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Thermal Analysis of Convex Pin Fin Heat Sink

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Abstract- *In Modern electronics thermal management face considerable challenges in the wake of component efficiency which has led to higher demands on net heat dissipation. Due to that heat dissipation the electronic device get damaged. The main aim of this paper is to their various cooling mechanisms having been continuously employed to remove heat from heat sinks. Fins are used in a large number of applications to increase the heat transfer from surfaces. Typically, the fin material has a high thermal conductivity. The fin is exposed to a flowing fluid, which cools or heats it, with the high thermal conductivity allowing increased heat being conducted from the wall through the fin. The design of fins is encountered in many situations and we thus examine heat transfer in a fin as a way of defining some criteria for design. The preference of an optimal heat sink based on a number of geometric parameters such as fin height, fin length, fin thickness, number of fins, base plate thickness, space between fins, fin shape or profile, material etc. The fins are supported or maintained in a convex array by a structure. Heat dissipation capability is augmented by forcing a cooling fluid such as air through the convex fins. In this project, heat transfer coefficients may be used to determine by using ANSYS software. That code is used for the simulations and analysis of convex pin fin heat sinks for electronics cooling is investigated. Based on the results obtained it can be concluded that in the sense of junction temperature convex pin fins are efficient. These heat sink designs promises to remain electronic circuits cooler than standard pin-fin heat sinks. It is also found that total weight of the system may be reduced considerably with the use of advanced materials relative to most commonly used heat sink materials at the same thermal performance.*

Keywords- Electronic Devices, Heat dissipation, Heat Sink, Convex Pin Fin,ANSYS Software

I INTRODUCTION

Electronic components invariably generate unwanted heat during operation and as electronic systems have become both more compact and more powerful the problem of efficient and reliable heat removal, which is needed for safe operation of the component, has become difficult. Electronic components and assemblies tend to be of a small scale and they are typically cooled by air flowing at moderate velocities. The combination of small dimensions, the use of air as the cooling fluid and low velocities normally results in laminar convection and hence correspondingly low values for heat transfer coefficients. In general, when gas cooling needs to be enhanced, it is achieved by the use of cooling fins, which increase the surface area available for heat transfer. Extended heat transfer surfaces are often used with electronic systems with fins providing a heat sink for the thermal loading. When electronic products are operating, an equivalent amount of power is necessary to operate the electronic products. The larger the operation, the more power is necessary to activate the product. More power means more complex heat sinks are necessary to cool the electronic product. My project will deal in the design and analysis of heat sink by using different material like as copper, aluminum, and silumin.

Therefore, how to effectively dissipate the heat in a limited space to maintain the performance of the electronic devices becomes an important issue. There are many techniques available to enhance heat dissipation from electronic components and devices. Heat sinks are widely employed in electronic systems where space is limited. The use of passive natural convection cooled longitudinal straight plate-fin heat sinks offers substantial advantages in cost and reliability, but is often accompanied by relative low heat transfer rates. The heat sink comprises a plurality of extended straight fins that are used to enhance cooling of heat dissipating surfaces and a base plate that are used to conductively transport generated heat from a heat source to the fins. Each cooling channel is formed with adjacent straight plate fins. The plate fins are arranged parallel to the base normal line.

However, because the width of the channels is the same, when cooling flow passes through these channels, the velocity profile is identical except at the flow inlet regions. This indicates that the thickness of the flow boundary remains a constant both along the channel and across the channels. More even, the heat transfer coefficient is also a constant. The propensity of the heat sinks to create thermal turbulence is critical, because turbulent airflow increases the efficiency of the heat sinks and effectively increases the heat dissipated around an electronic component.

Figure 1. Standard pin fin heat sink

A heat sink is designed to maximize its surface area in contact with the cooling medium surrounding it, such as the air. Air velocity, choice of material, protrusion design and surface treatment are factors that affect the performance of a heat sink. Heat sink attachment methods and thermal interface materials also affect the idle temperature of the integrated circuit. Thermal adhesive or thermal grease improve the heat sink's performance by filling air gaps between the heat sink and the heat spreader on the device. The fins are rectangular-shaped pieces of metal that rise from a metal base.

