Design and Thermal Analysis of 250cc Engine Cylinder Fin by using Different Materials

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Abstract

The 250 cc engine is well-known mechanical component used for power generation, but this is subjected to very high temperature and thermal stresses. Therefore cooling of engine is essential. For this purpose we have two options either we use Liquid cooling system or Air cooling system. Nowadays many of the automotive industries prefers liquid cooling system for higher cc engine but this system have some DRAWBACKS which can be overcome by using Air cooling system(FINS). An air-cooled engine dissipates unwanted heat into surrounding with the help of conduction and convection. We can't increase conductive heat transfer as it is depends on properties of material used, but we can increase convective heat transfer simply by increasing area; therefore to increase area we use outward projections on cylinder called as fins. The main objective of this project is to design and thermal analysis of 250 cc engine cylinder fins by using different materials to replace liquid cooling system. The main purpose of using this FINS is to cool the 250cc engine cylinder by atmospheric air. But for thermal analysis of cylinder fins analyzing software ANSYS .we have to design whole complex 250 cc engine on designing software which is very difficult so a parametric model of engine cylinder with fins is created in 3D modeling software SOLIDWORKS.

Keywords- Heat Engine, Fins, Necessity of Cooling, Selection of Material, Analysis

I. INTRODUCTION

Due to increase in number of vehicles the demand of fossil fuel is increasing thereby depleting reserves day by day .Hence fuel prices are raising. It demands technology towards new inventions and research, which provides engines which are highly efficient and produces high specific power. Although water-cool engines are efficient but there are some disadvantages of this engines like more cost, consumption of power for water pump etc. this drawbacks can be overcome by using air cool engine. Air cool engine show great advantages like lower weight, less space requirement, less consumption of fuel etc. Due to this advantages the air cooled engines are preferred in most of the modern two wheelers. During combustion process in combustion chamber temperature reaches its peak value and then this temperature lowered to some standard value. This can be achieved by faster heat dissipation.

By using the extended surfaces (Fins) we can improve the heat transfer rate from engine cylinder. For this analysis of the heat transfer rate of the fins is imperative. Every combination of shape, size and material have their own efficiency thereby selecting the best possible combination which give maximum efficiency to get required heat transfer rate for maximum engine efficiency.

Extended area on the cylinder surfaces is use to increase the surface area in contact with the fluid flowing around it. Which further increases the rate of heat transfer from the base surface as compare to cylinder without the extensions provided to it. Types of fin provided on cylinder as rectangular extensions, trapezium extensions and triangular extension.

Heat transfer rates can be increased by increasing the 1.Temperature gradient between the object and the environment 2.Convection coefficient and 3.Surface Area of the object. Considering the feasibility and economical way of increasing the heat transfer rate, we can go for option 3 as stated above.

II. LITERATURE REVIEW

1) Golnoosh Mostafavi investigated the steady-state external natural convection heat transfer from vertically mounted rectangular interrupted finned heat sinks. Results show that adding interruptions enhances the thermal performance of fins and reduces the weight of the fin arrays, which in turn, can lead to lower manufacturing costs.
2) J.Ajay Paul et.al. Performed a parametric study of extended fins in the optimization of internal combustion engine and found that for high speed vehicles thicker fins provide better efficiency.

3) N. Nagarani et.alanalyzed the heat transfer rate and efficiency for circular and elliptical annular fins for different environmental conditions. Elliptical fin efficiency is found to be more than circular fin. If space restriction is there along one particular direction while the perpendicular direction is relatively unrestricted elliptical fins could be a good choice. To solid fins with reduction of cost of the material by 30%.
4) R.P.Patil et.al. Conducted CFD and experimental analysis of elliptical fins for heat transfer parameters, heat transfer coefficient and tube efficiency by forced convection. At air flow rate of 3.7 m/s the efficiency, increases as heat input increases.
5) Sable, M.J. et.al. Investigated for natural convection adjacent to a vertical heated plate with a multiple v- type partition plates (fins) in ambient air surrounding. As compared to conventional vertical fins, this v-type partition plate's works not only as extended surface but also as flow tabulator providing better fin array configurations.

III. THEORY

A. What is Heat Engine

According to thermodynamics, a system that converts heat or thermal energy of chemicals (fuels) into mechanical energy, which can then be used to do mechanical work is called as heat engine. While producing work the working substance move from a higher temperature state to a lower temperature state. A heat engine contains working substance which transfer higher temperature state generated by heat source to lower temperature state called as heat sink, while doing this it will produce work. While producing the work some amount of the thermal energy is converted into useful work with help of working substance, and remaining energy lost in the exhaust as well as friction. In most if the I.C.engines air is use as working substance.

