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EXPERIMENTAL AND INVESTIGATION OF CYLINDER FINS WITH DIFFERENT MATERIALS USING FINITE ELEMENT METHOD

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Abstract: The combustion chamber of an IC engine is subjected to high temperature variations and thermal stresses, on which fins are mounted in order to cool the cylinder and to increase the heat dissipation rate. In this report thermal analysis of engine block with fins were analyzed. By doing thermal analysis on cylinder block fins, it is helpful to know the temperature distribution and heat dissipation inside the cylinder. The principle behind the cooling of the cylinder block is to provide the fins over the cylinder block by which the heat transfer rate will be increased. In India, generally in two wheelers air cooled engines are used. For this purpose, extended surfaces i.e. fins are used, which are mounted on cylinder block and cylinder head. Though the efficiency of cooling in air cooled system is less as compared to the water cooled system still it is used because of less space available to keep accessories. In this project the extended surfaces i.e. fins of Honda Shine & Bajaj Discover two wheeler automotives are tested to investigate effect on heat transfer rate by Cross-section, Fin Pitch, Fin Material and Fin Thickness. The parametric model of engine block fins has been developed in 3D BY Using catia software and thermal analysis is done on the with holes and without holes fins and to determine heat flux and temperature distribution Currently the material used for manufacturing cylinder fin body is Aluminum 2014 and grey cast iron proposed material is Aluminum 6061 addition in this Thesis, materials are also analyzed. The thermal analysis is done using all three materials by changing geometries that is perforating to the actual model heat dissipation rate.

Keywords: Engine cylinder fins, Geometry, Material, Thermal Analysis.

I INTRODUCTION

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 800 to 1500°C. This is a very high temperature and may result into burning of oil film between the moving parts and may result into seizing or welding of the same. 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. It is also to be noted that: 20-25% of total heat generated is used for producing brake power (useful work).• Cooling system is designed to remove 30-35% of total heat. • Remaining heat is carried away by exhaust gases. The aim of this project is to find out the effect of fin geometry and fin pitch on cooling of the engine. As the fossil fuel reserves are depleting day by day, the spiraling fuel price is pushing the technology towards its limit to provide engines which are highly efficient and produces high specific power. Air cooled engines are gradually phased out and are being replaced by water cooled engines which are far more efficient in dissipating heat, but in cases of two wheelers and certain other applications, air cooled engines are the only viable option due to space

constraints. The heat which is generated during combustion in an internal combustion engine should be maintained at the highest level possible to increase its thermal efficiency, but in order to prevent the thermal damage to the engine components and the lubricants some amount of heat must be removed from the system.

In an combustion chamber of internal combustion engine, combustion occur at high temperature and pressure due to which chances of piston seizure , overheating, chances of piston ring, compression ring, oil ring etc can be affected. Excess temperature can also damage the cylinder material. Due to overheating chances of pre-ignition also occurs. In Air cooled motorcycle engines heat release to the atmosphere through forced convection. 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. Inside the cylinder the temperature of gases will be around 800 to 2000. This is very high temperature and may result into burning of oil film between the moving parts this temperature must be reduced to about 150-200 at which engine will work more efficiently.

Heat transfer is classified into three types. The first is conduction, which is defined as transfer of heat occurring through intervening matter without bulk motion of the matter. A solid has one surface at a high temperature and one at a lower temperature. This type of heat conduction can occur, for example, through a turbine blade in a jet engine. The outside surface, which is exposed to gases from the combustor, is at a higher temperature than the inside surface, which has cooling air next to it. The second heat transfer process is convection, or heat transfer due to a flowing fluid. The fluid can be a gas or a liquid; both have applications in aerospace technology. In convection heat transfer, the heat is moved through bulk transfer of a non-uniform temperature fluid. The third process is radiation or transmission of energy through space without the necessary presence of matter. Radiation is the only method for heat transfer in space. Radiation can be important even in situations in which there is an intervening medium; a familiar example is the heat transfer from a glowing piece of metal or from a fire. Convective heat transfer is between the surfaces and surrounding fluid can be increased by providing the thin strips of metal called fins. Fins are also referred as extended

surfaces. Whenever the available surfaces are inadequate to transfer the required quantity of heat, fins will be used. Fins are manufactured with different sizes and shape depends on the type of application. Air cooling for an IC Engine is well known example for Air cooling system in which air acting as a medium. Heat generated in the cylinder will be dissipated in to the atmosphere by conduction mode through the fins or extended surfaces are used in this system, which are incorporated around cylinder.