Figure 2. Convex pin fin heat sink

The fins are positioned perpendicular to the metal base, but run parallel to one another. Due to this perpendicular positisition the air flow not enter in proper manner so the heat transfer reduced in standard pin fin.The convex pin fin heat sink and hybrid pin fin heat sink are the models which are similar to the standard pi fin heat sink whose fins are in round structure but due to difference in materials and their geometrical parameters like its orientation etc there is difference in the performance The convex pin fin heat sink is the sink consists of a rectangular base plate with round fins are mounted on it .From the centre the fins are convex or oriented with different inclinations. Hence its structure is looking like convex.

Hybrid heat sinks are designed for devices that feature small and focused heat sources. It consists of two different materials are used for the base plate as aluminium and for the pinfins the materials used is silicon. By applying the above designs the heat dissipation rates was improved and also by applying the foot prints of standard dimensions the new model was obtained with various fin heights. The heat sink gives better performance when compared to standard pin fin heat sink.

When compared to the different types of materials like as copper, aluminium and silumin .The silumin material based convex pin fin heat sink will be the best one than standard pin fin heat sink, because the hybrid structure fully made up of silumin material (i.e silicon and aluminium).

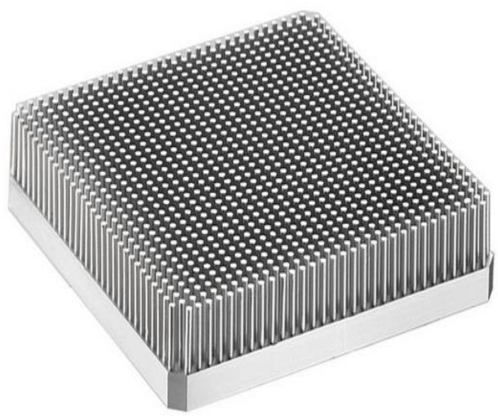

Figure 3. Hybrid pin fin heat sink

II . ASSUMPTIONS

The modeling of pin fin heat sinks is made by GIGA AMBIT 2.4.6 software.

1. Air is incompressible.
2. Air flow is perpendicular to fins.
3. Air properties are taken at film temperature
4. Flow is steady, laminar and 2D.
5. Temperature at base is uniform.
6. Fin material is homogenous and isotropic.

Heat sinks, used in electronic devices, usually consist of arrays of pin-fins arranged in an in- line manner as shown in Fig 4.

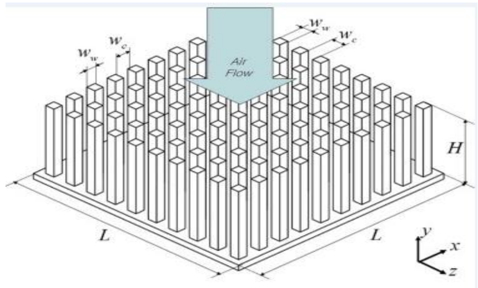

Figure 4.schematic of inline pinfin heat sink

The pins are attached to a common base and the geometry of the array is determined by the pin dimensions, number of pins and pin arrangement. Fig 4: Schematic of in-line pin-fin. Heat sinks the geometry of an in-line pin-fin heat sink is shown in Fig 5.The dimensions of the base plate are L × W × tb, where L is the length in the stream wise direction, W is the width, and tb is the thickness. Each pin fin has diameter D and height H.

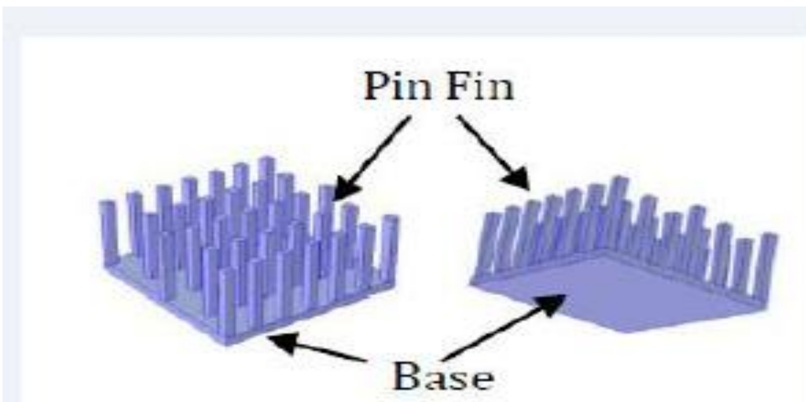

Figure 5. Arrangement of heat sink

1.1 Governing Equation

The rate of convection heat transfer from the extended surface
Where,
h = convection heat transfer coefficient (assumed constant)