B. Why Engines are cooled?

1) Overheating damages engine valves mechanism.
2) Due to higher temperature for long time the internal structure of cylinder and piston material (Granules) gets disturbed.
3) Life of lubricating oil decreases, it gets thinner.
4) Due to higher temperature variations the design of an engine fails at very low load.
5) Power stroke takes place before completion of compression due to the overheating of spark plug. Hence decreases the volumetric efficiency.
6) Without optimum cooling we can't have required efficiency.

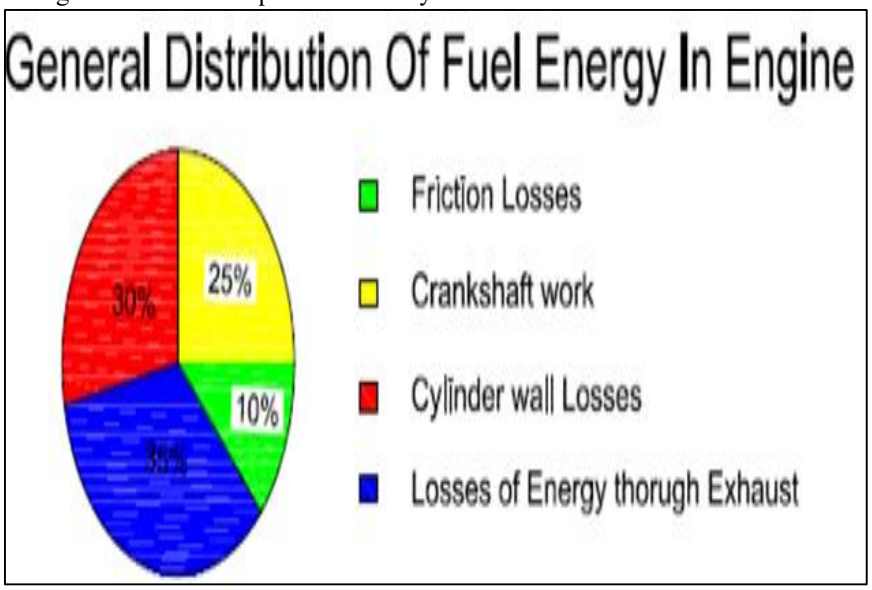

Fig. 1: General Distribution of Fuel Energy in Engine

Here we used air cooling system in the engine which uses extended surfaces (fins), due to extended area used to transfer the heat cooling of engine improves, resulting increase in the volumetric efficiency.
But overcooling results in the decrease of overall efficiency. Therefore fins are designed to its optimum value to avoid overcooling and overheating.

C. What are Fins

According to heat transfer engineering, the extended surfaces used to increase the rate of heat transfer to or from object to surrounding is called as fins. The overall heat transfer rate of object is combination of conduction, convection and radiation through that object. Heat transfer rate varies with temperature gradient, convective heat transfer coefficient and surface area of the object. Hence for increasing heat transfer rate we have to increase this three factors Due to economical and manufacturing limitation we

cannot increase first two factors beyond certain limit. Thus, increasing surface area is only economical solution for this problem. Hence we provide fins on cylinder.

D. Fin Material

1) Factors on which materials are selected

1) Machining cost
2) Surface finishing
3) Heat conductivity
4) Toughness
5) Co-efficient of friction

2) Some commonly used materials for fins

1) Chromium
2) Cast Iron
3) Brass
4) Aluminum Alloys
5) Magnesium Alloys

E. Properties of this Materials

Table 1: properties of materials

Materials	*Thermal conductivity (w/m-c)*	*Density* $(kg/m^3)\times10^3$	*Heat Transfer Coe.*(w/m^2c)	*Melting point (F)*	*Thermal Expansion* $(in/in/F\times10^{-6})$
Brass	*119*	*8.8*	*5*	*1724*	*11.2*
Cast Iron	*55*	*7.92*	*5*	*2150*	*6*
Magnesium Alloy	*156*	*1.8*	*5*	*1105*	*2.6*
Chromium	*94*	*7.18*	*5*	*3462*	*8.8*
Aluminum Alloy	*167*	*2.770*	*5*	*1240*	*2.3*

F. CADD Modeling

We prepare parametric model of for 250cc engine cylinder along with its fins. For this we can use any of the designing software as Autocad3D, Solid works, CATIA, CREO etc.
Here we have used solid works for designing. For analysis purpose we used ANSYS Workbench.
General information about our engine cylinder dimensions are as follows

Table 2: General information about engine cylinder dimensions

NO. of cylinders	*1*
Bore	*76mm*
Stroke	*55mm*
Piston Displacement	*249.6*
Compression ratio	*10.7*
Fin Quantity	*7*
Fin thickness	*3mm*
Fin position	*Horizontal*

