Heat Transfer Analysis of Engine Cylinder Fins of Varying Geometry with different Materials

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Abstract: ***The principle implemented in the project is to increase the heat dissipation rate by using the invisible working fluid, nothing but air. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main purpose of using these cooling fins is to cool the engine cylinder by air. The main aim of the project is to analyze the thermal properties by varying geometry, material of cylinder fins. When fins operate with large temperature differences between the fin base and the surrounding fluid, the effect of temperature-dependent thermal conductivity of the fin material must be included in the analysis if its thermal performance is to be evaluated precisely.***

Keywords: Air Cooling, ANSYS, Engine Performance, Fins, Heat Transfer

1. Introduction

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy (heat) between physical systems. . It flows from higher temperature region to regions of lower temperature i.e., heat is always transfer from high temperature body to low temperature body by spontaneously. There are three basic mechanisms of heat transfer which are often referred as modes of heat transfer. These are conduction, convection, and radiation. But in actual practice it may the combination of above.

1.1.1 Conduction heat transfer is the mode of heat transfer when medium is stationary. Heat transfer by conduction involves transfer of energy within a bulk material without any motion of the material as a whole. Conduction takes place when a temperature gradient exist in a solid (or stationary fluid) medium. Energy is transferred from the more energetic to the less energetic molecules when neighbouring molecules. The law that describes heat conduction at macroscopic level is called **Fourier's law**.

$$q = (Q/A) = -k(\Delta T/\Delta x)$$

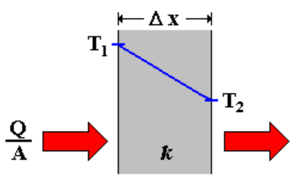


Figure 1.1.1: One Dimensional Conduction Direction

1.1.2 Convection usually refers to the energy transfer between a solid surface and an adjacent moving gas or liquid. Convection heat transfer is a combination of diffusion or molecular motion within the fluid and the bulk or macroscopic motion of the fluid. The rate of energy transfer from a system to the fluid is quantified by **Newton's law of cooling**:-

$$q'' = h(T_{fluid} - T_s)$$

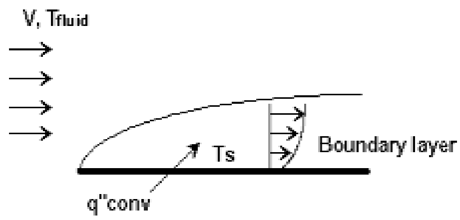


Figure 1.1.2: Convection Heat transfer

1.1.3 Unlike conduction and convection, **radiation** does not require the presence of a medium to propagate. Actually, radiation transfers heat energy most efficiently in a vacuum. Radiation energy is transported by electromagnetic waves.

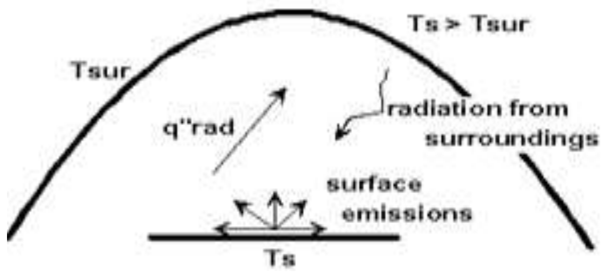


Figure 1.1.3: Radiation Heat transfer

1.2 An Overview of Fins

Fins are the extended surfaces that are linked to any surface in order to increase the rate of heat transfer from that surface. These are used when the available surface is found inadequate to transfer the required quantity of heat with the available temperature drop and convective heat transfer coefficient. A fin accommodates energy transfer by conduction within its boundaries, while its exposed surfaces transfer energy to the surroundings by convection or radiation or both. Fins are available in many shapes and forms, some of which are shown below:

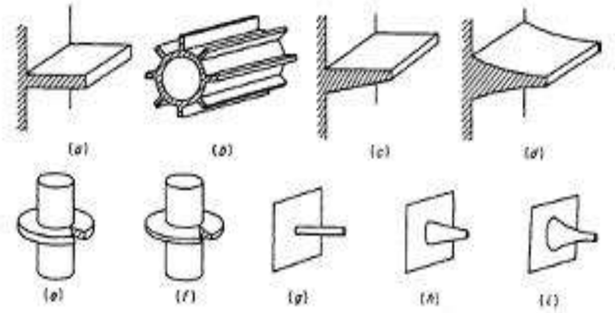


Figure 1.2: some typical examples of extended surfaces (a) longitudinal fin of rectangular profile; *(b)* cylindrical tube equipped with fins of rectangular profile; *(c)* longitudinal fin of trapezoidal profile; *(d)* longitudinal fin of parabolic profile; *(e)* cylindrical tube equipped with radial fin of rectangular profile; *(f)* cylindrical tube equipped with radial fin of trapezoidal profile; *(g)* cylindrical spine; *(h)* truncated conical spine; *(i)* truncated parabolic spine.

2. System Model

Modelling of the model which provides a complete set of design, and manufacturing capabilities. These capabilities include Solid modelling, Surfacing, Rendering, Simulation and NC and tooling design. Since the cooling system of the engine uses air, convection boundary is defined on all the outer surfaces (at fins) of the engine assembly. Modelling is performed by Solid works 2017 software Analysis work performed on ANSYS 14.5. In ANSYS 14.5 we calculate various thermal properties of the material. Thermal properties are calculated by transient thermal analysis, which is the part of ANSYS 14.5

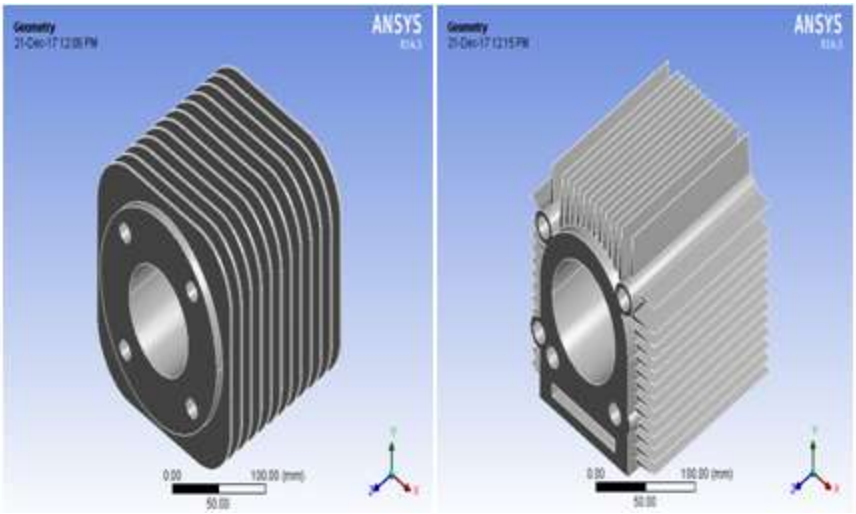


Figure 2.1: Engine Cylinder With Circular Fin Engine Cylinder With Triangular Fin

The above Solid Works 2017 model is analyzed and solved by ANSYS 14.5 for different types of fins and materials.

3. Proposed Methodology

3.1 Material Specifications

Three different material were selected which are as follows:
A380: (Si 7.5-9.5%, Fe 2.0%,Cu 3.0-4.0%,Mn 0.5%,Ni 0.5%,Zn 3.0%,Tin 0.35%, rest is Al)
B390-(Si 16-18%,Fe 1.3%,Cu 4-5%,Mg 0.45-0.65%,Mn 0.5%, Ni 1.5%,Ti 0.1%, rest is Al)
C443-(Si 4.5 to 6.0%, Fe 0 to 2.0%, Cu 0 to 0.6%, Ni 0 to 0.5%, Zn 0 to 0.5%, Sn 0 to 0.15%, Mg 0 to 0.1%, rest in Al)