AH = area of heated wall only

AF = summed area of all fins j
tFAv= average temperature along the length of fins
Which may be approximated as mean temperature of three temperature measured along length. The fin efficiency η is the ratio of the actual heat transfer from the surface to heat which would be transferred if the entire area were at base temperature.

The longitudinal and transverse pitches are SL and ST respectively. The direction of the flow is parallel to the x-axis. The base plate is kept at constant heat flux and the top surface (y = H) of the pins is adiabatic. The average local wall temperature of the pin surface is Tw(x). The heat source is idealized as a constant heat flux boundary condition at the bottom surface of the base plate. The mean temperature of the heat source is Ts transfer coefficient across bank of tubes Reference Velocity the mean velocity in the minimum free cross section between two rows, Vmax, is used as a reference velocity in the calculations of fluid flow and heat transfer for inline arrangement.

Table 1.Dimensions used to determine performance of heat sinks

QUANTITY	***DIMENSION***
Footprint (mm^2)	52 x 52
Base plate thickness (mm)	3
Overall height of fin (mm)	30
Thermal conductivity of solid Al (W/mK)	237
Thermal conductivity of solid Cu (W/mK)	401
Thermal conductivity of Silumin (W/mK)	134
Density of air (kg/m^3)	1.086
Specific heat of air (J/kgK)	1007
Ambient temperature (^{o}c)	22
Base plate temperature (^{o}c)	80

III. SIMULATION

The software creates simulated computer models of structures, electronics, or machine components to simulate strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes. Ansys is used to determine how a product will function with different specifications, without building test products or conducting crash tests. For example, Ansys software may simulate how a bridge will hold up after years of traffic, how to best process salmon in a cannery to reduce waste, or how to design a slide that uses less material without sacrificing safety.

Most Ansys simulations are performed using the Ansys Workbench software, which is one of the company's main products. Typically Ansys users break down larger structures into small components that are each modeled and tested individually. A user may start by defining the dimensions of an object, and then adding weight, pressure, temperature and other physical properties. Finally, the Ansys software simulates and analyzes movement, fatigue, fractures, fluid flow, temperature distribution, electromagnetic efficiency and other effects over time.

3.1 Heat transfer coefficient over flate plate

Reynolds's number (ReL) = (ρ v L)/μ (1)

Nu = 0.332 ReL0.5 Pr 0.333 (2)

Nu= h1L/k (3)

h1 = Nu k/L (4)

3.2 Heat Transfer Coefficient across Bank of Tubes Reference Velocity

The mean velocity in the minimum free cross section between two rows, Vmax, is used as a reference velocity in the calculations of fluid flow and heat transfer for inline arrangement, and is given by

Vmax= [ST/(ST-D)] Uapp(5 where Uapp is the approach velocity,

SL, and ST are the dimensionless longitudinal and transverse pitches,

ReDmax= ρ vmax D (6)

Nu= C (ReDmax) n (7)

For the values of C and n from data book

Nu= h2D/k (8)

h2 = Nu k/D (9)

IV. RESULTS & DISCUSSION

Discussed earlier from the previous papers the copper base plate is of high heat spreading capabilities when compared to the aluminum but here convex structure with hybrid pin fin heat sink is giving better performance when compared to standard pin fin heat sink.

