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CFD Analysis and Optimization of Pin Fin Heat Sink

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Abstract : In the present paper, the 3-dimensional CFD simulation of heat transfer and air flow in circular pin fin heat sink are presented for Electronic component cooling application. The circular pin fin heat sink are simulated for different alloys like Aluminium alloys i.e.6063-T83, 7075-O(SS) and Copper alloys i.e. Chromium Copper. In this study comparing the heat transfer rate with respect to different alloys under Natural Convection. The goal of this study was to maximize the thermal performance of heat sink with respect to different material such that it helps to finding material selection, low cost material and good heat transfer rate for designing the heat sink.

Index Terms: Pin fin Heat sink, material optimization, CFD, Natural convection, thermal performance, solid works

1. Introduction

Power dissipation of electronic components are increasing and more and more electronic packages are requiring some form of thermal enhancement to adequately cool the components. One of the commonly used methods of improving thermal performance is to use heat sinks. In number of applications, such as UPS, Inverter, Thermo-electric generator etc. Air flow Velocity and direction are not very well defined or controlled such application require heat sink that are not sensitive to air flow direction pin fin heat sinks are one of the types that are not sensitive to air flow direction and are widely used in electronic applications.

This paper presents the results of a study to optimize the material of pin fin heat sink for use of electronic component cooling applications that is UPS, Thermo-electric generator etc. The goal of this study was to maximize the thermal performance. It was conclude that Maximum temperature has been found out for plate fins which is 53.062 °C and Maximum Temperature is found out for Fins With circular pin fin which is 71.677 °C [1]. Circular pin fin heat sink displayed higher heat transfer rate than the plat fin heat sink [2]. The overall performance of the six different heat sinks with different shaped pin-fin structures was studied in this paper for different velocities varying from 5, 10 & 12 m/s [3]. Heat sink with Rhombus prism pin fins (HS-RPPF) is found to be more effective in dissipating heat compared to other configuration of fins [4]. The results obtained for heat sink with rectangular pin fin have been established by comparing the FEM and analytical techniques [5]. As the number of fins were increased, the total heat transfer rate also increases [6].

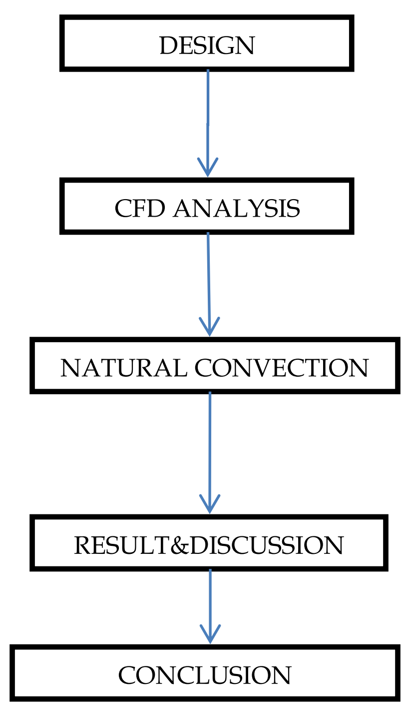
2. RESEARCH GAP

Many of project work concentrated on design optimization of heat sink but in this study concentrated in material optimization. Materials used in this work are alluminium alloys i.e.6063-T83, 7075-O(SS) and Copper alloys i.e. Chromium Copper. These types of materials not used in many of project work.

3. OBJECTIVES

Designing and analysis of the pin fin heat sink by using solid work. Study of heat transfer rate with respect to different material .To study the heat transfer rate of heat sink pin fin under Natural convection.

4. METHODOLOGY



5. MATERIAL PROPERTIES

a. Al 6063-T83

Property	Value	Units
Elastic Modulus	69000	N/mm^2
Poisson's Ratio	0.33	N/A
Shear Modulus	25800	N/mm^2
Mass Density	2700	Kg/m^3
Tensile Strength	255	N/mm^2
Yield Strength	240	N/mm^2
Thermal Expansion Coef-ficient	2.34e-05	/k
Thermal Conductivity	201	W/(m-k)

b. Al 7075-O(SS)

