat sink worked on following steps and accomplished its working. First the heat generation source which generated heat and dissipated the heat constantly from the working component. Components may be electrical, mechanical chemical or solar use.

PRINCIPLE OF HEAT SINK

The basic principle of heat sink working is based on heat conduction Fourier Law where temperature gradient is proportional to the heat dissipated and as per law of conduction flow of heat is always higher to lower. As per the conduction theory objects in contact, there is collisions in molecules level, and in result of energy transfer occurs.

On the basis of Fourier's conduction principle, the equation for heat transfer rate and temperature gradient with surface area is as follows: $\mathbf{Q = -kA(dT/dx)}$ **(1)**

in steady state condition and applying the Newton's principle of cooling the equation for heat sink is as follows :

$\mathbf{Q = mc_{pin} (T_{air,outside} – T_{air,inside})}$ **(2)**

$\mathbf{Q = (T_{hs} – T_{air,average})}$ **(3)**

As per the above equations, $\mathbf{T_{air,average} = ((T_{air,outside} + T_{air,inside})/2}$ **(4)**

'm' corresponds to the mass flow rate of air measured in kg/s

$c_{p,in}$ corresponds to the heat capacity of the air that flows inside measured in J/(kg $mc_{p,in}$ C)

Rhs corresponds to the thermal resistance value of the heat sink

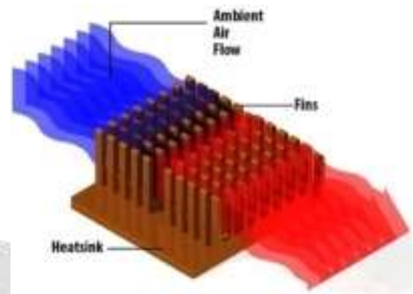


Figure 1.1 Heat Flow in Heat Sink

TYPES OF HEAT SINK Heat sinks are mainly distinguished into three types:

i)active heat sinks **ii) passive heat sinks.** **iii) Hybrid heat sinks**

.**i)**In passive type heat sinks, heat transfer is done by convection type where air circulated and this airflow carried the heat away from the system . The main advantage of system is absence of secondary control or power source and its makes passive sinks more efficient than active sink .

ii) active heat sinks used the forced convection concept to carry heat from the device. By means of forced air the fluid flow actively take all heat across the device and this hot air generated by means of blower or fan.

iii)In third type of heat sink where combination is used to achieve higher heat transfer is Hybrid heat sinks**.** This is basically non conventional type system where a control system is installed and it is continuously feedback the temperature monitoring

FACTORS AFFECTING HEAT TRANSFER PERFORMANCE OF HEAT SINK

Factors which are involve in affecting heat transfer performance of heat sink are as follows:

1. Thermal Resistance of material 2. Airflow through the heat sink 3. Density of fins installed 4. Spacing of fins 5. Width and length of fins

2. LITRETURE REVIEW

R.C. Adhikari et al. [1] investigated the rectangular fin optimization with natural convection cooling by using computational fluid dynamics. Researcher focused on the combine effect of the spacing between the height and length of the fin. There is more heat dissipiation in per unit base area according to fin spacing, length and height of fin.

Ambarish Maji et al. [2] In this literature pin fin are arranged in various shapes and prime findings are related to thermal transmission of perforated fin is more than solid fin. Paper also concluded about different shapes of fins like diamond circular and elliptical type thermal transmission.

Vidyadhar Karl apalem et al. [3] researches about perforated branching fins where two orientations, vertical and horizontal used. The size of perforation varied from 1. 1 mm to 6.6 mm results showed better orientation in vertical base and higher thermal dissipation.

Ambarish Maji et al. [4] investigated about perforated fins with different materials using computational fluid dynamics. Overall performance of copper is best among different materials. As comparison with aluminum, copper has greater thermal transmission with the perforation diameter increased up to 3mm. Also concluded that drop of pressure in heat sink is decreased with increase in size of perforation. Perforated fin having better thermal efficient than solid fins and heat dissipation is depends upon the material.

Ambaris h Maji et al. [5] reviewed the improvement of heat transfer using the different types like perforated and porous. In this review researcher concluded about the porous fin dissipate better heat as compare with the solid fins. Perforated fins have better contact area with the different fluid. Also there is different geometries and different materials like high speed steel, copper and aluminum influenced the heat transfer of the fin. Different parameters like Reynold number, Nusselt number and drop in pressure also concluded the better performance as compare with solid fins. Smaller size perforation fin having better thermal transmission.