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.

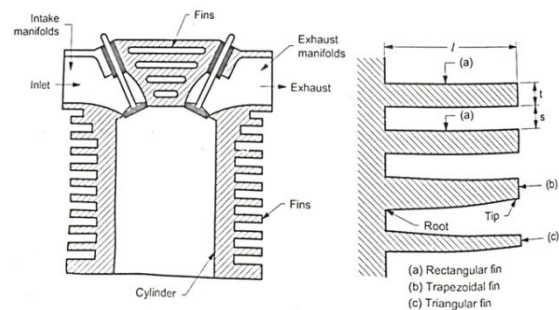


Figure 1 Automobile Fin

II LITERATURE SURVEY

Gokul Karthik [10] composed a sunken rectangular blade body utilized as a part of a Honda Unicorn Motorcycle and display in parametric 3D demonstrating programmingPro/Engineer. Present utilized material for balance body is Aluminum 2024composite. The state of the balance is rectangular; they have changed the shape with rectangular curvedmolded. The default thickness of blade is 3mm; they are diminishing it to 2.5mm. By decreasing the thickness furthermore by changing the state of the balance to bend formed, the heaviness of the blade body lessens along these lines expanding the proficiency. The heaviness of the blade body is additionally lessened. They have done warm examination on the balance body by changing geometry and thickness. By watching the investigation results, utilizing Rectangular sunken balance, material Aluminum composite

6061 and thickness of 2.5mm is better since warmth exchange rate is more. Be that as it may, by utilizing rectangular curved balances the heaviness of the blade body is likewise diminished. So on the off chance that we consider weight, utilizing bended blades is superior to anything different geometries. So we can presume that utilizing material Aluminum 2024 combination is better, diminishing thickness to 2.5mm is better and utilizing balance shape rectangular inward by investigation and blade shape bended by weight is better. By watching the outcomes, utilizing curved blades the warmth lost is more, productivity and adequacy is additionally more.

N. Phani Raja Rao et.al. analyzed the thermal properties by varying geometry with and without holes, material and thickness of cylinder fins. Different material used for cylinder fin were Aluminium Alloy 2024, 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.

Pulkit Agarwal etc. [1] simulated the heat transfer in motor cycle engine fan using CFD analysis. It is observed that ambient temperature reduces to the very low value; it results in over cooling and poor efficiency of the engine. They have concluded that over cooling also affects the engine efficiency because over cooling excess fuel consumption occurs.

Masao Yosidha etc. [2] investigated effect of number of fins, fin pitch and wind velocity on air cooling using experimental tunnel. Heat releases from cylinder did not improved when the cylinder have the more fins and too narrow a fin pitch at lower wind velocities because it is difficult for the air to flow into the narrower space between the fins, the temperature between them increased..

Fernando Illan 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 analyzed 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. Babu and M. Lavakumar analyzed 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/mk 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.

J. Ajay Paul et.al. 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 on 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 high

III PROJECT OVER VIEW

Problem Definition:

In the present Project investigation on thermal issues on automobile fins were carried out. Investigation yields the temperature behaviour and heat flux of the fins due to high temperature in the combustion chamber. Ansys work bench is utilized for analysis. The analysis is done for different models of fins that are commercially available now a days and a comparison is thus established between them. Also the material and design changed (with holes and without holes) so that better heat transfer rate can be obtained.

Objectives of the project:

The following are the main objectives of the present work:

- 1) To design cylinder with fins for a 125cc engine by same geometry such as with holes and without holes concept.
- 2) To determine steady state thermal properties of the proposed fin models.

3) To identify suitable alloy for the fabrication based on results obtained from finite element analysis and analytical method.

Methodology

Step 1: Collecting information and data related to cooling fins of IC engines.

Step 2: A fully parametric model of the Engine block with fin is created in catia software.

Step 3: Model obtained in igs is analyzed using ANSYS 14.5, to obtain the heat rate, temperature distribution

Step 4: Manual calculations theoretically and analytically are done.

Step 5: Finally, we compare the results obtained from ANSYS and compared different geometry and materials.

3.4 EXPERIMENTAL SETUP:



Figure 2 EXPERIMENT SET UP

Experimental setup is shown in figure 5.1 the setup simply consist of thermocouple rod placed on surface of fin of which temperature readings are to be taken. Thermocouple rod is attached to thermocouple temperature trainer kit which consist of digital display which will provide us actual readings directly. The k-type thermocouple is used in experiment. The readings are taken on stationary engine after reaching to steady state condition. Following observations are found.

