Thermal Analysis of Engine Cylinder with Fins by using ANSYS Workbench

Mulukuntla Vidya Sagar
Student, Mechanical Engineering Department,,
Warangal Institute of Technology & Science, Warangal,
Telangana, India

Nalla Suresh
Assistant Proffesor, Mechanical Engineering Department,
Warangal Institute of Technology & Science, Warangal,
Telangana, India

Abstract**: The Engine cylinder is one of the major automobile component, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the surface of the cylinder to increase the rate of Heat transfer. By doing thermal analysis on the engine cylinder and fins around it, It is helpful to know the heat dissipation rate and Temperature Distribution inside the cylinder. 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 aim of the present project is to analyse the thermal properties like Directional Heat Flux, Total Heat Flux and Temperature Distribution by varying Geometry(Circular, Rectangular),material(Aluminium Alloy, Magnesium Alloy) and thickness of Fin (3mm,2mm) of an approximately square cylinder model prepared in SOLIDWORKS-2013 which is imported into ANSYS WORKBENCH-2016 for Transient Thermal analysis with an Average Internal Temperature and Stagnant Air-Simplified case as Cooling medium on Outer surface with reasonable Film Transfer Coefficient as Boundary Conditions.**

Keywords: Dissipation, Thermal conductivity, Film transfer coefficient, Internal Temperature, Stagnant Air-Simplified case, Boundary Conditions, SOLIDWORKS-2013, ANSYS WORKBWNCH-2016.

I. INTRODUCTION

1.1. Engine Cylinder and Combustion Chamber:

We know that in case of Internal Combustion engines, combustion of air and fuel takes place inside the engine cylinder and hot gases are generated. The temperature of gases will be around 2300-2500°C. This is a very high temperature and may result into burning of oil film between the moving parts and may result in seizing or welding of same that is chances of piston seizure, chances of piston ring, compression ring, oil ring etc. can be affected. Excess temperature can also damage the cylinder material. So this temperature must be reduced to about 150-200°C at which the engine will work most efficiently. Too much cooling is also not desirable since it reduces the thermal efficiency. So, the object of cooling system is to keep the engine running at its most efficient operating temperature. It is to be noted that the engine is quite inefficient when it is cold and hence the cooling system is designed in such a way that it prevents cooling when the engine is warming up and till it attains to maximum efficient operating temperature, then it starts cooling.

To avoid overheating, and the consequent ill effects, the heat transferred to an engine component (after a certain level) must be removed as quickly as possible and be conveyed to the atmosphere. It will be proper to say the cooling system as a temperature regulation system. It should be remembered that abstraction of heat from the working medium by way of cooling the engine components is a direct thermodynamic loss.

The rate of heat transfer depends upon the wind velocity, geometry of engine surface, external surface area and the ambient temperature. In this work analysis is done on engine block fins considering temperature inside by means of conduction and convection, air velocity is not consider in this work. Motorbikes engines are normally designed for operating at a particular atmosphere temperature, however cooling beyond optimum limit is also not considered because it can reduce overall efficiency. Thus it may be observed that only sufficient cooling is desirable.

Air-cooled engines generally use individual cases for the cylinders to facilitate cooling. Inline motorcycle engines are an exception, having two-, three-, four-, or even six-cylinder air-cooled units in a common block. Water-cooled engines with only a few cylinders may also use individual cylinder cases, though this makes the cooling system more complex. The Ducati motorcycle company, which for years used air-cooled motors with individual cylinder cases, retained the basic design of their V-twin engine while adapting it to water-cooling.

1.1. Natural Air Cooling:

In normal cause, larger parts of an engine remain exposed to the atmospheric air. When the vehicles run, the air at certain relative velocity impinges upon the engine, and sweeps away its heat. The heat carried-away by the air is due to natural convection, therefore this method is known as Natural air-cooling. Engines mounted on 2-wheelers are mostly cooled by natural air. As the heat dissipation is a function of frontal cross-sectional area of the engine, therefore there exists a need to enlarge this area. An engine with enlarge area will becomes bulky and in turn will also reduce the power by weight ratio. Hence, as an alternative arrangement, fins are constructed to enhance the frontal cross-sectional area of the engine. Fins (or ribs) are sharp projections provided on the surfaces of cylinder block and cylinder head. They increase the outer contact area between a cylinder and the air. Fins are, generally, casted integrally

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

with the cylinder. They may also be mounted on the cylinder.

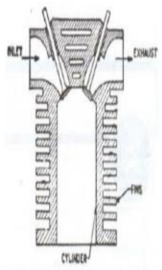


Fig-1.1. Natural air cooling

1.3 Fins:

A Fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, radiation of an object determines the amount of heat it transfers. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the Heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin to the object, however, increases the surface area and can sometimes be economical solution to heat transfer problems. Circumferential fins around the cylinder of a motor cycle engine and fins attached to condenser tubes of a refrigerator are a few familiar examples.

Fig-1.2. Automobile Fin

The temperature distribution within an SI engine is extremely important for proper engine operation to maximize the thermal efficiency of an engine; it has to be operated at specific thermal condition. This condition is controlled by cooling process of fins that tends to remove the heat that is highly critical in keeping an engine and engine lubricant from thermal failure and thermal effects. Actually Fins are provided because, they provide a channel for cooling the engine whenever it gets hot. Fins doesn't let the engine to burn out. The fins provided on the engine cylinder depends on the capacity of the engine. Higher the capacity of the engine, more number of fins provided on the surface of the engine block.

Fig-1.3.Malossi air-cooled cylinder for two-stroke scooters. The exhaust port is visible to the right.

Fig-1.4.Air-cooled *boxer* engine on a 1954 BMW motorcycle

1.3.1. Fin terminology and types:

Fin base,

- Fin tip ,
- Straight fin,
- Variable cross-sectional area fin,
- *Spine* or a pin fin,
- *Annular* or cylindrical.

1.4. THERMAL ANALYSIS:

Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. Several methods are commonly used – these are distinguished from one another by the property which is measured:

- Dielectric thermal analysis (DEA): dielectric permittivity and loss factor
- Thermal Analysis (DTA): temperature difference versus temperature or time
- Differential Scanning Calorimetry (DSC): heat flow changes versus temperature or time
- Dilatometry (DIL): volume changes with temperature change
- Dynamic Mechanical Analysis (DMA or DMTA) : measures storage modulus (stiffness) and loss modulus (damping) versus temperature, time and frequency
- Evolved Gas Analysis (EGA) : analysis of gases evolved during heating of a material, usually decomposition products
- Laser flash analysis (LFA): thermal diffusivity and thermal conductivity
- Thermo gravimetric Analysis (TGA): mass change versus temperature or time
- Thermo mechanical analysis (TMA): dimensional changes versus temperature or time

- Thermo-optical analysis (TOA): optical properties
- Derivatography: A complex method in thermal analysis

Thermal analysis calculates the temperature and heat transfer within and between components in your design and its environment. This is an important consideration of design, as many products and material have temperature dependent properties. Product safety is also a consideration—if a product or component gets too hot, you may have to design a guard over it.

Fig-1.5.Thermal analysis

The heat flow through the components can be in a steady state (where the heat flow does not change over time) or transient in nature. The thermal analogy of a linear static analysis is a steady-state thermal analysis, while a dynamic structural analysis is analogous to a transient thermal analysis.
Heat transfer problems can be solved using structural and fluid flow analysis methods:

- In a thermal structural analysis, the effect of the moving air or a moving liquid is approximated by a series of boundary conditions or loads.
- In a thermal fluid analysis, the effect of the air or a liquid is calculated, increasing the run time but also increasing to overall solution accuracy.