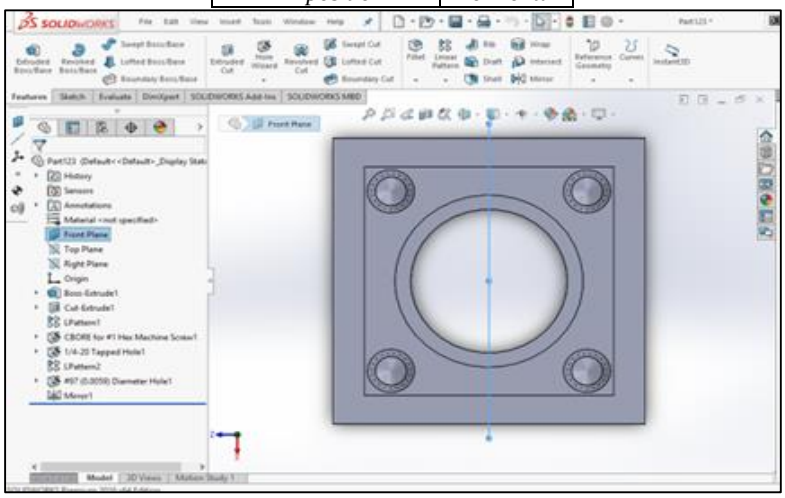

Fig. 2: Top view

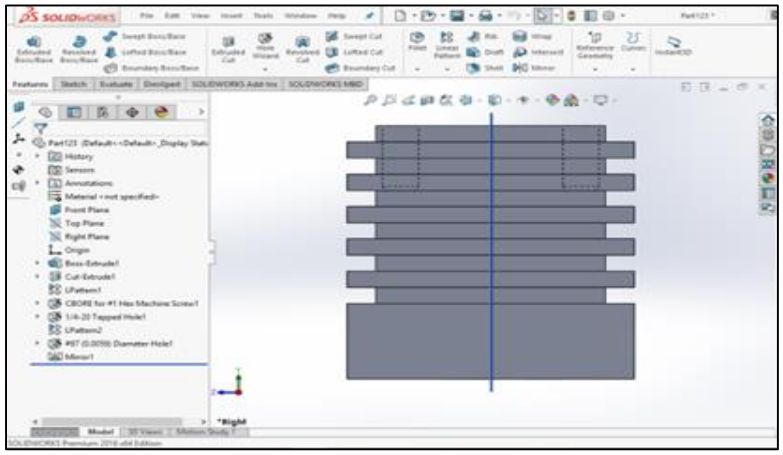

Fig. 3: Front view

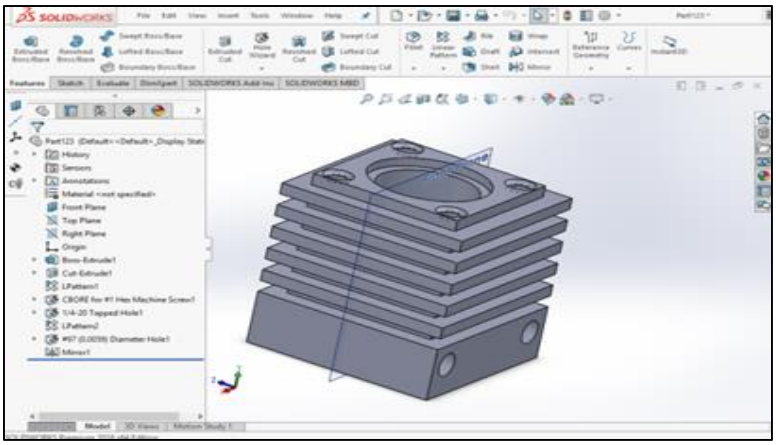

Fig. 4: Isometric view

IV. MATHEMATICAL REPRESENTATION OF FINS

Heat transfer coe. Is given as,

$$Q=hA(T_w - T_\infty)$$

Let the cross section area of fin be A and perimeter be P then the energy quantities are,

Energy in = $Q_x = -kA\frac{dT}{dx}$

Energy out = $Q_x + d_x = -kA(\frac{dT}{dx}+\frac{d^2T}{dx^2}dx)$

Energy lost by convection = $hPdx(T-T_\infty)$

By combining above equations we get,

$$\frac{d^2T}{dx^2} - \frac{hP}{kA}(T - T_\infty) = 0$$

Let $\Theta = (T - T_\infty)$

$$\frac{d^2\theta}{dx^2} - \frac{hP}{kA}\Theta = 0$$

One boundary condition is,

$$\Theta = \Theta_0 = T - T_\infty \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{at } x=0$$