Table 1 Observation for temperature reading of Honda Shine

Model name	Honda Shine
CC	125
Stroke(mm)	58
Bore(mm)	52
No. of fins	6
Fin pitch(mm)	10
Fin thickness(mm)	2.5
Fin material	Al alloy
Position of Fins w.r.t. cylinder axis	Perpendicular

Table 2 TEMPERATURE READINGS

S.NO	FIN No	Temperature(c°)
1	1	129
2	2	126
3	3	121
4	4	120
5	5	119
6	6	115

Note: The time to reach steady state was 90 minutes there after the readings were taken.

Calculations for Peak Temperature Produced in Cylinder of Honda Shine

(Data taken from technical specification of automotive vehicle)

Initial temperature during suction, T1 = 30 °C

Initial pressure P1 = 1 bar

Compression ratio, rc = 9.5

Peak pressure produced, P3 = 35 bar

$$P2 = P1 \times rc^\gamma$$

$$= 1 \times (9.5)^{1.4}$$

$$= 23.378 \text{ bar}$$

$$T2 = T1 \times (rc)^{\gamma-1}$$

$$= 303 \times (9.5)^{1.4-1}$$

$$= 745.64 \text{ °K}$$

$$T3 = P3 / P2 \times T2 = 35 / 23.378 \times 745.64$$

$$= 1116.32 \text{ K}$$

$$= 843.32 \text{ °C}$$

Calculation for Heat Dissipated From Surface of Fins of Honda Shine

Assumptions made to calculate the heat dissipated or heat flux:-

- 1) Steady state one dimensional heat conduction.
- 2) Finite long fin and with negligible heat loss from fin tip.
- 3) Constant properties. Considering, h = Heat transfer coefficient

A_c = Cross section area of fin

K = Thermal conductivity

L = Length of fin.

w = Width of fin

t = Thickness of fin

P = Perimeter of fin

T_0 = Fin temperature

T_∞ = Ambient temperature of air.

For fin no 1

$$A_c = L \times t = (132 \times 10^{-3}) \times (2.5 \times 10^{-3})$$

$$= 0.132 \times 0.0025$$

$$= 0.00033 = 330 \times 10^{-6}$$

$$P = 132 \times 10^{-3} \text{m}$$

$$ML = \sqrt{\frac{h \times p}{K \times A_c}} \times w$$

$$= \sqrt{\frac{30 \times 132 \times 10^{-3}}{240 \times 330 \times 10^{-6}}} \times 0.024$$

$$= \sqrt{\frac{3.96}{0.0792}}$$

$$= \sqrt{50} \times 0.024 = 0.1697$$

$$Q_1 = \sqrt{h \times P \times K \times A_c} \times (T_0 - T_\infty) \times \tanh (mL)$$

$$= \sqrt{30 \times 0.132 \times 240 \times 0.00033} \times (129 - 30) \times \tanh (0.169)$$

$$= \sqrt{0.313632}$$

$$= 0.560 \times 99 \times \tanh (0.169)$$

$$= 0.560 \times 99 \times 0.1674$$

$$Q_1 = 9.280 \text{ W}$$

Similarly for other fins heat dissipated can be calculated

$$Q_2 = 8.3083 \text{ W}$$

$$Q_3 = 7.237 \text{ W}$$

$$Q_4 = 6.5198 \text{ W}$$

$$Q_5 = 6.0048 \text{ W}$$

$$Q_6 = 5.4331 \text{ W}$$

Total heat transfer from fins, $Q_{\text{Honda Shine}} = 42.783 \text{ W}$

Heat flux calculation:-

Calculation from fin no 1

$$q_1 = \frac{\text{heat dissipated by fin}}{\text{area of cross section for fin}}$$

$$= \frac{Q_1}{A_c}$$

$$= \frac{31.29}{0.00033}$$

$$= 28121.21 \text{ W/m}^2$$

Similarly, heat flux can be calculated for other fins.

$$q_2 = 25176.66 \text{ W/m}^2$$

$$q_3 = 21930.30 \text{ W/m}^2$$

$$q_4 = 19756.96 \text{ W/m}^2$$

$$q_5 = 18196.36 \text{ W/m}^2$$

$$q_6 = 16463.93 \text{ W/m}^2$$

Designing to develop the work :

The 3-d model of cylinder head fin of rectangle shape is drawn catia v5 interface using tools, is shown in fig create the circle in sketcher 52mm fin thickness is taken as 2.5mm, and remaining all dimensions are taken as per standard conditions, stroke length is 58 no.of fins is 6 fin pitch is 10 fig shows cylinder head fin of rectangular shape is drawn in catia v5 interface using tools by this is a just modified design with holes hole diameter is 3 mm of above sketch by changing geometry only.