1.4.1. Transient Thermal Analysis:

The ANSYS/ Multi physics, ANSYS / Mechanical, ANSYS/Thermal, and analysis determines temperatures and other thermal quantities that vary over time. Engineers commonly use temperatures that a transient thermal analysis calculates as input to structural analyses for thermal stress evaluations. Many heat transfer applications-heat treatment problems, nozzles, engine blocks, piping systems, pressure vessels, etc.-involve transient thermal analyses.
A transient thermal analysis follows basically the same procedures as a steady-state thermal analysis. The main difference is that most applied loads in a transient analysis are functions of time. To specify time-dependent loads, you first divide the load-versus-time curve into load steps. Each "corner" on the load-time curve can be one load step, as shown in the following sketches.

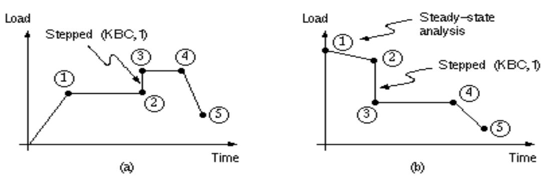


Fig-1.6. Examples of load-versus-time curves

For each load step, you need to specify both load values and time values, along with other load step options such as stepped or ramped loads, automatic time stepping, etc. You then write each load step to a file and solve all load steps together. To get a better understanding of how load and time stepping work, see the example casting analysis scenario in this chapter.

II. LITERATURE SURVEY

Fernando Allan [1] simulated the heat transfer from cylinder to air of a two-stroke internal combustion finned engine. The cylinder body, cylinder head (both provided with fins), and piston have been numerically analysed and optimized in order to minimize engine dimensions. The maximum temperature admissible at the hottest point of the engine has been adopted as the limiting condition. Starting from a zero-dimensional combustion model developed in previous works, the cooling system geometry of a two-stroke air cooled internal combustion engine has been optimized in this paper by reducing the total volume occupied by the engine. A total reduction of 20.15% has been achieved by reducing the total engine diameter D from 90.62 mm to 75.22 mm and by increasing the total height H from 125.72 mm to 146.47 mm aspect ratio varies from 1.39 to 1.95. In parallel with the total volume reduction, a slight increase in engine efficiency has been achieved. **G. Babe and M. Lava Kumar [2]** analysed the thermal properties by varying geometry, material and thickness of cylinder fins. The models were created by varying the geometry, rectangular, circular and curved shaped fins and also by varying thickness of the fins. Material used for manufacturing cylinder fin body was Aluminium Alloy 204 which has thermal conductivity of 110-150W/me and also using Aluminium alloy 6061 and Magnesium alloy which have higher thermal conductivities. They concluded that by reducing the thickness and also by changing the shape of the fin to curve shaped, the weight of the fin body reduces thereby increasing the efficiency. The weight of the fin body is reduced when Magnesium alloy is used and using circular fin, material Aluminium alloy 6061 and thickness of 2.5mm is better since heat transfer rate is more and using circular fins the heat lost is more, efficiency and effectiveness is also more**. Ajay Paul et.al. [3]** Carried out Numerical Simulations to determine heat transfer characteristics of different fin parameters namely, number of fins, fin thickness at varying air velocities. A cylinder with a single fin mounted and explained it was tested experimentally. The numerical simulation of the same setup was done using CFD. Cylinders with fins of 4 mm and 6 mm thickness were simulated for 1, 3, 4 & 6 fin configurations. They concluded that
1. When fin thickness was increased, the reduced gap between the fins resulted in swirls being created which helped in increasing the heat transfer.
2. Large number of fins with less thickness can be preferred in high speed vehicles than thick fins with less numbers as it helps inducing greater turbulence and hence higher heat transfer**in. Phani Raja Rao et.al [4]**.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Analyzed the thermal properties by varying geometry, material and thickness of cylinder fins. Different material used for cylinder fin were Aluminium Alloy A204, Aluminium alloy 6061 and Magnesium alloy which have higher thermal conductivities and shown that by reducing the thickness and also by changing the shape of the fin to circular shaped, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin. The results shows, by using circular fin with material Aluminium Alloy 6061 is better since heat transfer rate, Efficiency and Effectiveness of the fin is more. **Young Researchers, Central Tehran Branch, Islamic Azad University, Tehran, Iran [5]** has stated that heat transfer in a straight fin with a step change in thickness and variable thermal conductivity which is losing heat by convection to its surroundings is developed via differential transformation method (DTM) and variation iteration method (VIM). In this study, we compare DTM and VIM results, with those of homotopy perturbaion method (HPM) and an accurate numerical solution to verify the accuracy of the proposed methods. As an important result, it is depicted that the DTM results are more accurate in comparison with those obtained by VIM and HPM. After these verifications the effects of parameters such as thickness ration, α, dimensionless fin semi thickness, δ, length ratio, λ, thermal conductivity parameter, β, Biot number, Bi, on the temperature distribution are illustrated.

III. METHODOLOGY

The main aim this project is to increase the heat dissipation rate of the given square engine cylinder and to analyze distribution of different properties like Temperature, Total heat flux and Directional heat flux by varying the material used for the cylinder, Geometry of the Cylinder and Linear Dimensions.

There are two ways to increase the rate of Heat transfer for dissipation of Heat from the Cylinder walls

1. Increasing the Surface Heat transfer coefficient(h value),
2. Increasing the Outer surface area of the Component (Cylinder) which is in contact with the ambient atmospheric air.

1. Increasing the surface heat transfer coefficient:

To increase the Surface Heat transfer coefficient, The flowing fluid which flows with a Natural frequency and To which Heat is transferring need to flow with higher velocity so that value of Surface Heat transfer coefficient may increase. Because heat transfer coefficient is directly proportional to the velocity of fluid flowing. But it requires Artificial means like Installation of Pump or Blower to force which we call it as Forced convection.

One another means is that the existing material can be replaced by another material which have higher value of heat transfer coefficient than that of previous one. But we cannot give any assurance to the Economy of the product because the cost of material may increase or sometimes the replaced material cannot serve as good as the first one concern with another properties of the Ideal material required. For Example the requirement is that material for an x-component should be ductile in nature and need to have higher heat transfer coefficient.

Take material-1 which is purely ductile in nature but it's value of heat transfer coefficient is moderate and let us consider that the material-2 is having good heat transfer coefficient value but not ductile in nature may be harder n brittle in nature. For cases like these we go for alloys different materials to satisfy the needs of both structural and thermal requirements.

Hence maximum effort need to be put to produce alloys which is not economical and time consuming. That's why the alternate method called fins extended surfaces is followed by Industrialists, Designers etc.

2. Increasing the Surface area of the given Component:

In the study of heat transfer, **fins** are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment increasing the surface area of the object increases the heat transfer. Sometimes it is not feasible or economical to change the first option. Thus, adding a fin to an object, increases the surface area and can sometimes be an economical solution to heat dissipation.

This process is more Economical and convenient to use when compared with the first method of increasing the value heat transfer coefficient.

Fig-3.1.Heat sinks

Few Reasons that Illustrating Importance of usage of fins:

1. "K" should be as high as possible, (copper, aluminium, iron). Aluminium is preferred: low cost and weight, resistance to corrosion.
2. p/A_c should be as high as possible. (Thin plate fins and slender pin fins)
3. Most effective in applications where h is low. (Use of fins justified if when the medium is gas and heat transfer is by natural convection).