Agnihothra Sarma O, A Ramakrishna [6] investigate the pin fin heat sink selection by using computational fluid dynamics. Different results obtained from research, jumction temperature of splayed pin fin are efficient. Hybrid pin fin heat sinks create better heat transfer and more efficient than copper and aluminum pin fin.

Christopher L.Chapman, Seri Lee, Bill L.Schmidt [7] did a series of investigation on the thermal performance of elliptical pin fin heat sink, cross cut pin heat sink and straight fin heat sink. The overall performance of elliptical pin fin heat sink is compared with the Straight and cross cut fin heat sinks.

3. RESEARCH METHODOLOGY

COMPUTATIONAL FLUID DYNAMICS (CFD)

CFD is a method relates to numerical calculation and used to different fluid dynamics problems. In this method, analysis is done by dividing the space into small volume parameters and considering these small volumes as an element of numerical analysis. By use of mathematical models, it is possible to simulate all phases of matter like solid, liquid and gas. Basically computation fluid dynamics is also applicable for problems related to static and dynamics parts both. CFD method also gives flexibility to do different steady flow problem analysis and turbulent flow model analysis..

4 MESH DETAILS & RESULTS

GRID VIEW In figure 4.1 there is data related to circular fin model associated with the base paper. In present research work, model regenerated and the **number of nodes and elements are 8897 and 4504** respectively.

RESULTS.

Figure 4.1 HOLLOW RECTANGULAR FIN WITH ELLIPTICAL HOLE BASE

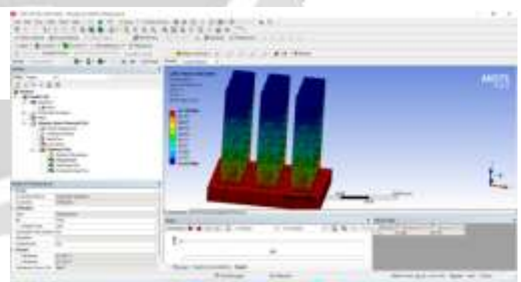


Figure 4.1 showed the The maximum value of temperature is 65.7^{o}C and minimum temperature is near about 61.02^{o}C where higher temperature at base and lower temperature occurred in upper part of fin parameter

4.2 HOLLOW RECTANGULAR FIN WITH ELLIPTICAL HOLE BY REDUCING 1MM THICKNESS THROUGH INNER DIA

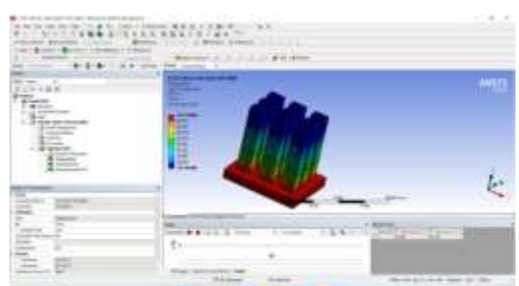
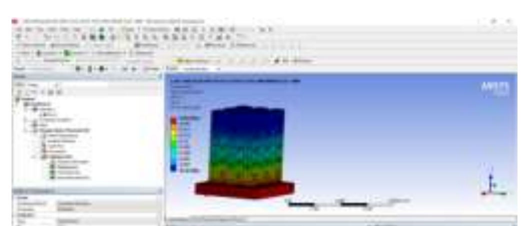


Figure 4.2 showed the temperature profile, where higher temperature at base and lower temperature occurred in upper part of fin parameter. The maximum value of temperature is 65.13^{o}C and minimum temperature is near about 59.17^{o}C



4.3 HOLLOW RECTANGULAR FIN WITH ELLIPTICAL HOLE BY REDUCING 1MM THICKNESS THROUGH INNER DIA WITH 1MM FILLET RADIUS

Figure 4.3 showed the the maximum value of temperature is 64.66^{o}C and minimum temperature is near about 59.30^{o}C.

4.4 HOLLOW RECTANGULAR FIN WITH ELLIPTICAL HOLE BY REDUCING 2 MM THICKNESS THROUGH INNER DIA WITH 1MM FILLET RADIUS

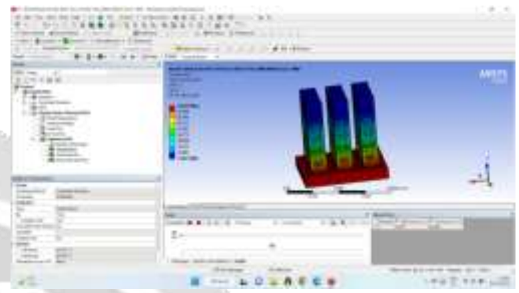


Figure 4.4 showed the temperature profile where the maximum value of temperature is 64.39^{o}C and minimum temperature is near about 57.87^{o}C.