The other boundary condition depends on following physical situations,

CASE 1 : Very long fin

CASE 2 : Finite length fin

CASE 3: Insulated end fin

Let $m = \sqrt{\frac{hP}{kA}}$

$$\Theta = C_1 e^{-mx} + C_2 e^{mx}$$

For CASE 1

$$\Theta = \Theta_0 \quad \ldots\ldots\ldots\ldots\ldots\text{at } x=0$$
$$\Theta = 0 \quad \ldots\ldots\ldots\ldots\ldots\text{at } x=\infty$$

Therefore solution:

$$\frac{\theta}{\theta 0} = \frac{T - T_\infty}{T_0 - T_\infty}$$

For CASE 3:

$$\Theta = \Theta_0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{at } x=0$$

$$\frac{d\theta}{dx} = 0 \quad \ldots\ldots\ldots\ldots \text{at } x=L$$

Thus,

$$\Theta_0 = C_1 + C_2$$

$$0 = m\,(-C_1\, e^{-mx} + C_2\, e^{mL})$$

Solving for constants C_1 & C_2

$$\frac{\theta}{\theta 0} = \frac{\cosh(m(L-x))}{\cosh(mL)}$$

CASE 2

Solution for case 2 is more involved algebraically & the result is,

$$\frac{T - T_\infty}{T_0 - T_\infty} = \frac{\cosh(m(L-x)) + \left(\frac{h}{mk}\right)\sinh(m(L-x))}{\cosh mL + \left(\frac{h}{km}\right)\sinh ml}$$

In most cases however the first equation is easier to apply, for case 1

$$Q = -kA(-m\Theta_0 e^{-m(0)}) = m\Theta_0$$

The heat flow for case 2 is,

$$Q = m(T_0 - T_\infty)\,\frac{\sinh mL + \left(\frac{h}{mk}\right)\cosh mL}{\cosh mL + \left(\frac{h}{mk}\right)\sinh mL}$$

$$\text{Efficiency of fin} = \frac{\text{Actual heat transferd}}{\text{Heat that would be transferd if entire fin area at base temp.}}$$

Effectiveness of fin is given by,

$$\frac{q(\text{with fin})}{q(\text{without fin})} = \frac{\tanh mL}{\sqrt{\frac{hA}{kP}}}$$

V. THERMAL ANALYSIS ON COOLING FINS

For analysis of fins we use following boundary conditions

1) Temperature inside the bore = 600^0C
2) Outer boundary condition that is atmospheric temperature = 25^0C