3.1. Fins Approach:

- An important consideration is the selection of the proper *fin length L.* Increasing the length of the fin beyond a certain value cannot be justified unless the added benefits outweigh the added cost.
- The efficiency of most fins used in practice is above 90 percent.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Temperature distribution and heat loss for fins of uniform cross section

Case	Tip Condition ($x = L$)	Temperature Distribution θ/θ_b	Fin Heat Transfer Rate q_f
A	Convection heat transfer: $h\theta(L) = -k\,d\theta/dx\|_{x=L}$	$\frac{\cosh m(L-x) + (h/mk)\sinh m(L-x)}{\cosh mL + (h/mk)\sinh mL}$	$M\frac{\sinh mL + (h/mk)\cosh mL}{\cosh mL + (h/mk)\sinh mL}$
B	Adiabatic $d\theta/dx\|_{x=L} = 0$	$\frac{\cosh m(L-x)}{\cosh mL}$	$M \tanh mL$
C	Prescribed temperature: $\theta(L) = \theta_L$	$\frac{(\theta_L/\theta_b)\sinh mx + \sinh m(L-x)}{\sinh mL}$	$M\frac{(\cosh mL - \theta_L/\theta_b)}{\sinh mL}$
D	Infinite fin ($L \to \infty$): $\theta(L) = 0$	e^{-mx}	M

$\theta \equiv T - T_\infty$ $\quad m^2 \equiv hP/kA_c$
$\theta_b = \theta(0) = T_b - T_\infty$ $\quad M \equiv \sqrt{hPkA_c}\,\theta_b$

Table-3.1

3.2. Problem Definition:

In the present Project investigation on thermal issues on automobile fins were carried out. Investigation yields the temperature behaviour and Total Heat flux and Directional heat flux of the Cylinder fins due to high temperature in the combustion chamber. ANSYS WORKBENCH-2016 is utilized for analysis. The analysis is done for different models of almost a square engine and a comparison is thus established between them by changing geometry and Fin thickness. Also the material is changed so that better heat transfer rate can be obtained.

3.3. The ANSYS Workbench Interface:

The ANSYS Workbench interface consists primarily of a Toolbox region, the Project Schematic, the Toolbar, and the Menu bar. Depending on the analysis type and/or application or workspace, you may also see other windows, tables, charts, etc. One way to work in ANSYS Workbench is to drag an item such as a component or analysis system from the Toolbox to the Project Schematic or to double-click on an item to initiate the default action. You can also use the context menus, accessible from a right-mouse click, for additional options. You will view your analysis systems -- the components that make up your analysis -- in the Project Schematic, including all connections and links between the systems. The individual applications in which you work will display separately from the ANSYS Workbench GUI, but the results of the actions you take in the applications may be reflected in the Project Schematic.

3.4. Toolbox:

The ANSYS Workbench Toolbox presents the types of data that you can add to your project. The Toolbox is context-sensitive; as you select different items in the Project Schematic or other workspaces, the contents of the Toolbox may change to reflect the components and actions available to you. When working in other workspaces, such as Engineering Data or Parameters, you can return to the Project Workspace by clicking the **Return to Project** button on the Toolbar.

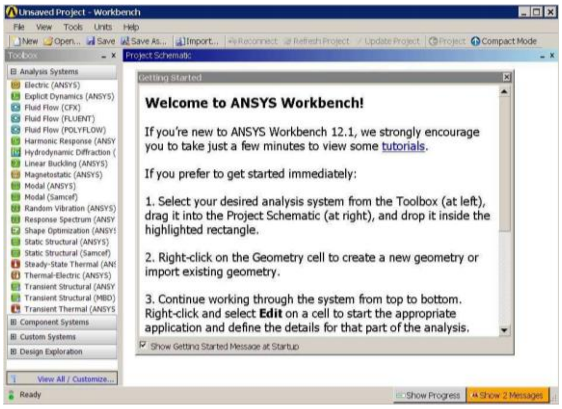


Fig-3.2.ANSYS WORKBENCH TOOL BOX

❖ As we Discussed earlier there are two main types of thermal analysis normally used they are:

1. Steady state thermal analysis,
2. Transient thermal analysis.

1. *Steady state thermal analysis:*

A Steady state thermal analysis calculates the effect of steady thermal load on a system or component, analyst were also doing the steady state analysis before performing the transient analysis. We can use this analysis to determine temperature, thermal gradient, heat flow rates and heat flux in an object that do not vary with time.

A Steady state thermal analysis may be either linear with constant material properties or nonlinear with material properties that depend on temperature. The thermal properties of most material do vary with temperature, so analysis is usually nonlinear.

2. *Transient thermal analysis:*

A transient thermal analysis follows basically the same procedures as a steady-state thermal analysis. The main difference is that most applied loads in a transient analysis are functions of time. To specify time-dependent loads, you first divide the load-versus-time curve into load steps. Each "corner" on the load-time curve can be one load step, as shown in the following sketches.

From the definition of both Steady state thermal analysis and Transient thermal analysis, it is observed that individually both analysis have their own advantage in their respective fields of application but the present scenario is to analyse the variation of properties either linear or non-linear with respect to time.

So, Transient thermal analysis is chosen for thermal analysis of the four models developed in SOLIDWORKS-2013 for a square engine. By changing the Material(Magnesium alloy, Aluminium alloy), Geometry(Circular, Rectangular) and Fin thickness(2mm,3mm) analysis is done and their effect on the time taken for reaching the steady state is plotted on a graph of time verses a property and the different properties analysed are as discussed above Temperature, Directional heat flux, Total heat flux.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Assumptions for analysis:

- The temperature of the surrounding air do not change significantly.
- Constant heat transfer coefficient is considered at the air side.
- The heat generation is neglected.
- Loads are constant.
- Most of physical properties are constant

IV. DESIGN DETAILS

4.1. Modelling of Cylinder Fin:

Cylinder along with fin was modelled in SOLIDWORKS-2013. The dimensions of the cylinder along with fin were taken for a square engine whose stroke ratio is unity. Fins with different geometries (circular and rectangular) were modelled using SOLIDWORKS-2013.

4.2. Procedure to draw the rectangular and cylindrical fins in SOLIDWORKS-2013:

i. Observe and Understand the given model's top and font views clearly and their dimensions,
ii. Adjust the Unit system in SOLIDWORKS as SI-system,
iii. Go to Sketch,
iv. Select the front view from the given views,
v. First draw the Centre line assumed distance by using line command,
vi. Then draw one side of front view with assumed dimensions
vii. By using the smart dimension command adjust the fin length, groove length, upwards projection of cylinder and Projection distance from center line which is the diameter of the fin flank in case of circular fins and for rectangular fins take it as the diagonal length of the fin flank.
viii. For both cases the internal and external diameter of the cylinder are fixed,
ix. Then by using revolute command revolute the drawn section,
x. In case of circular fins, The fin model is ready but in case of rectangular fins we need to perform extrude cut in downward direction by using the extrude cut option and film cut need to performed to remove the excess projections of rectangular shape.
xi. Both circular and rectangular cylindrical fins are available now and their respective dimensions need to be changed as per the given data by changing the fin thickness.