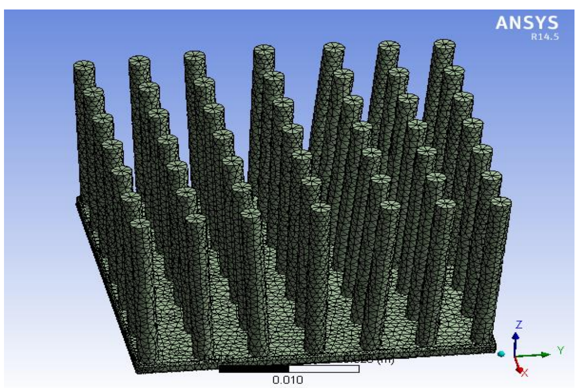

Figure 6. Mesh diagram

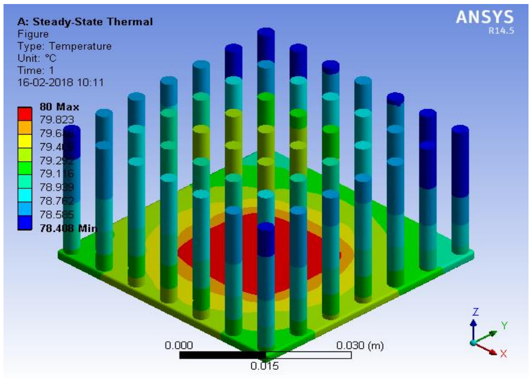

Figure 7. Aluminium for zero degree

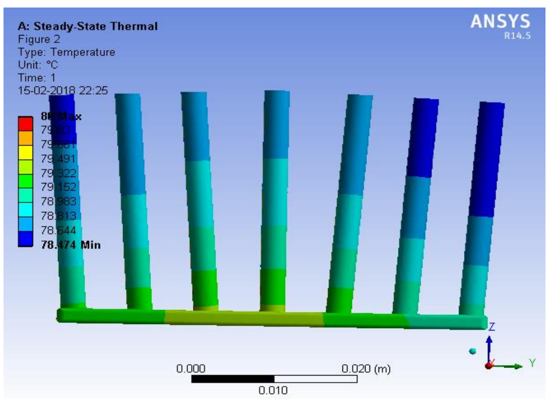

Figure 8 .Aluminium for four degree

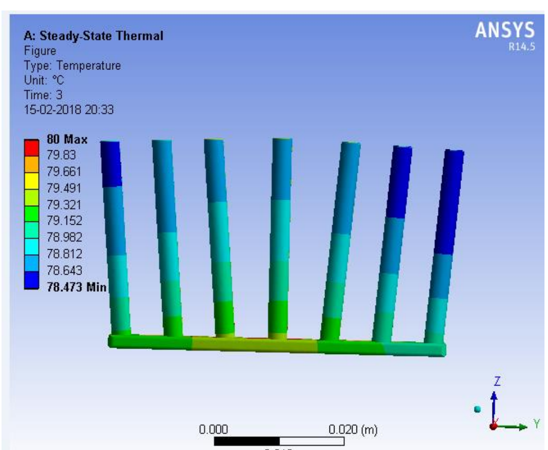

Figure 9.Aluminium for five degree

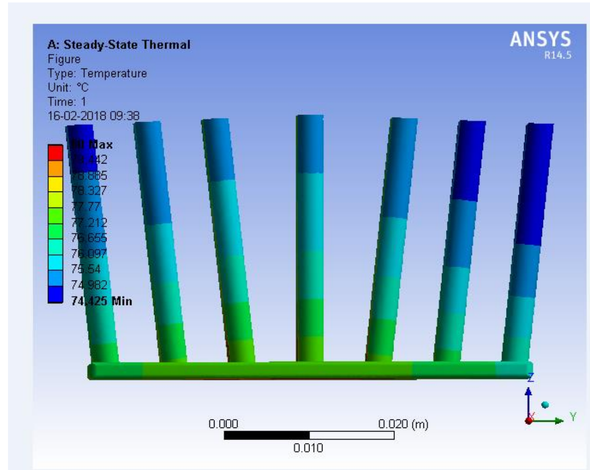

Figure 10 .Aluminium for six degree

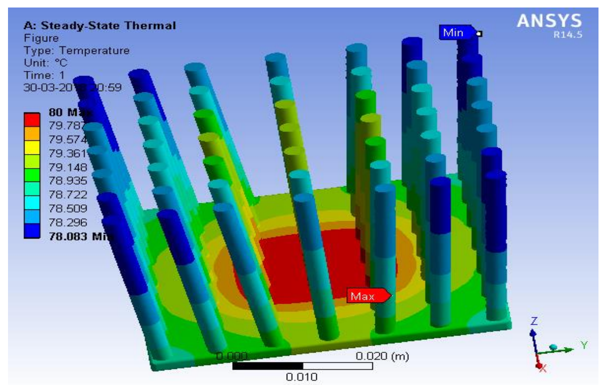

Figure 11. Aluminium for seven degree

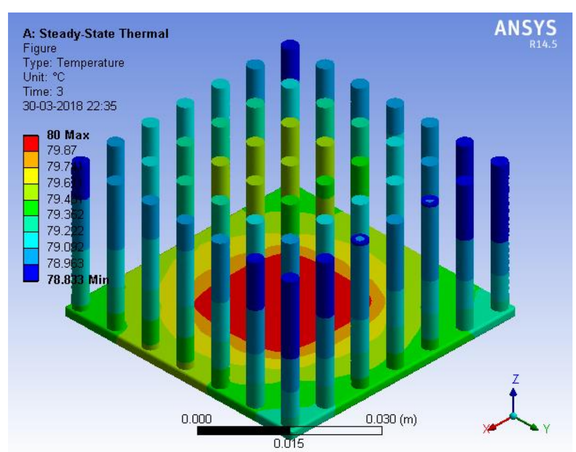

Figure 12.Copper for zerodegree

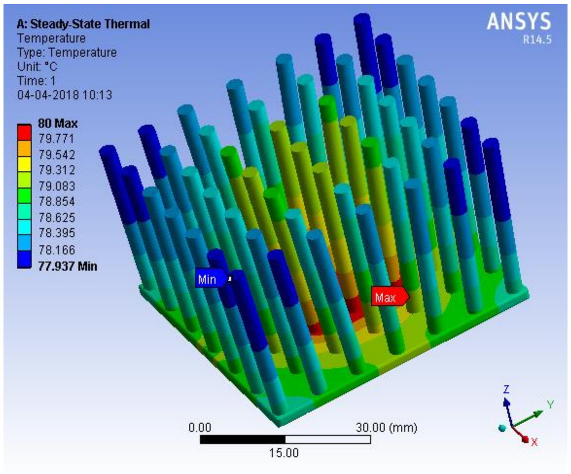

Figure 13.Copper for four degree

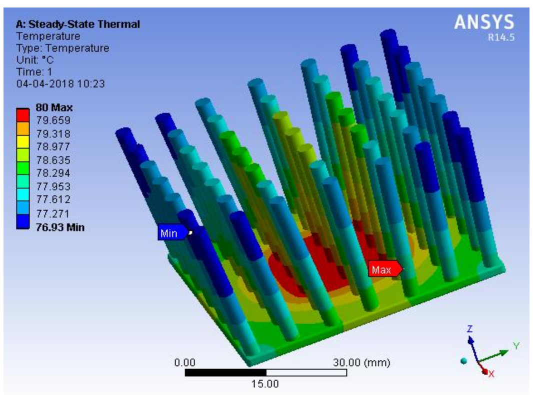

Figure 14.Copper for five degree

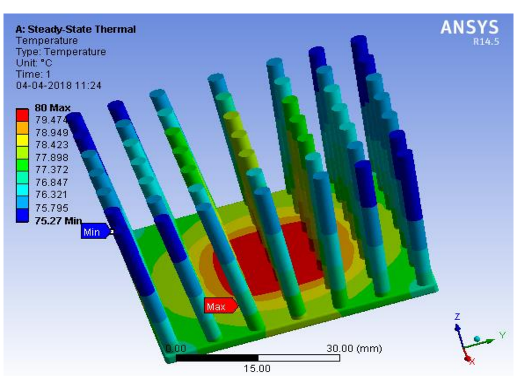

Figure 15.Copper for six degree

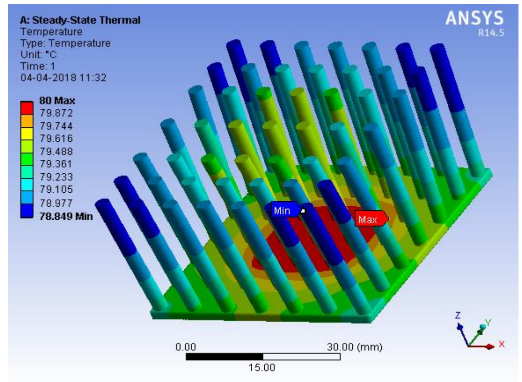

Figure 16.Copper for seven degree