And convective heat transfer coefficient = 5 w/m^2/^{0}C

A. Results of Analysis

1) Selected Material: - Brass

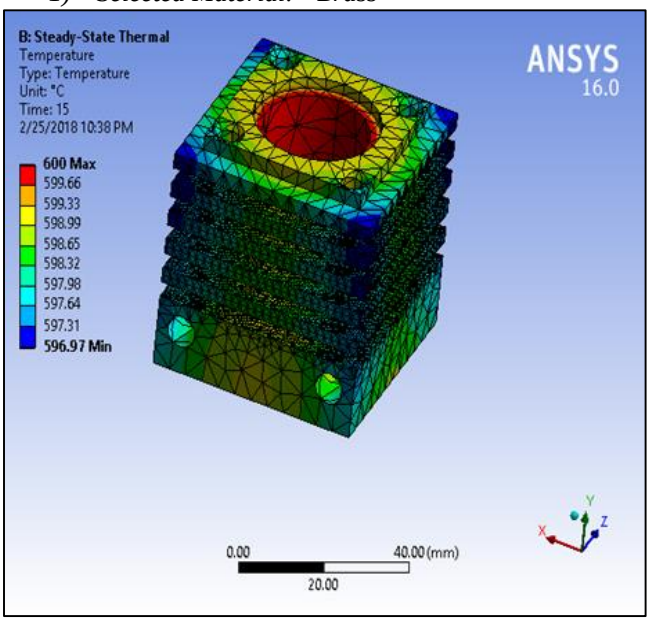

Fig. 5: Temperature Distribution

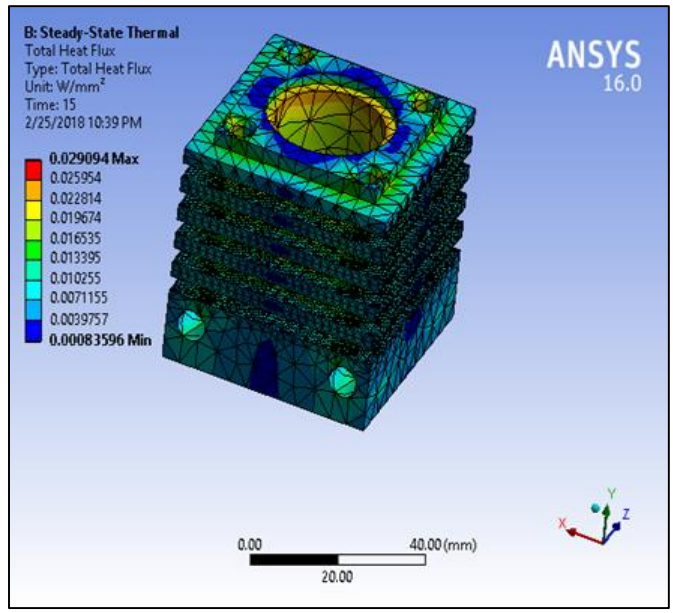

Fig. 6: Heat Flux

Results

Temperature Distribution(^{0}c)	*Heat Flux(W/M^2)*
596.52	*29094*

2) Selected Material:- Cast Iron

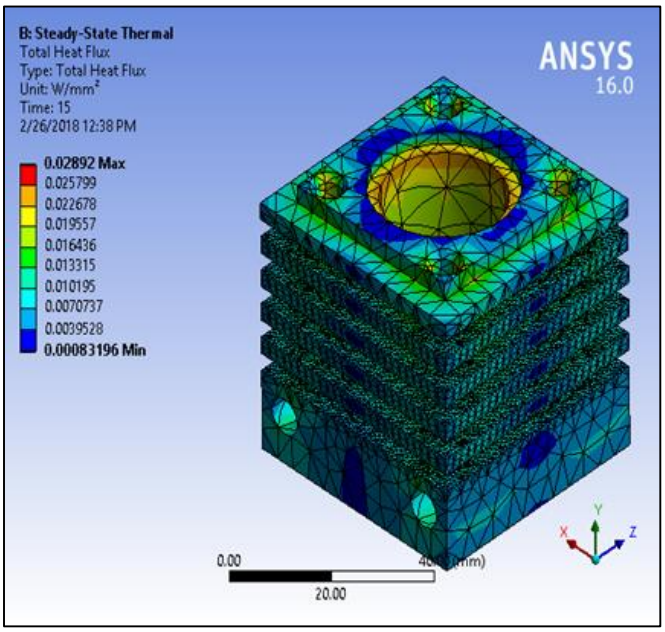

Fig. 7: Temperature Distribution

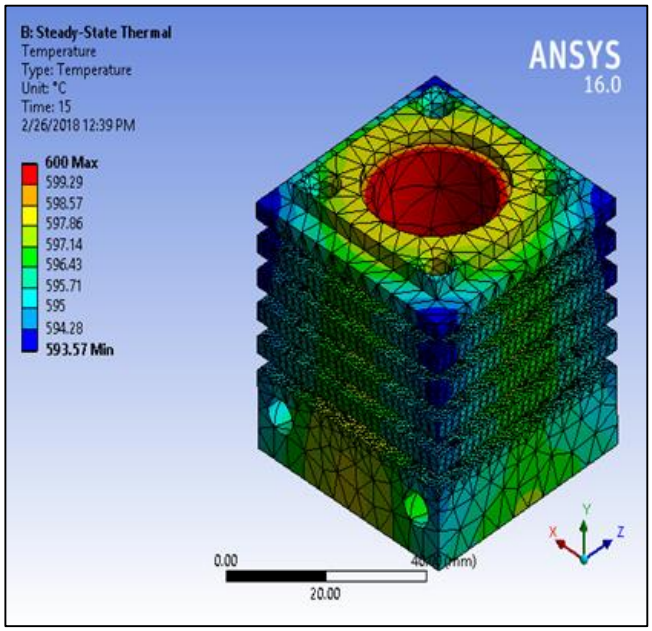

Fig. 8: Heat Flux

Results

Temperature Distribution(^{0}c)	*Heat Flux(W/M^2)*