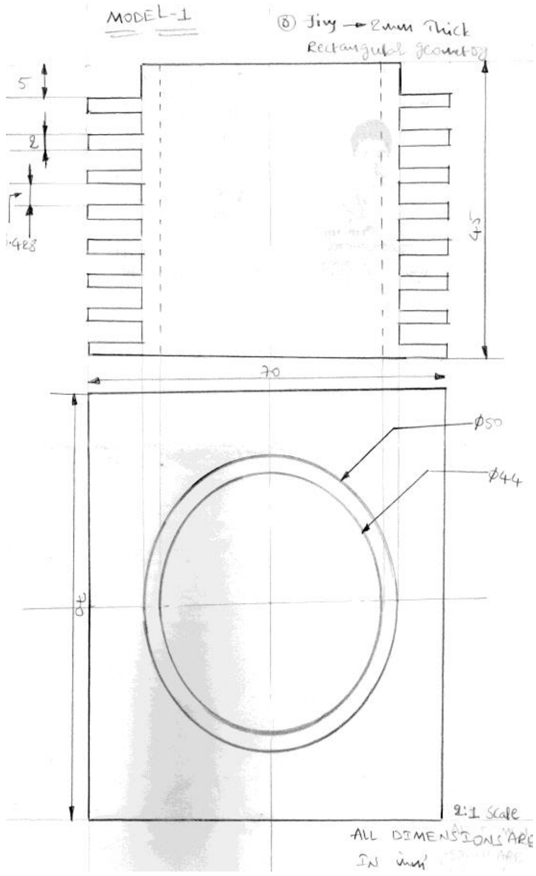


Fig-4.1 MODEL-1

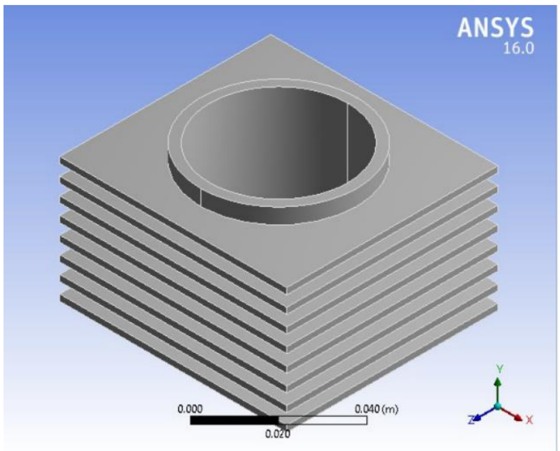


Fig-4.2.Rectangular fins of 2mm thickness

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

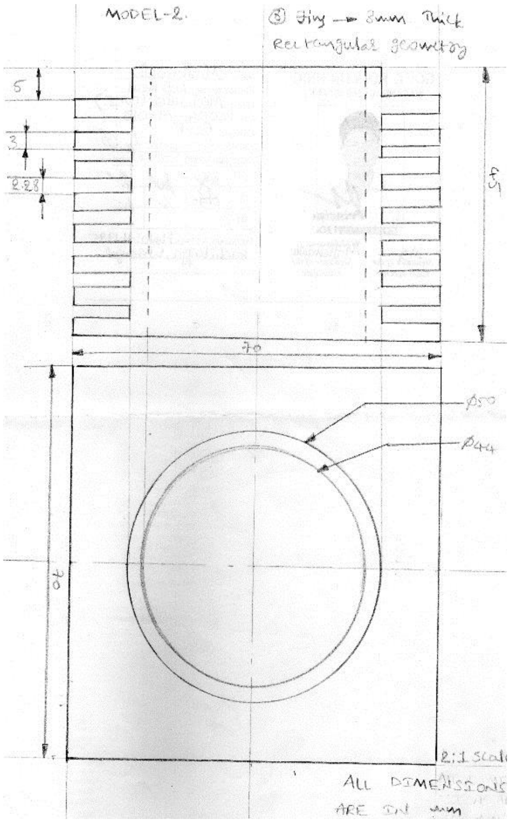


Fig-4.3 MODEL-2

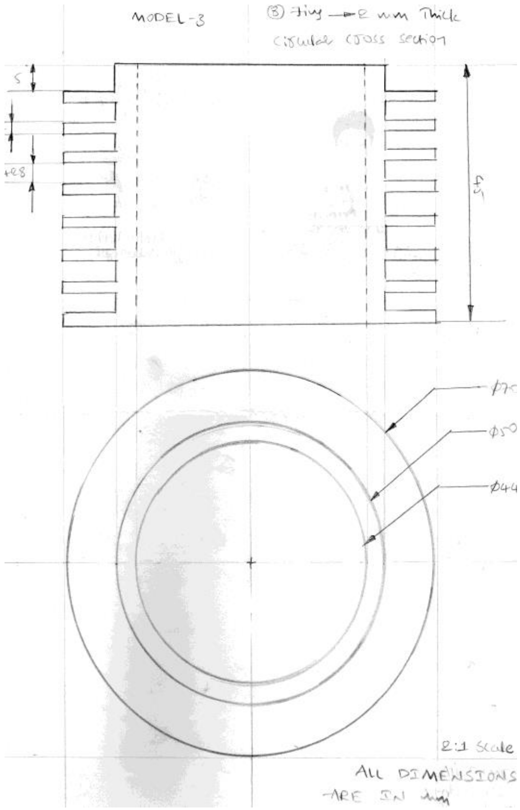


Fig-4.5 MODEL-3

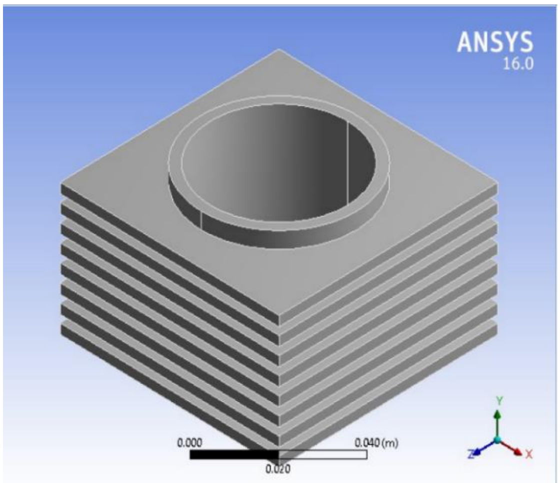


Fig-4.4.Rectangular fins of 3mm thickness
Fig. Rectangular cylindrical fin

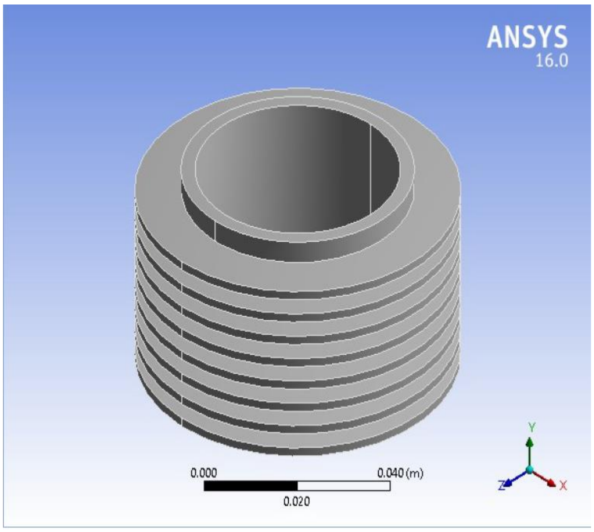


Fig-4.6.Circular fins of 2mm thickness

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

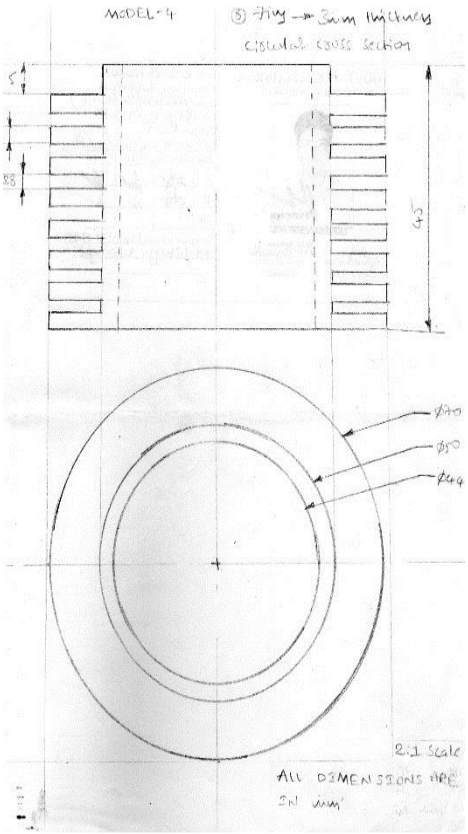


Fig-4.7 MODEL-4

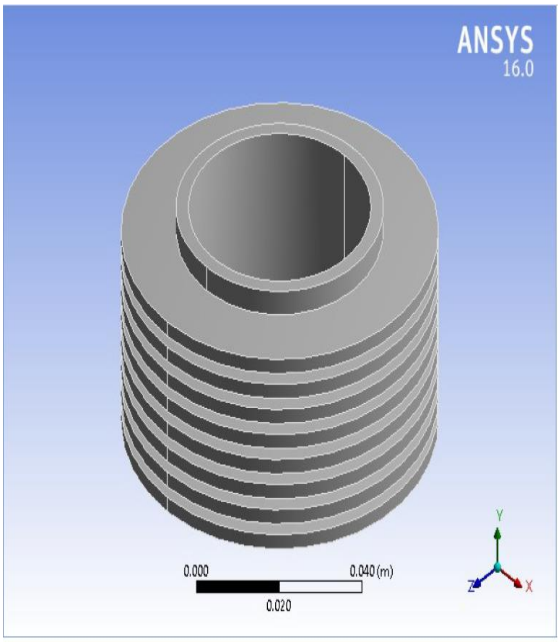


Fig-4.8.Circular fins of 3mm thickness

Fig. Circular cylinder fin

V. EXPERIMENTAL DETAILS

5.1. The Boundary Conditions are:

Table: **5.1**-Input Parameters

Sl. No.	Loads	Units	Value
1	Inlet temperature	K	1073
2	Film coefficient	W/m^2 K	5
3	Ambient temperature	K	303
4	Material		Aluminium Alloy, Magnesium Alloy

5.2. Material Data:

Aluminium Alloy:

Table: 5.2-Aluminium Alloy Constants

Density	**2770 kg m^-3**
Coefficient of Thermal Expansion	**2.3e-005 C^-1**
Specific Heat	**875 J kg^-1 C^-1**

Magnesium Alloy:

Table: 5.3-Magnesium Alloy Constants

Density	**1800 kg m^-3**
Coefficient of Thermal Expansion	**2.6e-005 C^-1**