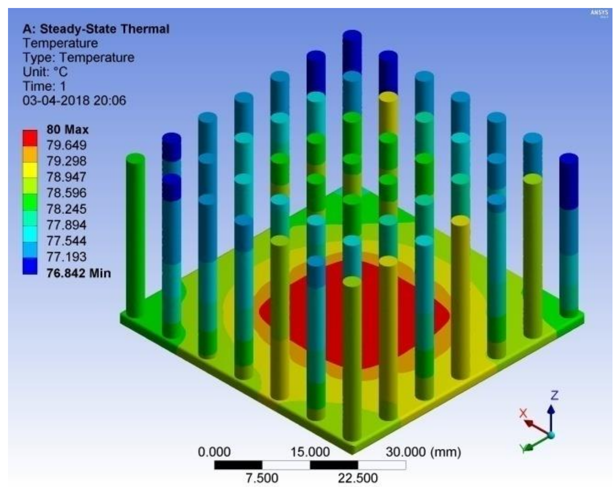

Figure 17.Silumin for zero degree

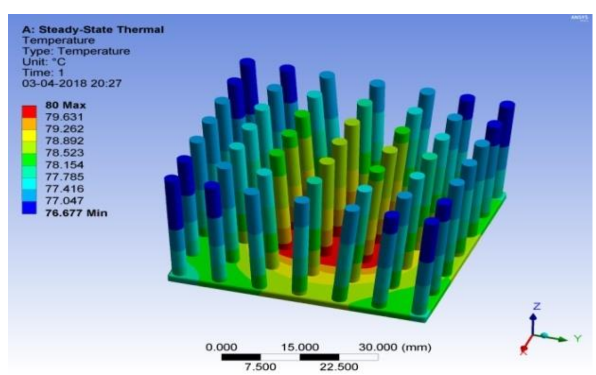

Figure 18.Silumin for four degree

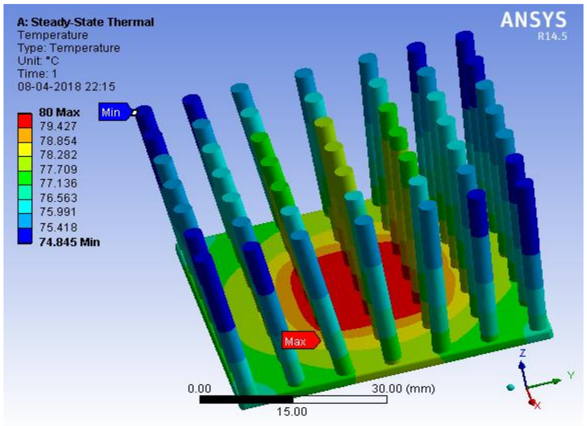

Figure 19.Silumin for five degree

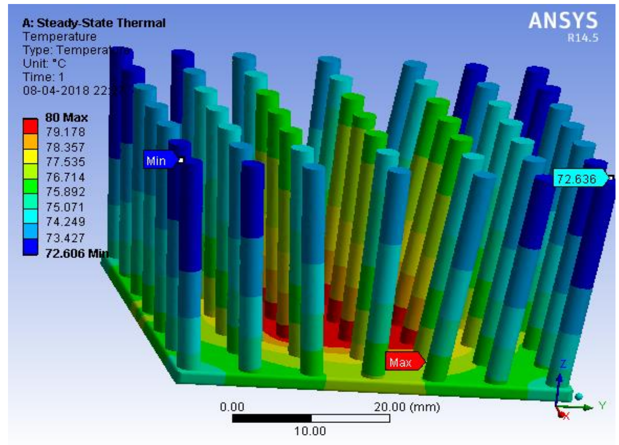

Figure20 .Silumin for six degree

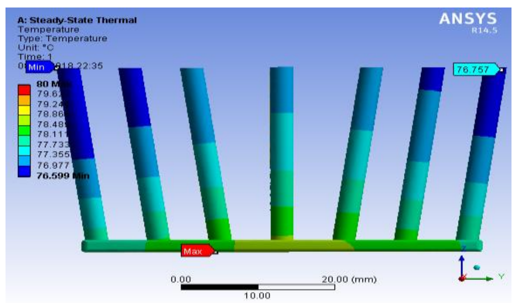

Figure 21. Silumin for seven degree

Now, the different material like aluminum, copper and silumin values analysis will be displayed in table as given below. The silumin will be the best one when comparing to the both aluminum and copper.

Table 2. Analysis for Aluminium material with different angle is given below.

S NO	*DEGREE*	*TEMPERATURE (°C)*
1	Standard	78.408
2	Four	78.474
3	Five	78.473
4	Six	74.425
5	Seven	78.083

Table 3. Analysis for copper material with different angle is given below.

S NO	***DEGREE***	***TEMPERATURE (°C)***