3.2 Fins Specification

Length of the fin (L) = 130 (mm) = 0.13 (m)
Width of the fin (b) = 130 (mm) = 0.13 (m)
Thickness (y) = 3 (mm) = 0.003 (m)
Thermal Conductivity of fin material = K (W/m × K)
Heat transfer coefficient = 0.000025 (W/mm^2 × K) or 25 (W/m^2 K) Ref [19]
Given condition

T_a = atmospheric temperature = 295.16 (K)
Heat flux= 0.25 (W/ mm^2)

Some initial values like we give the initial values are convection coefficient h=0.000025 (W/mm^2×K), heat flux 0.25 (W/mm^2) and ambient temperature is 295.15 (K).

For circular design: With the help of Mesh generation tool, after meshing there are 34604 nodes and 17960 elements are made

For Triangular Design: With the help of Mesh generation tool, after meshing there are 42157 nodes and 21773 elements are made.

Table 2.2: Thermal conductivity of material

Sr. No	Aluminium Alloy	Thermal conductivity(W/mK)
1	A380	96
2	B390	134
3	C443	140

3.3 Circular fin of Al alloy (A380)

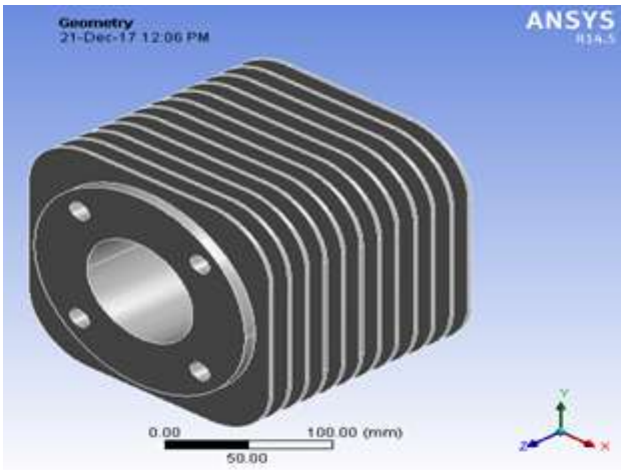


Figure 3.3.1: Circular fin of Al alloy(A380)

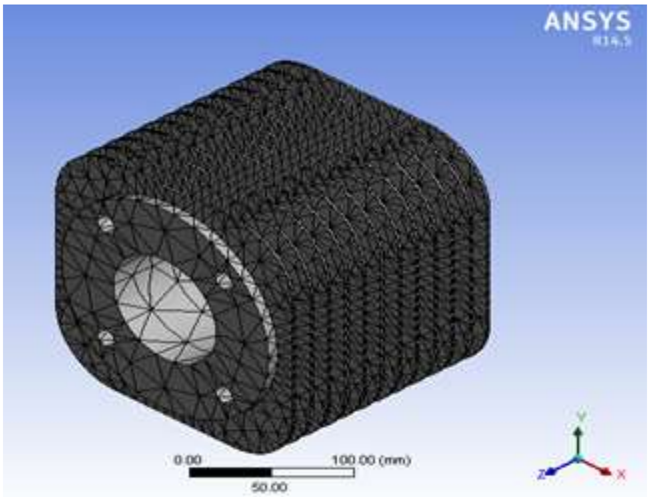


Figure 3.3.2: Mesh generated body of Circular Fin of Al alloy(A380)

Model is prepared by Slid Works2017, after this use of Add-ins we directly import the model from Solid Works 2017. In ANSYS 14.5 we give the material property to the model.