IV DESIGN PROCEDURE IN CATIA:

We created existing component original dimensions. The specification of first model engines cylinder block HONDA SHINE 125cc with dimensions of 132 x132x58 was made in 3D modeling software catia. There are Total number of fins were 8 , with number of gaps between the fins are 10,the thickness of fin are 2.5 mm, where the gap between the fins are 6 mm , in this model length of stroke is 58 mm. First go to sketcher workbench create the sketch 132x132x58 and now go to the existing workbench in part design apply pad option now it is converted into solid after go to sketcher workbench now create the rectangular fins now again go to the existing workbench apply groove option . finally appears like that as shown in the figure.

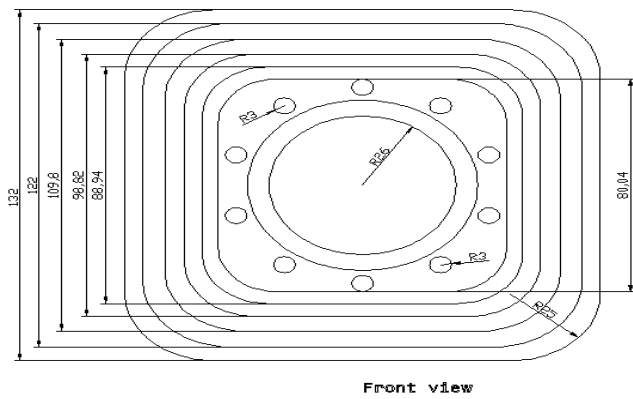


Figure 3 GEOMETRY DIMENSIONS WITH HOLES

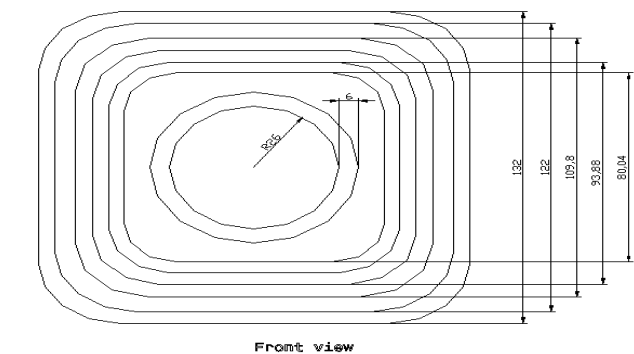


Figure 4 WITHOUT HOLES

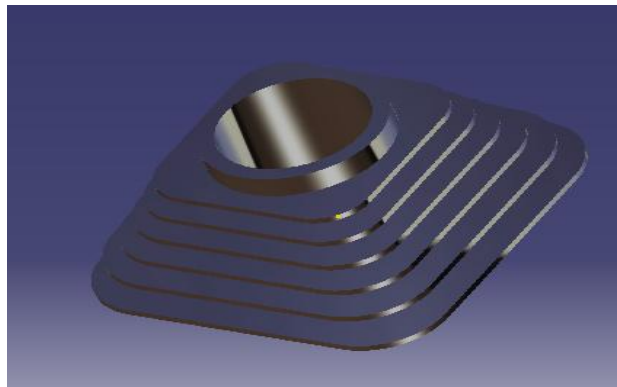


Figure 5 MODELING WITHOUT HOLES

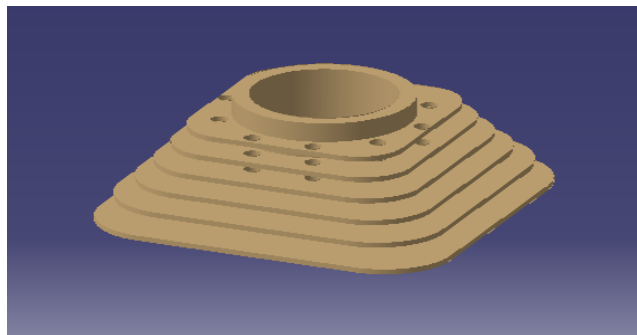


Figure 6 MODELING WITH HOLES

V 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. A steady state analysis can be the last step of transient thermal analysis. We can use steady state thermal 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 non linear with material properties that depend on temperature. The thermal properties of most material do vary with temperature, so the analysis is usually non linear.