4.5 RECTANGULAR FIN WITH ELLIPTICAL HOLE WITH 2MM INNER TAPER PROFILE

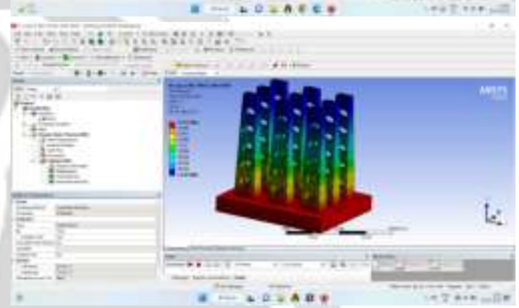


Figure 4.5 showed the maximum value of temperature is 75.157^{o}C and minimum temperature is near about 67.491^{o}C, where higher temperature at base and lower temperature occurred in upper part of fin parameter.

4.6 CIRCULAR FIN WITH 2MM INNER DIA TAPER PROFILE

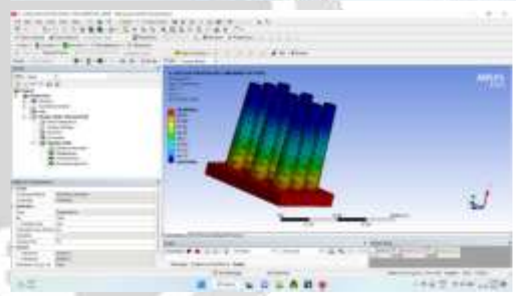


Figure 4.6 clearly showed the temperature distribution where the value varies from maximum 68.9 ^{o}C to 64.04 ^{o}C

4.7 RECTANGULAR FIN WITH ELLIPTICAL HOLE BY REDUCING 3 MM THICKNESS THROUGH INNER DIA. AND 1 MM FILLET RADIUS

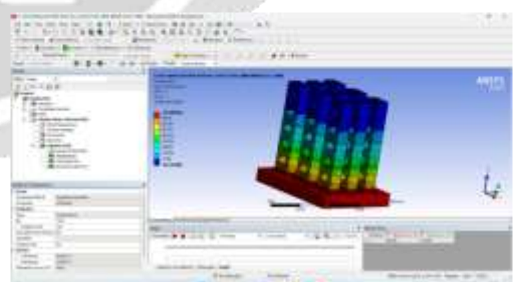
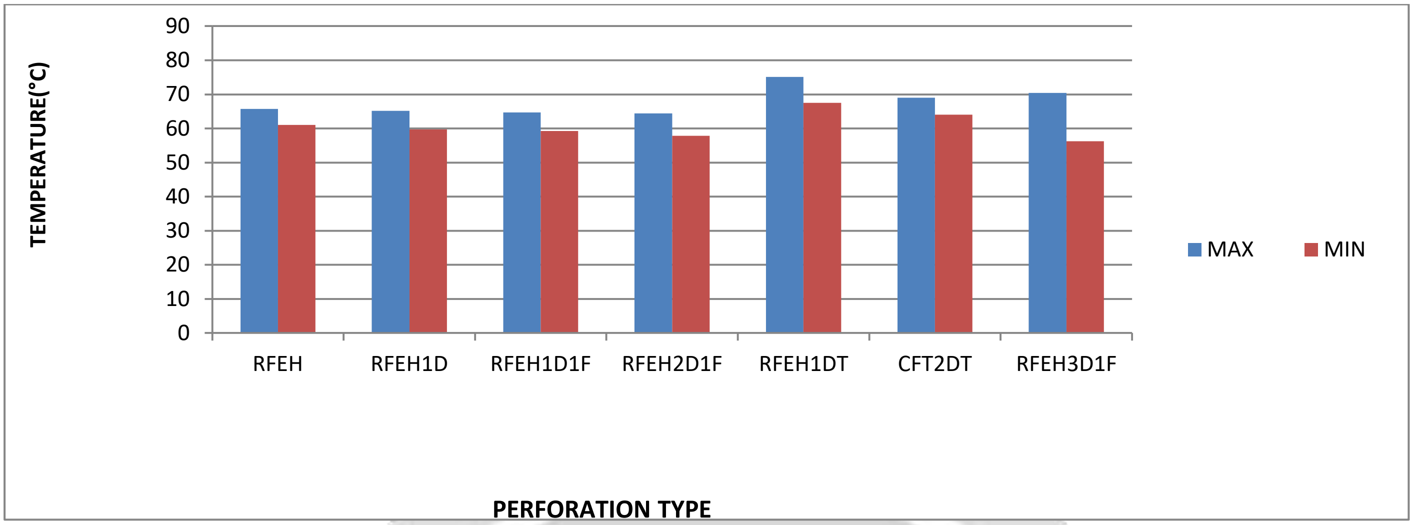
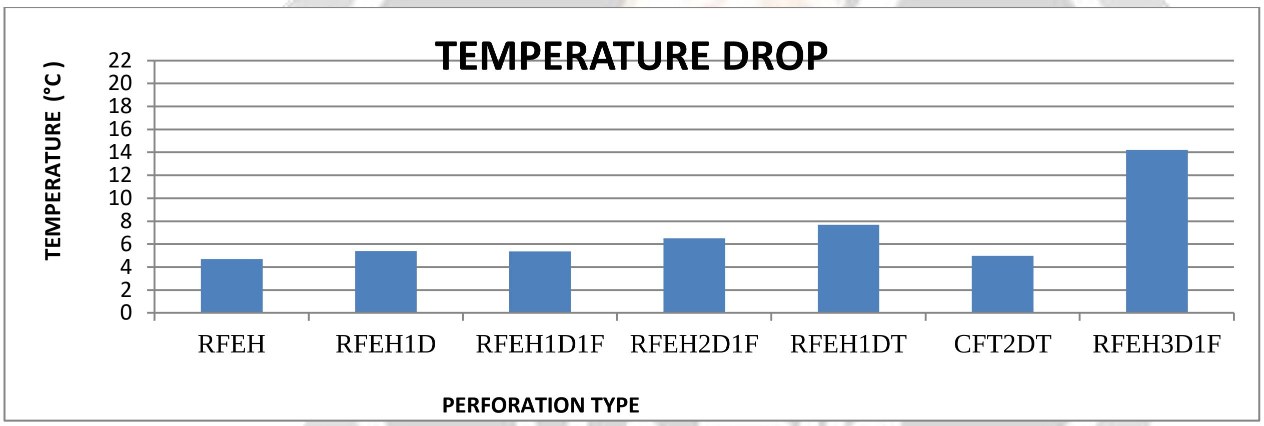