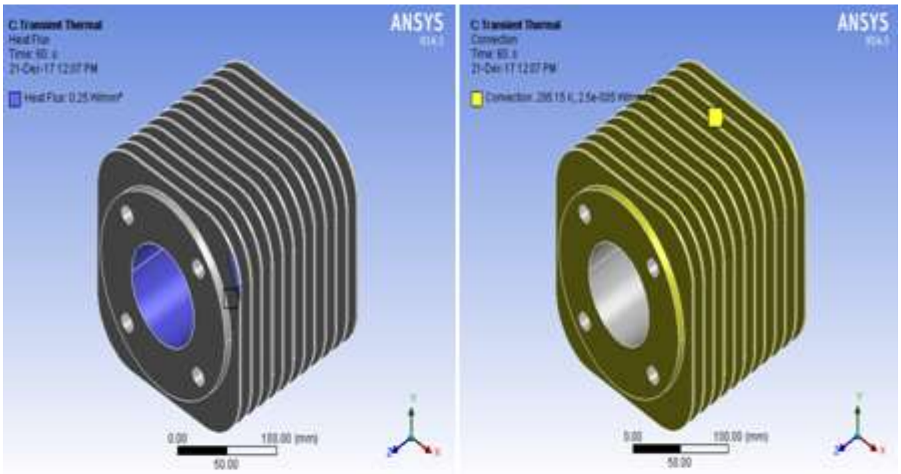
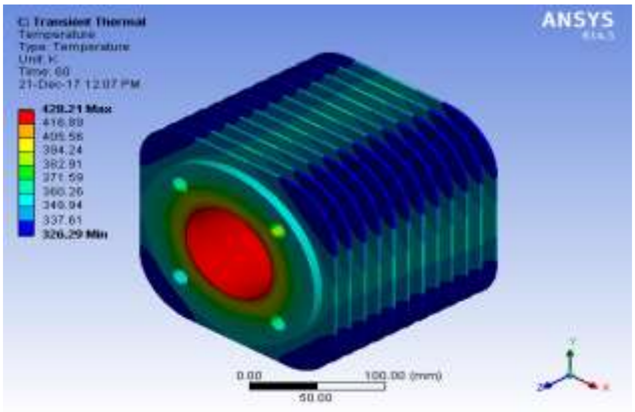


Figure 3.3.3: given load on Circular fin Al alloy A(380)



Temperature distribution in Circular fin Al alloy A(380)

Temperature distribution of circular fin of Al alloy shows that maximum value of temperature is 428.21K and minimum temperature is 326.29K

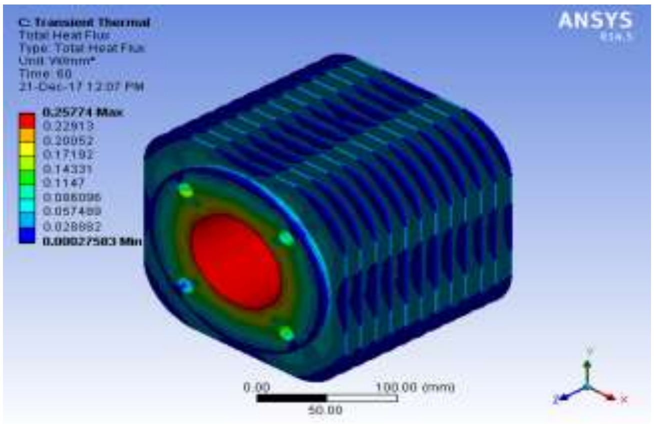


Figure 3.3.4: Heat flux distribution in Circular fin Al alloy A(380)

Figure shows that the heat flux inside Circular fin of Al alloys have maximum value 0.25774 (W/mm^2).