Property	Value	Units
Elastic Modulus	71999.9	N/mm^2
Poisson's Ratio	0.33	N/A
Shear Modulus	26899.9	N/mm^2
Mass Density	2810.00	Kg/m^3
Tensile Strength	219.9	N/mm^2
Yield Strength	94.9	N/mm^2
Thermal Expansion Co-efficient	2.4e-5	/k
Thermal Conductivity	173	W/(m-k)

c. Chromium copper

Property	Value	Units
Elastic Modulus	130000	N/mm^2
Poisson's Ratio	0.181	N/A
Shear Modulus	50000	N/mm^2
Mass Density	8890	Kg/m^3
Tensile Strength	379	N/mm^2
Yield Strength	97	N/mm^2
Thermal Expansion Coefficient	1.76e-05	/k
Thermal Conductivity	323.4	W/(m-k)

6. DESIGN OF HEAT SINK MODEL

a. Circular pin fin heat sink

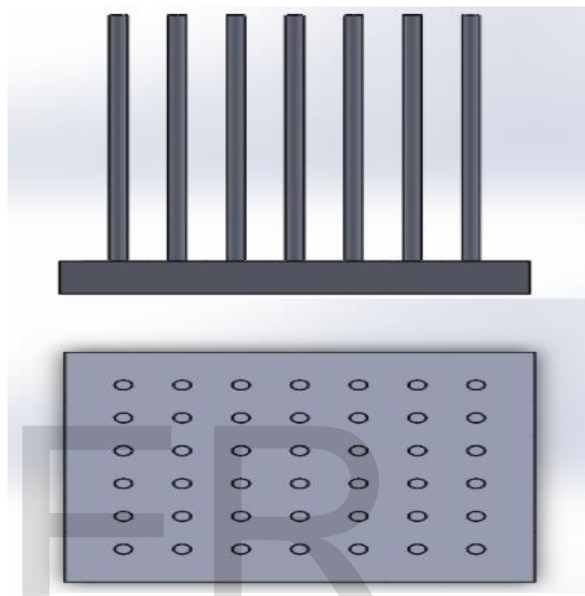


Fig 1: Front and top view

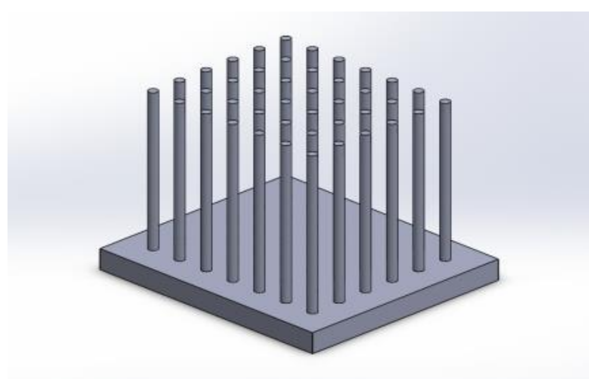


Fig 2: Isometric view

b. Heat Sink Model Dimension

7. ANALYSIS OF HEAT SINK MODEL

a. Meshed model

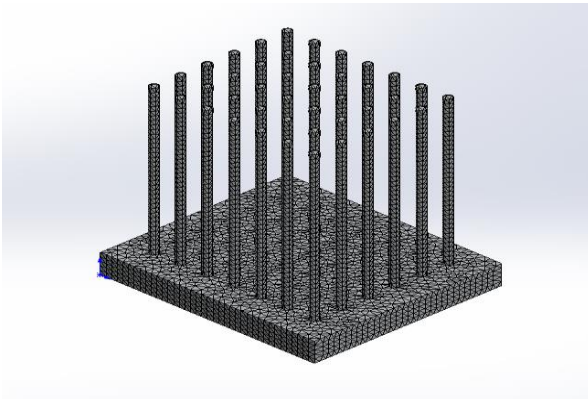


Fig 3: Al 6063-T83

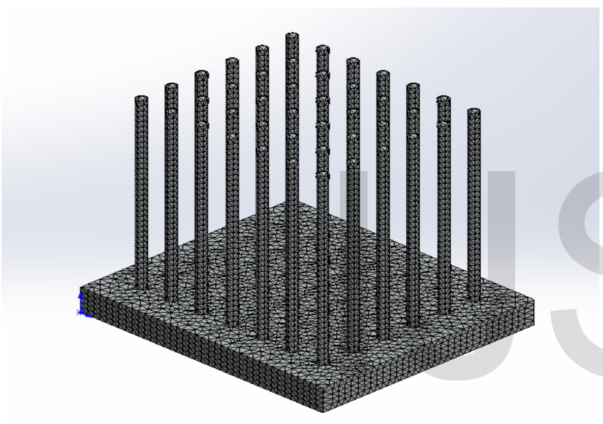


Fig 4: Al 7075-O(SS)