593.57	*29066*

3) Selected Material: - Magnishium Alloy

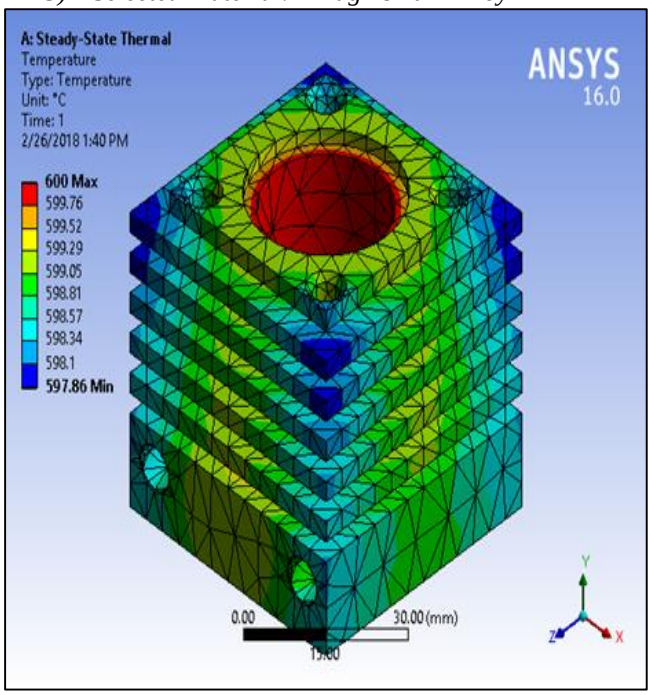

Fig. 8: Temperature Distribution

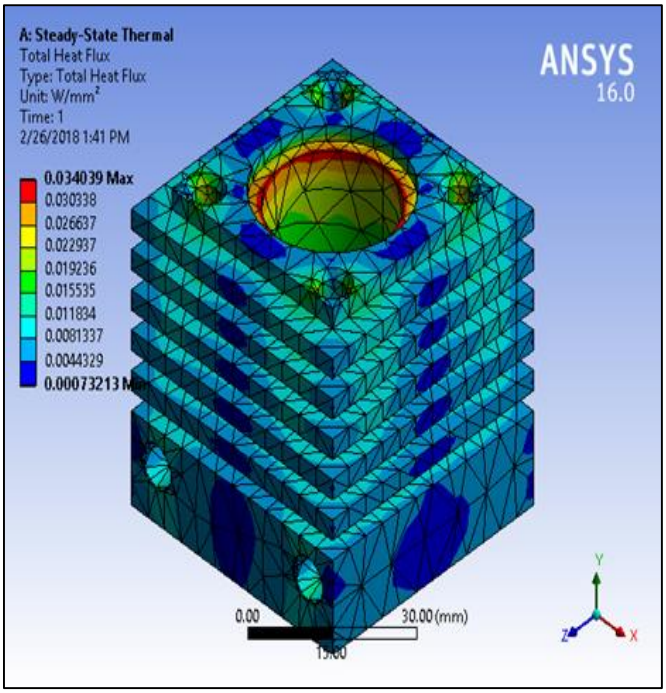

Fig. 9: Heat Flux

Results

Temperature Distribution(^{0}c)	*Heat Flux(W/M^2)*
596.92	*34039*

4) Selected Material:-Chromium

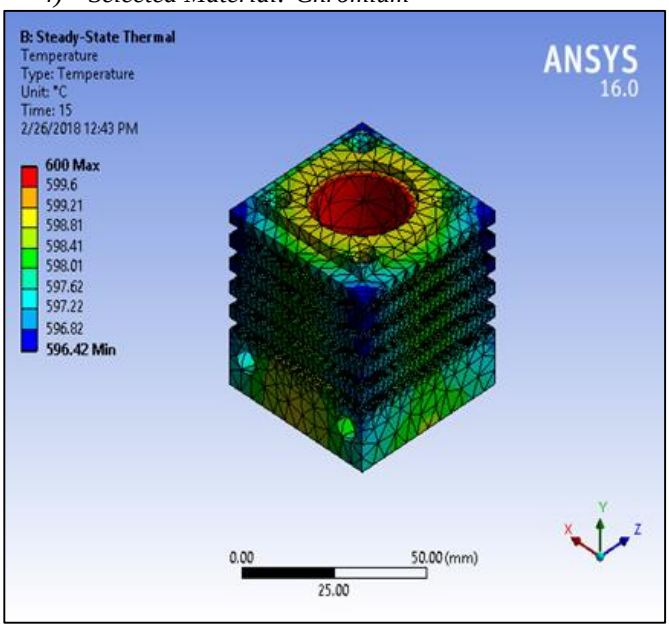

Fig. 9: Temperature Distribution

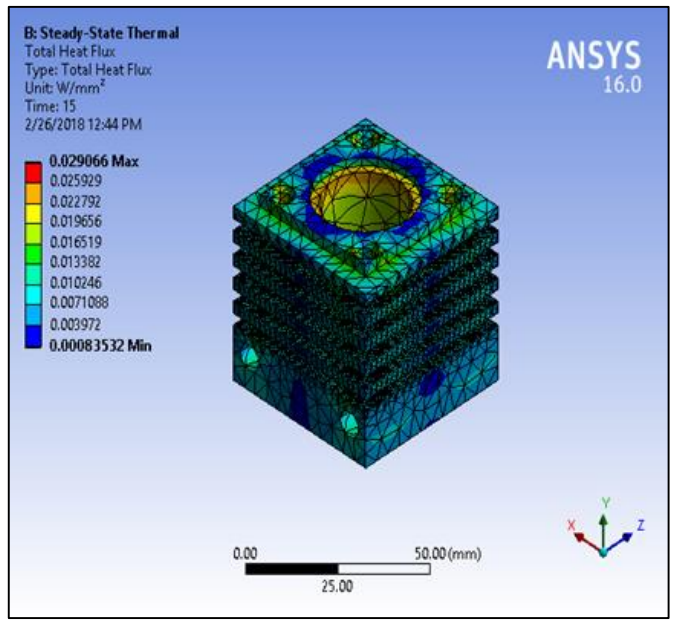

Fig. 10: Heat Flux

Results

Temperature Distribution(^{0}c)	*Heat Flux(W/M^2)*
590.49	*28920*