Specific Heat	**1024 J kg^-1 C^-1**
Thermal Conductivity	**156 W m^-1 C^-1**
Resistivity	**7.7e-007 ohm m**

VI. RESULTS AND DISCUSSION

A model of cylinder with fins mounted on it is used for analysis in the present project. This is imported into ANSYS workbench environment and boundary conditions were applied as mentioned above. Analysis is carried out for different geometry of fins (circular and rectangular) with various thicknesses and materials. The results are shown below,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

MODEL-1
Type : rectangular
Material : aluminium alloy
Fin thickness: 2mm

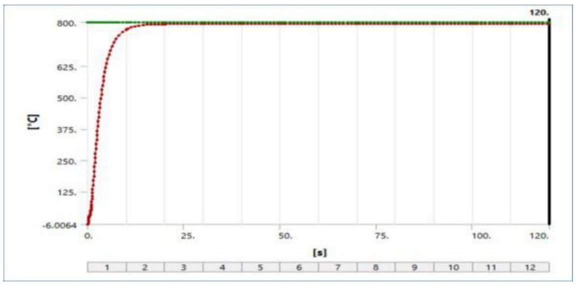


Fig 6.1: Time verses Temperature graph of Model-1

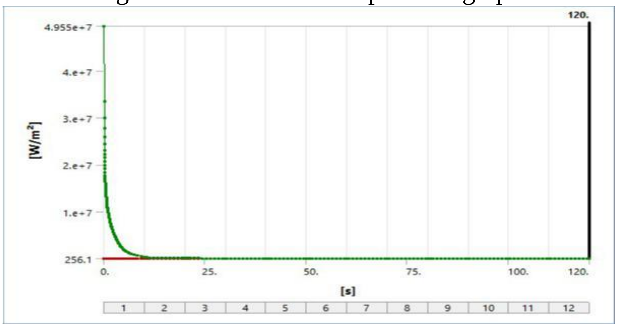


Fig 6.2: Time verses Total heat flux graph of Model-1

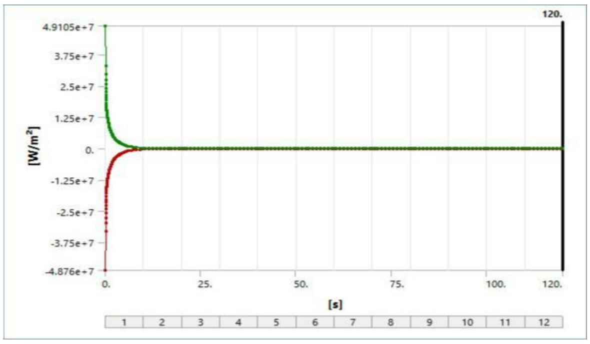


Fig 6.3: Time verses Directional heat flux graph of Model-1

Table 6.1: Results of Model-1

RESULTS			
Minimum	**793.71 °C**	**2321.3 W/m²**	**-69934 W/m²**
Maximum	**800. °C**	**82965 W/m²**	**70639 W/m²**
Minimum Value Over Time			
Minimum	**-6.0064 °C**	**256.1 W/m²**	**-4.876e+007W/m²**
Maximum	**793.71 °C**	**9370.9 W/m²**	**-69934 W/m²**
Maximum Value Over Time			
Minimum	**800. °C**	**82965 W/m²**	**70639 W/m²**
Maximum	**800. °C**	**4.955e+007 W/m²**	**4.9105e+007 W/m²**