3.4 Triangular fin of Al Alloy (A380)

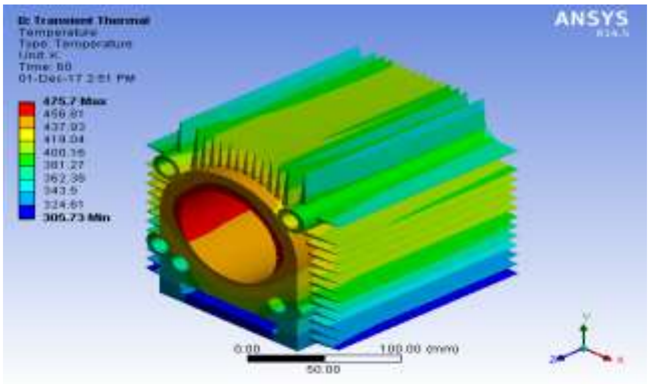


Figure 3.4.1: Temperature distribution in Triangular fin of Al Alloy (A380)

Temperature distribution of Triangular fin of Al Alloy shows that maximum value of temperature is 475.62 K and minimum temperature is 305.73 K.

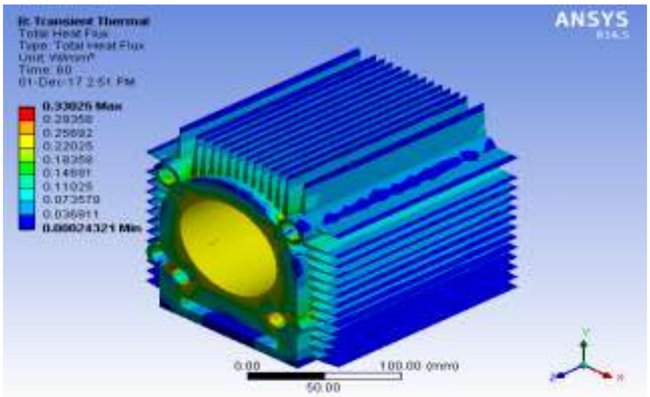


Figure 3.4.2: Total heat flux inside Triangular fin of Al Alloy (A380)

Figure shows that the heat flux inside Triangular fin of Al Alloy have maximum value 0.33025 (W/mm^2).

3.5 Circular fin of Al alloy (B390)

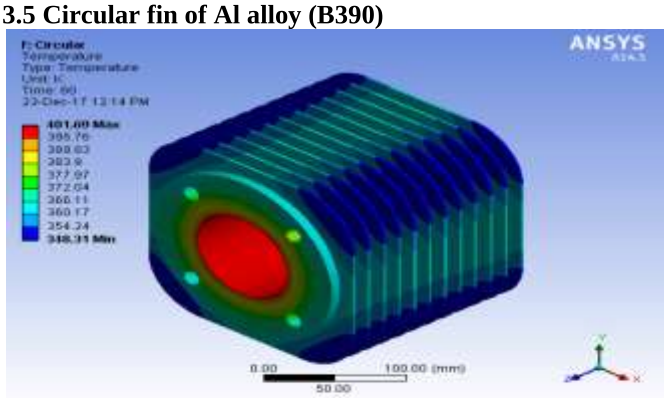


Figure 3.5.1: Temperature distribution in Circular fin of Al alloy (B390)

Temperature distribution of Circular fin of Al alloy shows that maximum value of temperature is 401.69K and minimum temperature is 348.31K.

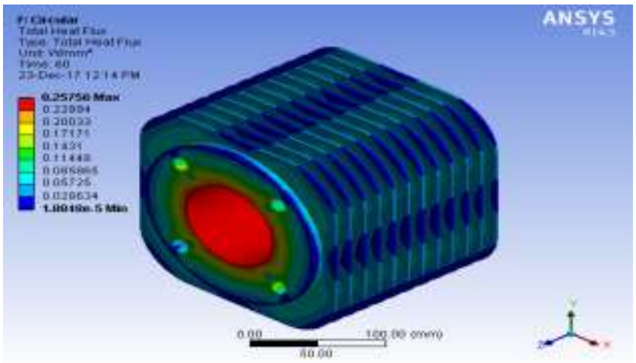


Figure 3.5.2: Total heat flux inside Circular fin of Al alloy (B390)

Figure shows that the maximum value of heat flux is 0..25756 (W/mm^2) inside the circular fin of Al alloy.