5) Selected Material:-Aluminium Alloy

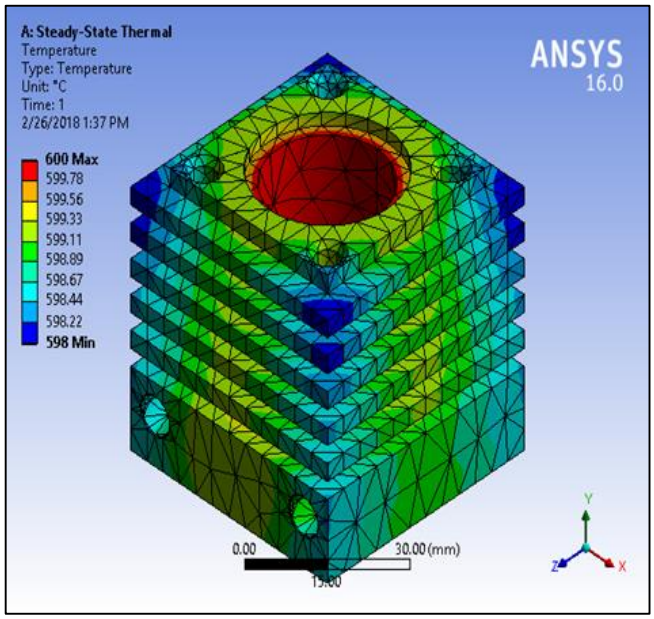

Fig. 11: Temperature Distribution

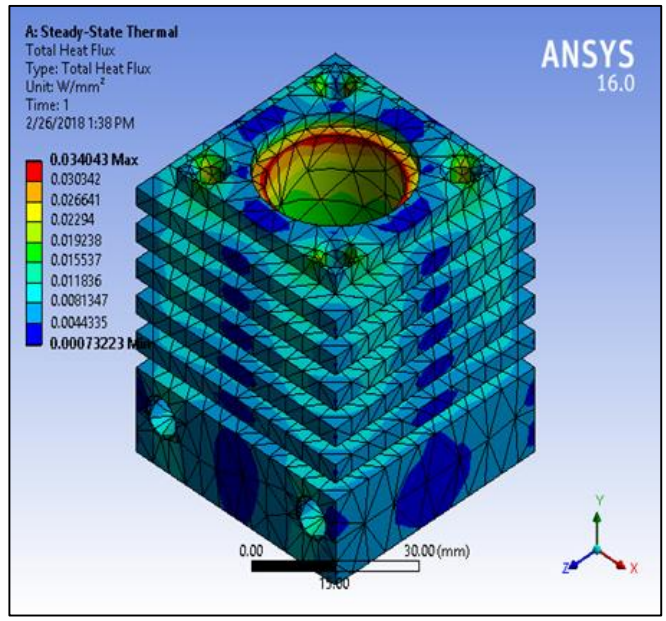

Fig. 12: Heat Flux

Results

Temperature Distribution(^{0}c)	*Heat Flux(W/M^2)*
598.37	*34043*

B. Summary of Results Obtained in Ansys

Table 3: summary of results obtained in Ansys

Material	*Temperature Distribution(^{0}c)*	*Total Heat Flux (W/M^{2}k)*
Brass	*596.52*	*29094*
Cast Iron	*593.57*	*29066*

Magnishium Alloy	*596.92*	*34039*
Chromium	*590.49*	*28920*
Aluminium Alloy	*598.37*	*34043*