MODEL-2
Type : rectangular fin
Material : magnesium alloy
Fin thickness : 2mm

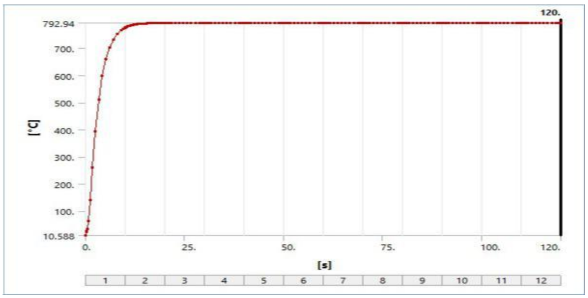


Fig 6.4: Time verses Temperature graph of Model-2

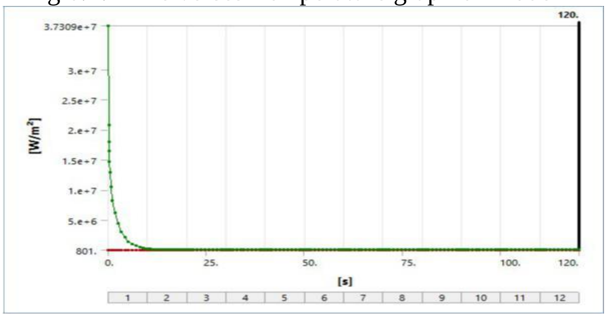


Fig 6.5: Time verses Total heat flux graph of Model-2

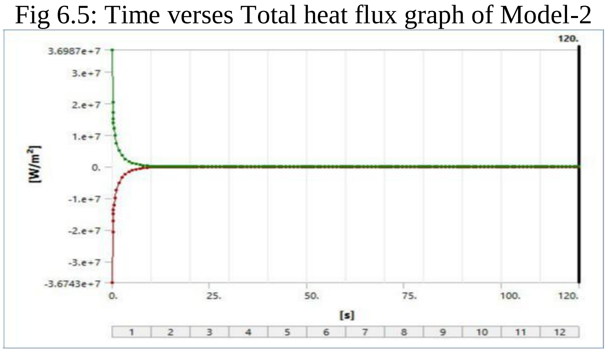


Fig 6.6: Time verses Directional heat flux graph of Model-2

Table 6.2: Results of Model-2

Results			
Minimum	**795.33 °C**	**2328.6 W/m²**	**-49044 W/m²**
Maximum	**800. °C**	**63273 W/m²**	**48177 W/m²**
Minimum Value Over Time			
Minimum	**-2.875 °C**	**555.52 W/m²**	**-5.0515e+007 W/m²**
Maximum	**795.33 °C**	**9891.5 W/m²**	**-49044 W/m²**
Maximum Value Over Time			
Minimum	**800. °C**	**63273 W/m²**	**48177 W/m²**
Maximum	**800. °C**	**5.1579e+007 W/m²**	**5.1357e+007 W/m²**

MODEL-3
Type : rectangular fin
Material : aluminium alloy
Fin thickness : 3mm

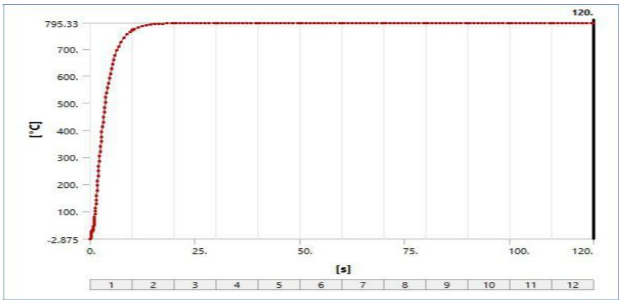


Fig 6.7: Time verses Temperature graph of Model-3

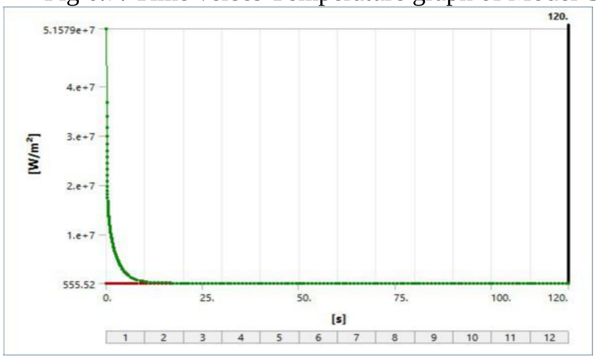


Fig 6.8: Time verses Total heat flux graph of Model-3

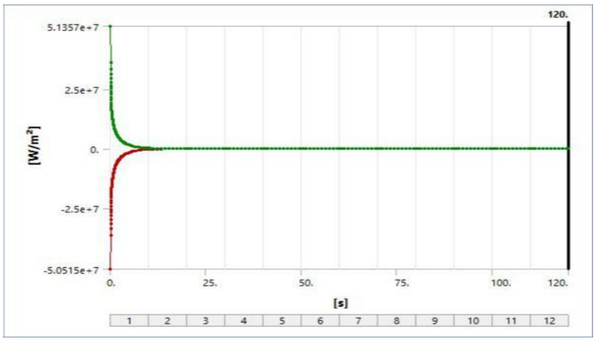


Fig 6.9: Time verses Directional heat flux graph of Model-3

Table 6.3: Results of Model-3

RESULTS			
Minimum	795.33 °C	2328.6 W/m²	-49044 W/m²
Maximum	800. °C	63273 W/m²	48177 W/m²
Minimum Value Over Time			
Minimum	-2.875 °C	555.52 W/m²	-5.0515e+007 W/m²
Maximum	795.33 °C	9891.5 W/m²	-49044 W/m²
Maximum Value Over Time			
Minimum	800. °C	63273 W/m²	48177 W/m²
Maximum	800. °C	5.1579e+007 W/m²	5.1357e+007 W/m²

MODEL-4
Type : rectangular
Material : magnesium alloy
Fin thickness : 3mm

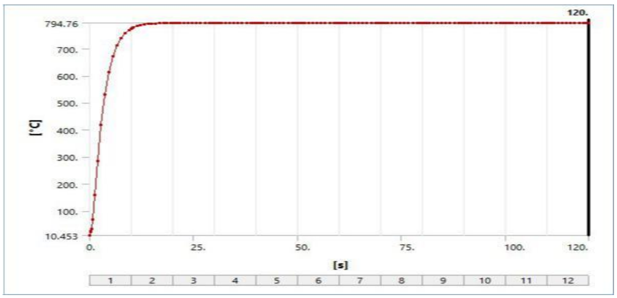


Fig 6.10: Time verses Temperature graph of Model-4

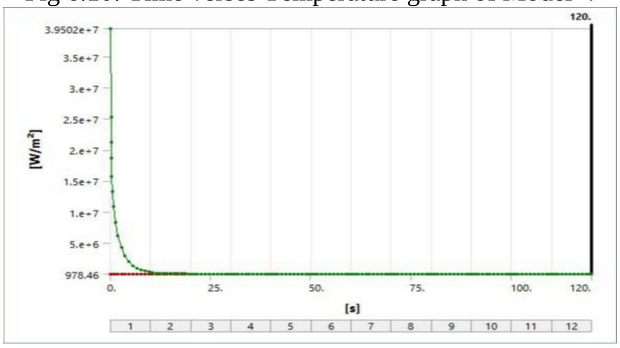


Fig 6.11: Time verses Total heat flux graph of Model-4

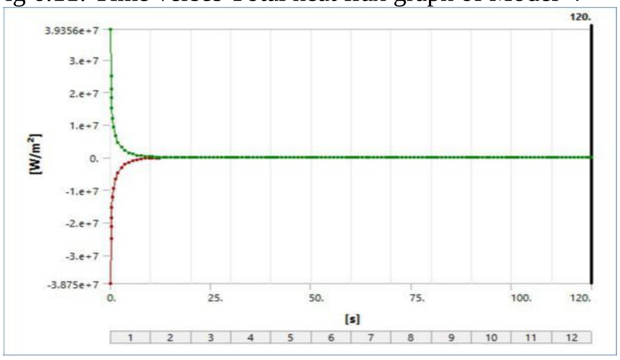


Fig 6.12: Time verses Directional heat flux graph of Model-4

Table 6.4: Results of Model-4

RESULTS			
Minimum	795.33 °C	2328.6 W/m²	-49044 W/m²
Maximum	800. °C	63273 W/m²	48177 W/m²
Minimum Value Over Time			
Minimum	-2.875 °C	555.52 W/m²	-5.0515e+007 W/m²
Maximum	795.33 °C	9891.5 W/m²	-49044 W/m²
Maximum Value Over Time			
Minimum	800. °C	63273 W/m²	48177 W/m²
Maximum	800. °C	5.1579e+007 W/m²	5.1357e+007 W/m²