3.6 Triangular fin of Al alloy (B390)

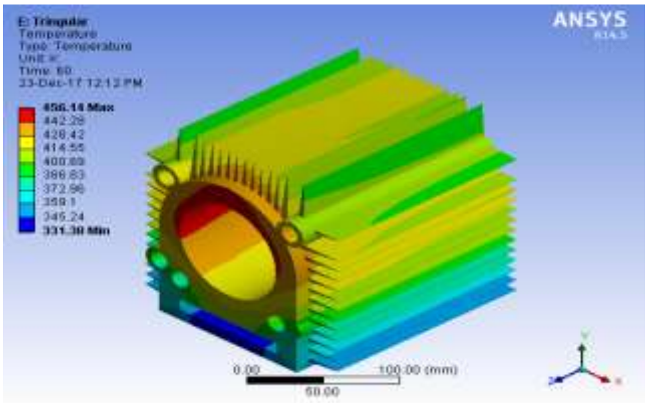


Figure 3.6.1: Temperature distribution of Triangular fin of Al alloy (B390)

Temperature distribution of Triangular fin of Al alloy (B390) shows that maximum value of temperature is 456.14K and minimum temperature is 331.38K.

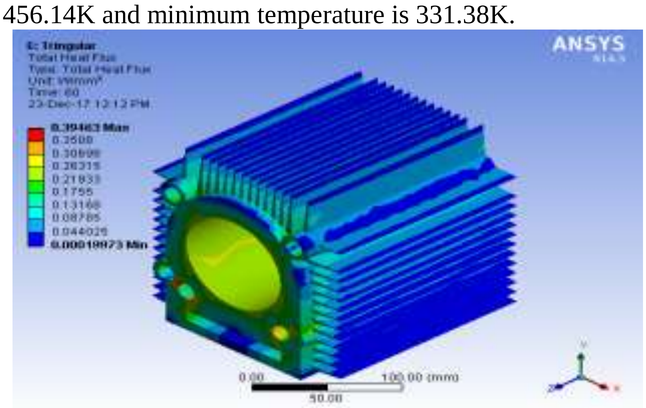


Figure 3.6.2: Total heat flux inside Triangular fin of Al alloy (B390)

Figure shows that the maximum value of heat flux is 0.39463 (W/mm^2) inside the Triangular fin of Al alloy

3.7 Circular fin of Al alloy (C443)

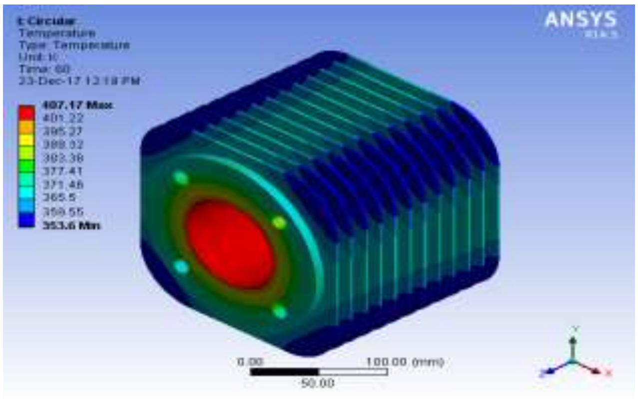


Figure 3.7.1: Temperature distribution of Circular fin of Al alloy (C443)Temperature distribution of Circular fin of Mg alloy shows that maximum value of temperature is 407.17 K and minimum temperature is 353.6 K.