Meshing :

Mesh for with holes and without holes

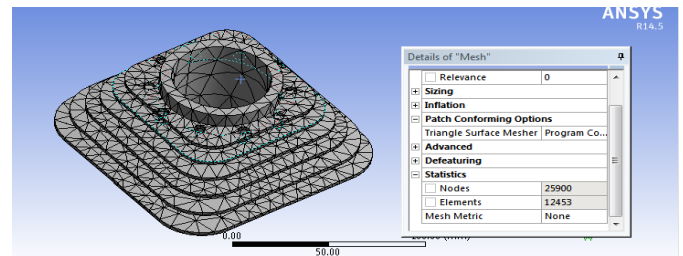


Figure 7 mesh with holes

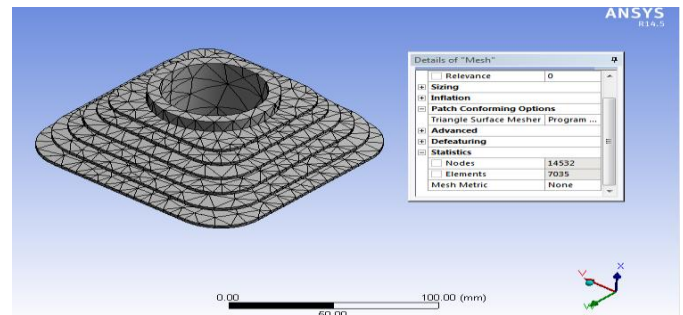


Figure 8 mesh without holes

VI BOUNDARY Conditions:

The following are the input parameters:

Table 3 input parameters

S.No	LOADS	UNITS	VALUE
1	INSIDE TEMPERATURE	°c	843.32
2	FILM COEFFICIENT	W/m ² K	25
3	AMBIENT TEMPERATURE	K	303
4	MATERIALS		AL6061,AL2014,GREYCASTIRON