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

MODEL-5
Type : circular
Material : aluminium alloy
Fin thickness : 2mm

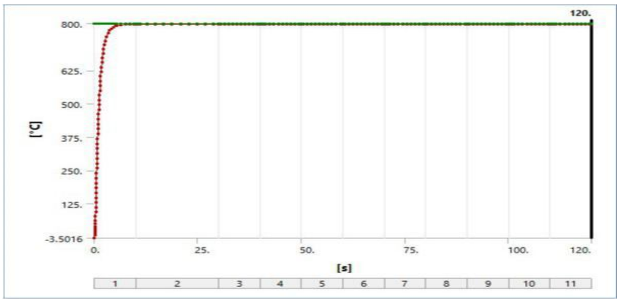


Fig 6.13: Time verses Temperature graph of Model-5

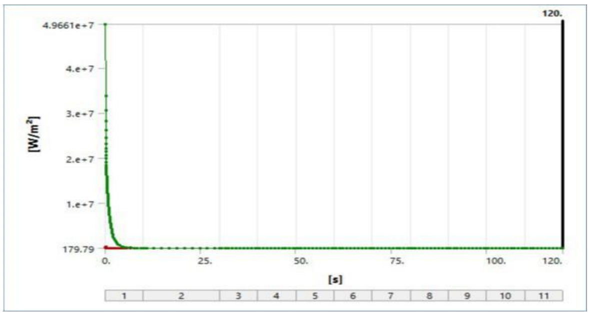


Fig 6.14: Time verses Total heat flux graph of Model-5

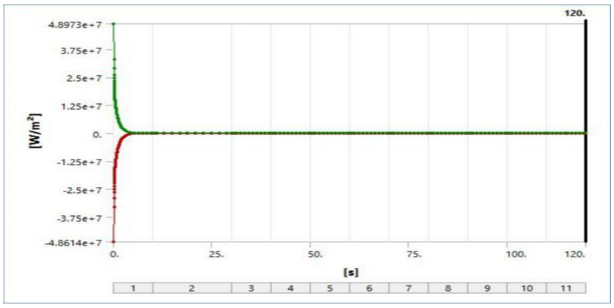
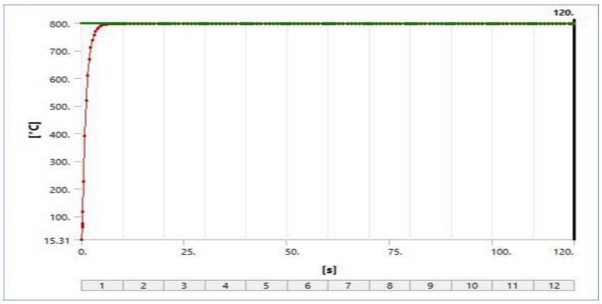


Fig 6.15: Time verses Directional heat flux graph of Model-5

MODEL-6
Type : circular
Material : magnesium alloy
Fin thickness : 2mm



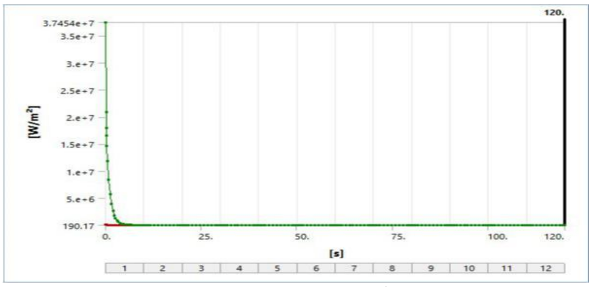


Fig 6.16: Time verses Temperature graph of Model-6

Fig 6.17: Time verses Total heat flux graph of Model-6

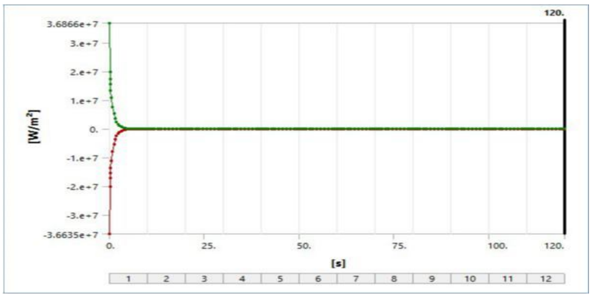


Fig 6.18: Time verses Directional heat flux graph of Model-6

Results			
Minimum	797.84 °C	1649.7 W/m²	-46844 W/m²
Maximum	800. °C	49178 W/m²	45732 W/m²
Minimum Value Over Time			
Minimum	-3.5016 °C	179.79 W/m²	-4.8614e+007 W/m²
Maximum	797.84 °C	4.1861e+005 W/m²	-46844 W/m²
Maximum Value Over Time			
Minimum	800. °C	49178 W/m²	45732 W/m²
Maximum	800. °C	4.9661e+007 W/m²	4.8973e+007 W/m²

Table 6.5: Results of Model-5

Results			
Minimum	797.58 °C	1648.7 W/m²	-46831 W/m²
Maximum	800. °C	49164 W/m²	45720 W/m²
Minimum Value Over Time			
Minimum	15.31 °C	190.17 W/m²	-3.6635e+007 W/m²
Maximum	797.58 °C	1.9031e+005 W/m²	-46831 W/m²
Maximum Value Over Time			
Minimum	800. °C	49164 W/m²	45720 W/m²
Maximum	800. °C	3.7454e+007 W/m²	3.6866e+007 W/m²

Table 6.6: Results of Model-6

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

MODEL-7

Type : circular
Material : aluminium alloy
Fin thickness : 3mm

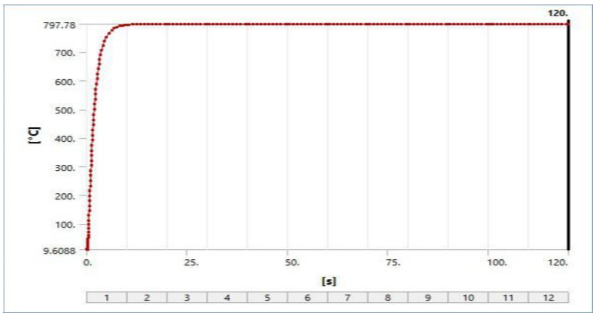


Fig 6.19: Time verses Temperature graph of Model-7

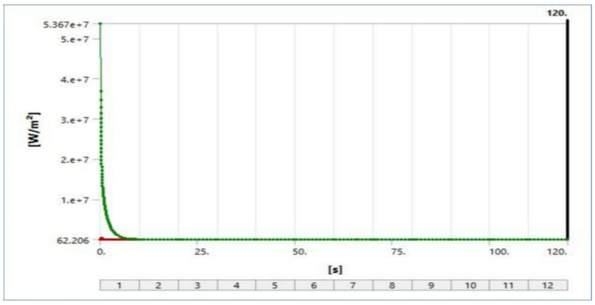


Fig 6.20: Time verses Total heat flux graph of Model-7

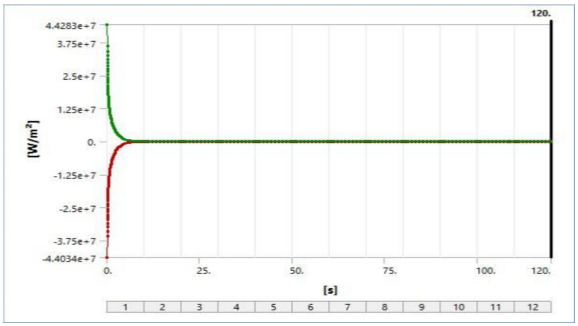


Fig 6.21: Time verses Directional heat flux graph of Model-7

Table 6.7: Results of Model-7

Results			
Minimum	797.78°C	2361.9 W/m²	-36746 W/m²
Maximum	800. °C	36888 W/m²	36592 W/m²
Minimum Value Over Time			
Minimum	9.6088 °C	62.206 W/m²	-4.4034e+007 W/m²
Maximum	797.78 °C	4.2114e+005 W/m²	-36746 W/m²
Maximum Value Over Time			
Minimum	800. °C	36888 W/m²	36592 W/m²
Maximum	800. °C	5.367e+007 W/m²	4.4283e+007 W/m²