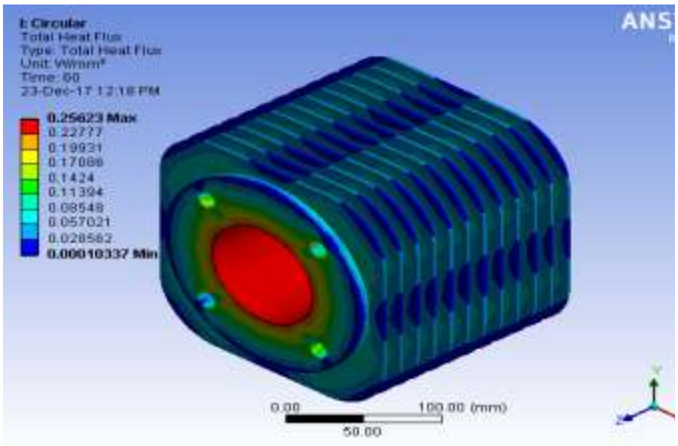


Figure 3.7.2: Total heat flux inside Circular fin of Al alloy (C443)

Figure shows that the maximum heat flux value 0.25623 (W/mm^2) for Circular fin of Al alloy

3.8 Triangular fin Al alloy (C443)

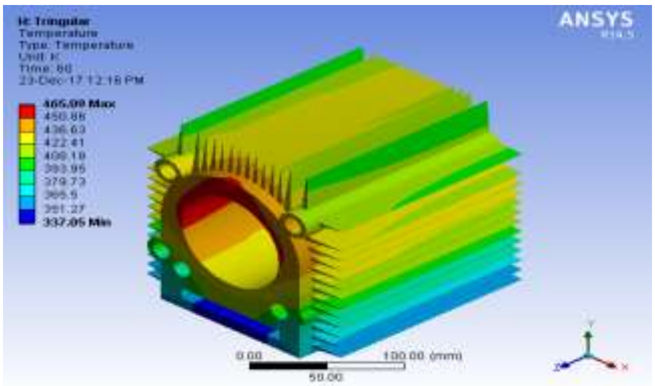


Figure 3.8.1: Temperature distribution of Triangular fin of Al alloy (C443)

Temperature Distribution of Triangular fin of Al alloy shows that maximum value of temperature is 465.09 K and minimum temperature is 337.05 K.

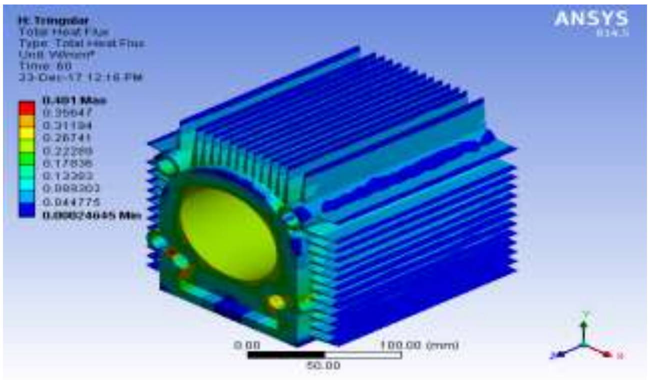


Figure 3.8.2: Total Heat flux inside Triangular fin of Al alloy (C443)

Figure shows that the maximum value of heat flux is 0.401 (W/mm^2) inside the Triangular fin of Al alloy

Simulation/Experimental Results

Table 4.1: Comparison of data

Sr. No	G. Babu and Lava Kumar		Present result		
	Al alloy 2024	Al alloy 6061	A380	B390	C443
Circular	0.723258	0.73814	0.25774	0.25756	0.25623

4. Conclusion

In present work, a cylinder fin body is modeled with the help of Solid Works 2017 software and transient thermal analysis is done by using ANSYS 14.5. These fins are used for air cooling systems for two wheelers. In present study, three alloy of Aluminum (A380,B390 and C443) are used and compared with G. Babu and M. LavaKumar results. The various parameters (i.e., shape and geometry of the fin) are considered in the study, shape (Circular and Triangular), and thickness (3 mm) by changing the shape of the fin to triangular shaped, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin.

5. Future Scopes

In this thesis, we concluded that using triangular fins is better, but circular fins are mostly used in vertical engines than horizontal engines and also by using that, the weight of the fin body is also increases. By using triangular fins, the fin body weight is less, so more experiments are to be done to use triangular fins for the fin body in future.

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