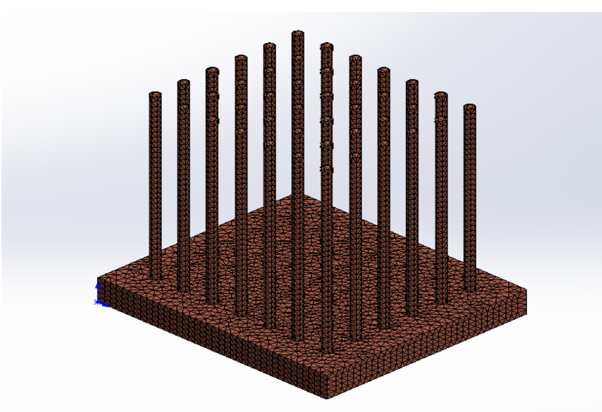


Fig 5: Chromium Copper

a. Applying Boundary Condition to Model

i. Assumed data

Physical Parameters	Values
Base Temperature	100°C
Ambient Temperature	30°C
Heat transfer Coefficient(H)	10W/m²°C

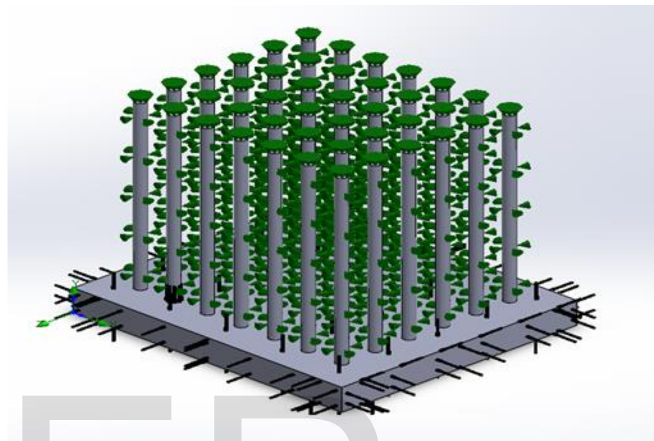


Fig 6: Boundary Condition to Model

8. RESULTS AND DISCUSSION

a. Temperature distribution of pin fin heat sink

Sr. No.	Model Dimensions	Values (mm)
1	Base Dimension (L×W)	80 x 70
2	Base thickness	10
3	Diameter of circular Pin fin	3
4	All Fins Length	75
5	Gap between fins	10