MODEL-8

Type : circular
Material : magnesium
Fin thickness : 3mm

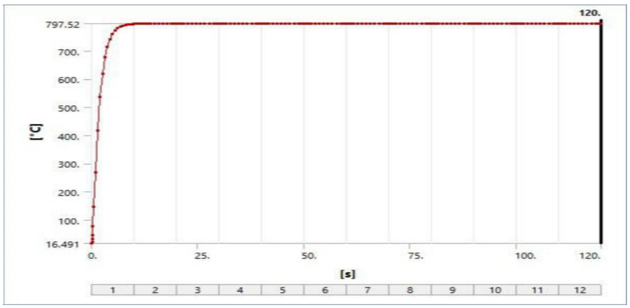


Fig 6.22: Time verses Temperature graph of Model-8

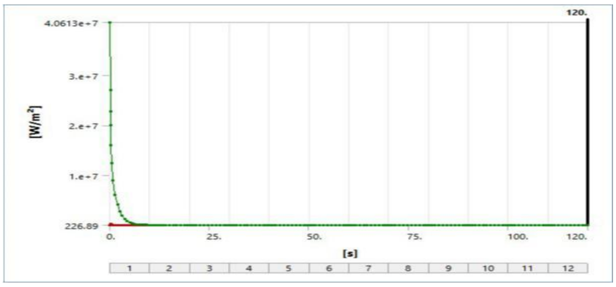


Fig 6.23: Time verses Total heat flux graph of Model-8

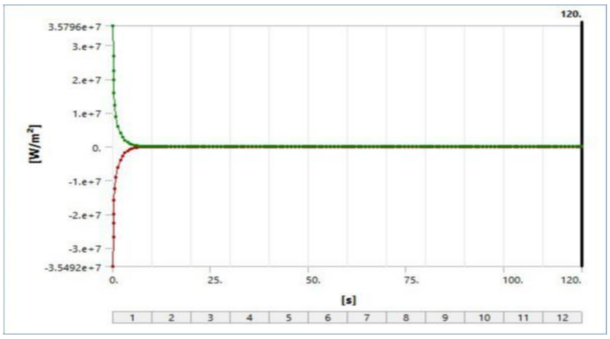


Fig 6.24: Time verses Directional heat flux graph of Model-8

Table 6.8: Results of Model-8

Results			
Minimum	797.52 °C	2360.8 W/m²	-36737 W/m²
Maximum	800. °C	36879 W/m²	36582 W/m²
Minimum Value Over Time			
Minimum	16.491 °C	226.89 W/m²	-3.5492e+007 W/m²
Maximum	797.52 °C	3.291e+005 W/m²	-36737 W/m²
Maximum Value Over Time			
Minimum	800. °C	36879 W/m²	36582 W/m²
Maximum	800. °C	4.0613e+007 W/m²	3.5796e+007 W/m²

6.1. Discussion:

➢ ***Temperature Distribution:***

From the above results, We can observe that the 5th model which is made of aluminium alloy with 2mm thick circular shaped circumferential fins can attain maximum temperature of 797.84°C**.**Which is also maximum amongst all the other model's values of maximum temperature and the time taken to attain this steady state is 14.8 seconds.

But on the other hand model-6 which is made of magnesium alloy with same features of 2mm thick and circular in geometry giving tight competition to the model-5.Whose attained value of maximum temperature is less when compared with model-5, which is 797.58 °C but to attain that temperature it took very less time amongst all the other models which is 10.9 seconds.

Rate of change of temperature is high for Model-8 which is made of Magnesium alloy with 3mm thick circular circumferential fins.

Hence, Both Attained value of Maximum Temperature and Temperature change with respect to time are high in Fins of Circular Geometry.

➢ ***Total Heat flux:***

When it is matter of total heat flux conducted by the cylinder the variation observed is as follows:

The model-1 which is made of aluminium alloy with 2mm rectangular circumferential fins conducts more total heat flux when compared with all the other models.

When material is the point of interest, aluminium alloy conducts more total heat flux because model-2 which is made of magnesium alloy with same features as model-1 except material change conducting less total heat flux.

And one another observation is that Total Heat flux conducted by a material increases with increase in amount of material. That's why its value is high in rectangular geometry then the circular geometry and it also decreases with increase in fin thickness.

Directional Heat flux:

In case of Directional Heat flux all the results are similar to Total Heat flux

The Directional heat flux conducted by the material increases with increase in amount of material but decreases with increase in fin thickness and it is high in rectangular geometry when compared with circular geometry.

Aluminium alloy fin conducts more directional heat than that of magnesium alloy fin with the same geometry and fin thickness

In the negative radial direction opposite to the positive direction same effects are applicable.

NOTE: All the above discussion regarding to the final data obtained after 120 seconds of operation and by the transient thermal analysis.

VII.CONCLUSION

In present work, a cylinder fin body is modelled by using SOLIDWORKS-2013 and Transient thermal analysis is done by using ANSYS WORKBENCH-2016. These fins are used for air cooling systems for two wheelers. In present study, Aluminium alloy is compared with Magnesium alloy. The various parameters (i.e., geometry and thickness of the fin) are considered, by reducing the thickness and also by changing the shape of the fin to circular shape from the conventional geometry i.e. rectangular, the weight of the fin body reduces there by increasing the heat transfer rate and efficiency of the fin.

The results shows, By using circular fin with material Aluminium Alloy is better since heat transfer rate of the fin is more. By using circular fins the weight of the fin body reduces compared to existing rectangular engine cylinder fin.

VIII. REFERENCES

1. Willard W. Pulkrabek, "Engineering fundamentals of the internal combustion engine", Prentice hall, 2005.
2. Gustof P "Determination of The Temperature Distribution in The Wet Cylinder Sleeve in Turbo Diesel engine"JAMME,Vol.27,Issue 2, April, 2008, pp.159-162.
3. Ning H, Sun P, Wang S, Yu S, "Finite Element Analysis of Thermal-Structure Coupled Field of Diesel Engine Cylinder Liner", International Conference on Optics, Photonics and Energy Engineering, 2010.
4. Zeng Wu Y," finite Element Analysis for the Thermal Load of Piston in a Dimethyl Ether Fueled Diesel Engine", Mechanic Automation and Control Engineering (MACE), 2010 Wuhan International Conference on 26-28 June 2010, pp.2895 – 2898.
5. Yusaf T "Modeling of Transient Heat Flux in Spark Ignition Engine During combustion and Comparisons with Experiment" American Journal of applied Sciences Vol.2 Issue 10, 2005, pp.1438-1444.
6. Holman J P" Heat Transfer In SI Units "Tata McGraw –Hill Publishing Company limited .2009
7. Hoffmann K.A., Chiang S.T., "Computational fluid dynamics for engineers ",McGraw-Hill,
8. Yunus C." Heat Transfer" McGraw –Hill Publishing Company limited .2006.