1	Standard	78.833
2	Four	77.937
3	Five	76.93
4	Six	75.27
5	Seven	78.849

Table 4. Analysis for silumin material with different angle is given below.

S NO	***DEGREE***	***TEMPERATURE (°C)***
1	Standard	76.842
2	Four	76.677
3	Five	74.845
4	Six	72.606
5	Seven	76.599

TABLE 5. The comparative temperature values for aluminum, copper and hybrid pin fin heat sinks with 6 degrees convex structures.

Case	***Al (°c)***	***Cu (°c)***	***Silumin (°c)***
Six Degree	74.425	75.27	72.606

This is the comparative table for all three type of material such as copper, aluminium and silumin. This analysis was taken for different degree as well as different angle for respective materials. The figure 22 represented the analysis graph for three different types of materials. Here the X –axis represented by degree and Y- axis represented by temperature in degree celcius.

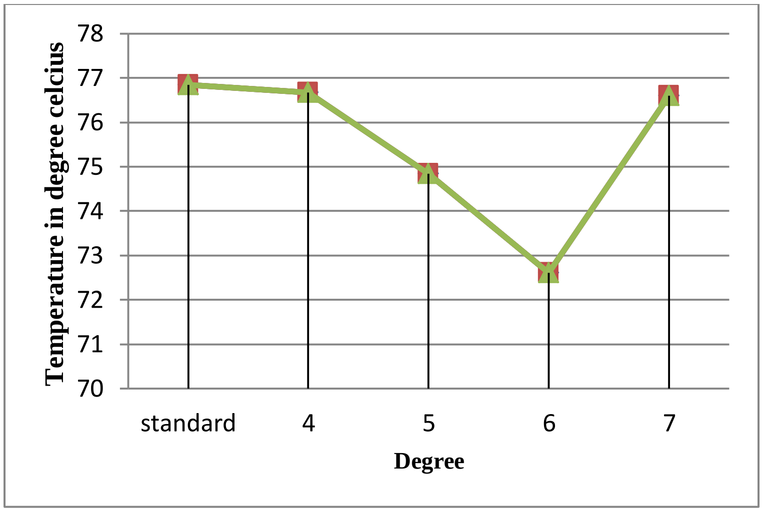

Figure 22. Analysis graph for Silumin material with different degrees

V CONCLUSION AND FUTURE SCOPE

The analysis is done in ANSYS version with, solid works modelling the component and the following conclusions were made from the ANSYS simulation it is observed that the standard pin fin heat sinks gives the result. But convex pin fins given more heat transfer beyond this hybrid heat sink performed well. But from this investigation the hybrid structures are giving better performance than standard convex pin fin heat sinks.

5.1 Future Scope

The work can be carried with various profiles also with different material compositions.Furtherly it can be applicable for desired industries application as electronic components manufacturing companies.

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