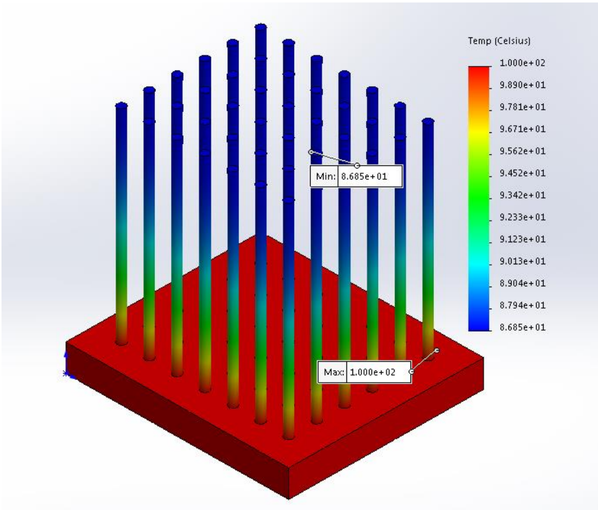


Fig 7: Temperature distribution of Al 6063-T83

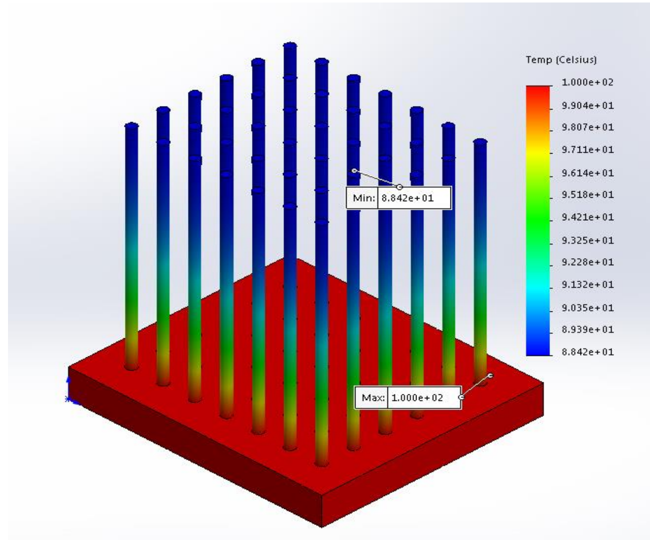


Fig 8: Temp. distribution of Al 7075-O(SS)

Materials	Maximum Temp. (°C)	Minimum Temp. (°C)	Total Temp. drop (°C)
Al 6063-T83	100	86.85	13.15
Al 7075-O(SS)	100	88.42	11.58
Chromium Copper	100	86.72	13.28

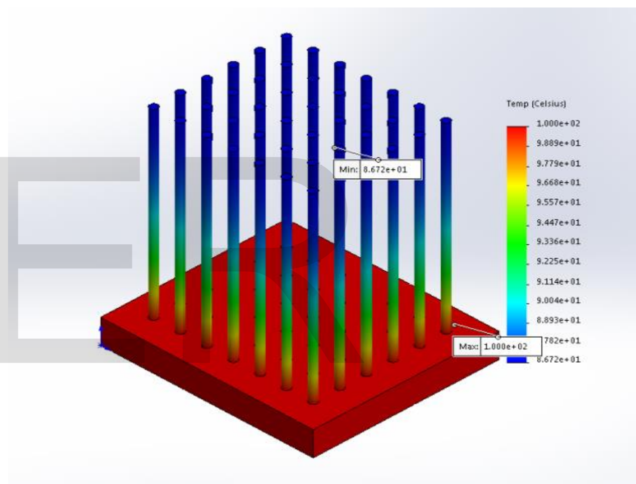


Fig 9: Temperature distribution of Chromium Copper

b. Table shows maximum and minimum temperature variation

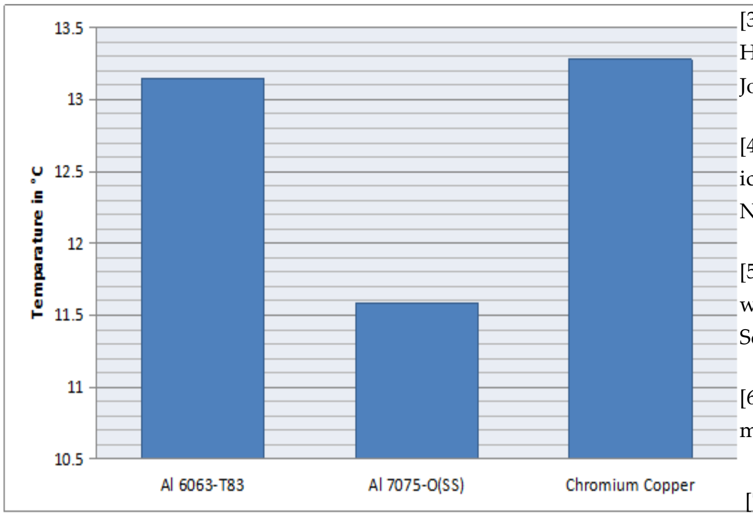


Fig 10: Total Temperature drop variations

c. Material Cost Comparison (1kgs)

Material	Price
Al 6063-T83	**200 Rs**
Al 7075-O	**500 Rs**
Chromium Copper	**750 Rs**

9. CONCLUSION

By observing CFD results, use of Circular pin fin heat sink with material Chromium Copper is better because temperature drop is more and good heat observing capacity Compare to Al 6063-T83, and Al 7075-O alloy.

By observing, cost of material Al 6063-T83 is less compare to other two materials. Temperature drop of Al 6063 is only 0.13°C lesser than Chromium copper.

Best material for manufacturing pin fin heat sink is Al 6063-T83 because low cost and light weight compare to other two materials.

10. FUTURE SCOPE

This analysis is concentrated only for circular pin fin heat sink but other shape heat sink design and different material also possible for studying this project work.

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