C. Graphical Representation of Results

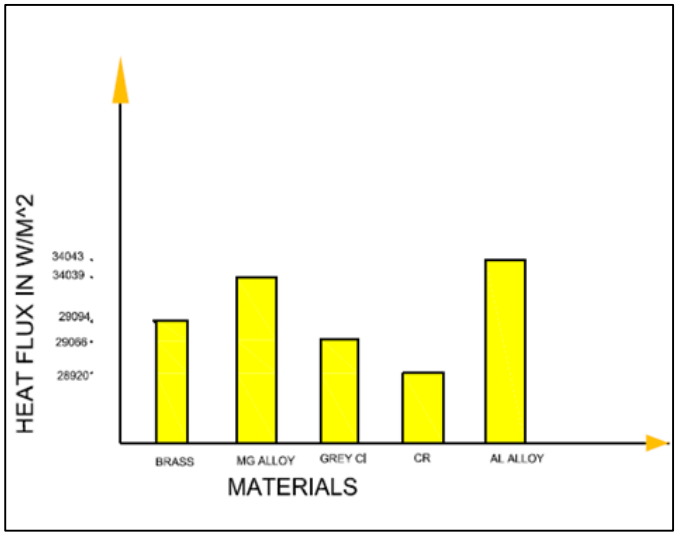

Fig. 13: Heat Flux

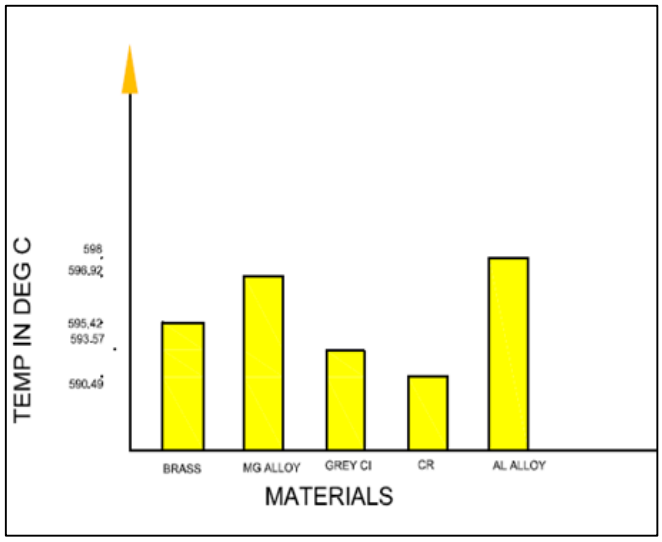

Fig. 14: Temperature Distribution

VI. FUTURE SCOPE

1) Improved fin design helps to increase efficiency. In this way we can improve the efficiency of I.C. Engine
2) By using materials having high thermal conductivity and lower density we can improve performance of the engine.
3) Current air cool engines comes with fins on the cylinder and cylinder head; But along with this if we use fins at bottom part of the engine near the oil sump; then cooling of engine can be increase also life of lubricating oil improve.

VII. DISCUSSION

In this Project, a cylinder fin body for a 250 cc motorcycle engine was modeled using designing software .The original model was changed by changing thickness of the fins. By using thinner fins overall efficiency increases also weight is reduced. Old engines have fin body made up of cast iron. In this thesis, other materials will be considered which have more thermal conductivities than cast iron. The materials are Aluminum alloys, Magnesium Alloy and chromium brass etc. Thermal analysis is performed for all materials selected for project. The material for our model is changed by taking consideration of their densities and all other factors.

VIII. CONCLUSION

The 250cc engine cylinder is one of the critical automobile components, which deals with higher temperatures and variable temperature stresses. For engine cooling the extended surfaces used on the cylinder to improve the rate of heat transfer. By doing thermal analysis on the 250cc engine cylinder fins, we get knowledge about heat distribution inside the cylinder.

The main objective of this project is to study the heat distribution and heat dissipation along the cylinder wall and select suitable material and shape of fin. From above analysis we conclude that Aluminum alloy is the best material for engine fins.

ACKNOWLEDGMENT

We are extremely fortunate to be involved in an exciting and challenging project like “DESIGN AND THERMAL ANALYSIS OF 250cc ENGINE CYLINDER FIN BY USING DIFFERENT MATERIALS”. It has enriched our life, giving us an opportunity to work in a field of Design Engineering.

This project increased our thinking and understanding capability and after the completion of this project, we experience the feeling of achievement and satisfaction.

We would like to express our greatest gratitude and respect to our Head of Mechanical Engineering Department Prof. Sunil Pagare, our project guide Prof. Sameer Mahamandre and project co-ordinator Prof. Amar Kumar for their excellent guidance, valuable suggestions and endless support. They have not only been a wonderful guide but also a genuine people. We

consider ourselves extremely lucky to be able to work under guidance of such a dynamic personalities. Actually they are one of such genuine person for whom our words will not be enough to express.

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Last but not the least; we want to convey our heartiest gratitude to our parents for their immeasurable love, support and encouragement.

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