Figure 4.26 showed the Temperature Distribution where higher temperature at base and lower temperature occurred in upper part of fin parameter. The maximum value of temperature is 70.448^{o}C and minimum temperature is near about 56.242^{o}C.

RESULT ANALYSIS



GRAPH SHOWING TEMPERATURE DISTRIBUTION ANALYSIS OF RECTANGULAR FINS WITH BASE AND PERFORATION TYPE



GRAPH SHOWING TEMPERATURE DROPS OF RECTANGULAR FINS WITH PERFORATION TYPE

Rectangular Fin Elliptical Hole	RFEH
Rectangular Fin Elliptical Hole 1mm thick	RFEH1D
Rectangular Fin Elliptical Hole 1mm thick 1mm fillet	RFEH1D1F
Rectangular Fin Elliptical Hole 2mm thick 1mm fillet	RFEH2D1F
Rectangular Fin Elliptical Hole 1mm thick Taper	RFEH1DT
circular with 2mm thick Taper Dia	CFT2DT
Rectangular Fin Elliptical Hole 3mm thick 1mm fillet	RFEH3D1F

5. CONCLUSION AND FUTURE SCOPE

Heat sink of hollow Rectangular fin with elliptical hole among all the fins with different perforations has more thermal transmission rate because the maximum temperature drop is found for Heat sink of hollow rectangular fin with elliptical hole with 3mm variation in inner dia with 1mm fillet design which is near to 14° C. As fins are hollow and perforated, increase the contact surface area of fluid medium with its surface. This is also due to the increase of porosity. Porosity of heat sink is the volume fraction of air inside the heat sink.

1. There no significant changes in respective directional heat flux and total heat flux.
2. Hollow fins manufacturing required less material and more efficient than the solid fins heat sink.

By CFD analysis following conclusions were made.

Due to light weight and better thermal conductivity aluminum selected for heat sink material.

For better condition output the ambient temperature taken as 45^{o}C. the inlet velocity taken as 12.m/s for better air flow condition which is constant in throughout the analysis.

FUTURE SCOPE

(1)Perforation can be made with different sets of geometry, for better flow of heat air foil shape can be used for hole.
(2) Different materials and alloys with higher conductivity can be used for CFD analysis.
(3) CFD results can be used as bench mark and practical manufacturing can be done with different material.

6. REFERRENCE

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