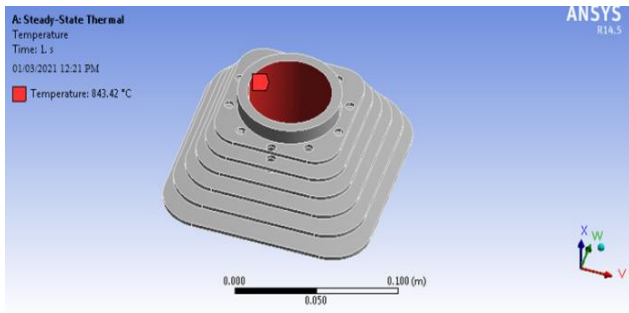


Figure 9 TEMPERATURE OF BOUNDARY CONDITIONS WITH HOLES

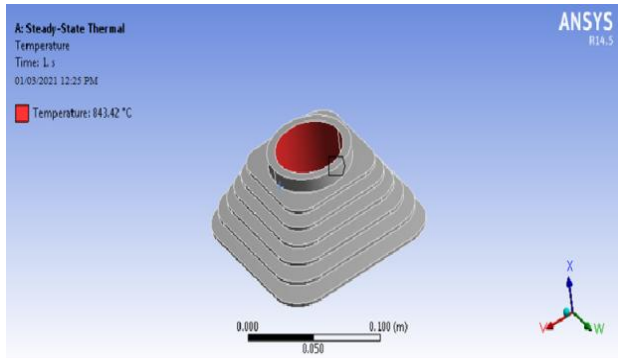


FIG10:TEMPERATURE OF BOUNDARY CONDITIONS WITHOUT HOLES

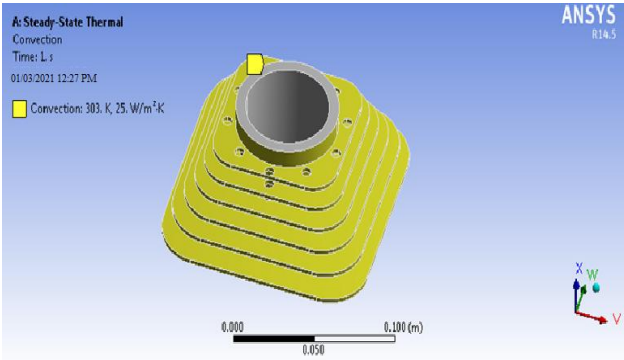


FIG 11:CONVECTION OF BOUNDARY CONDITIONS WITH HOLES

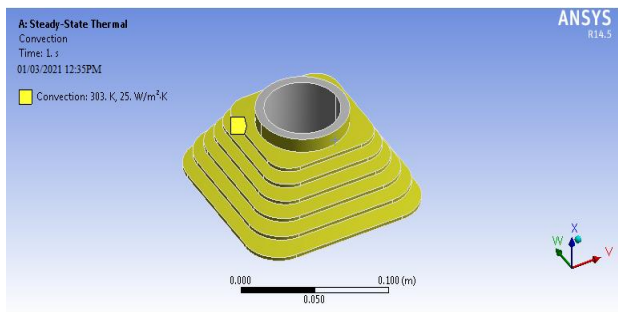


FIG12:CONVECTION OF BOUNDARY CONDITIONS WITH OUT HOLES

VII RESULTS AND DISCUSSION
 TEMPERATURE DISTRIBUTION OF EXISTING MODELS:
 WITH HOLES CYLINDER FIN:

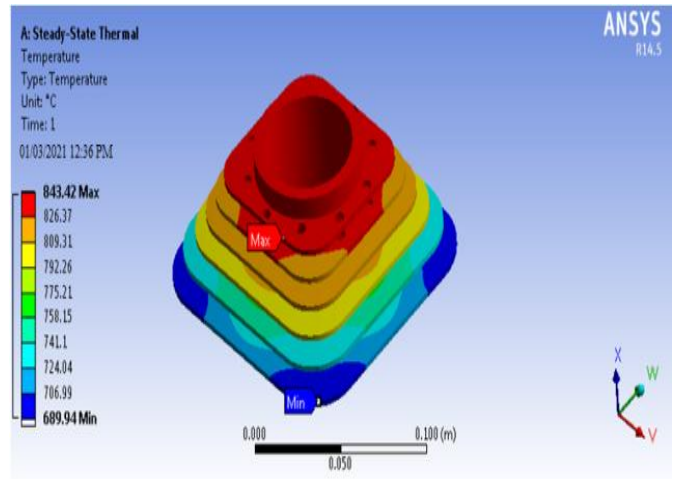


Figure 13 TEMPERATURE DISTRIBUTION ON AL2014

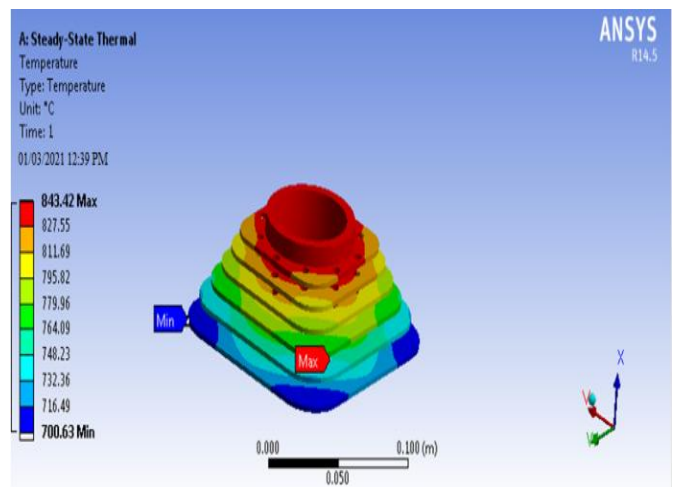


Figure14: TEMPERATURE DISTRIBUTION ON AL6061

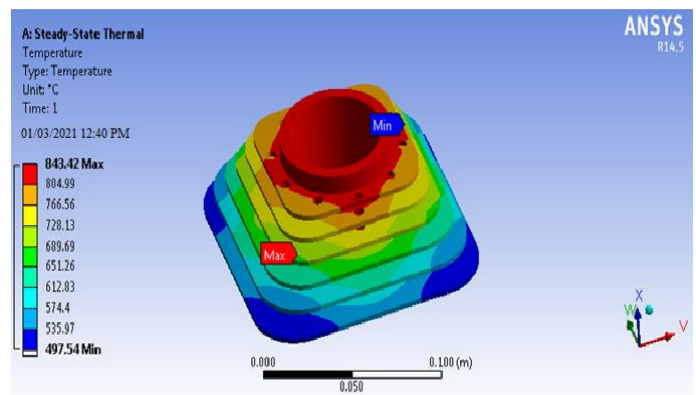


Figure 15: TEMPERATURE DISTRIBUTION ON GREY CAST IRON

**WITHHOLES CYLINDER FINS:
TEMPERATURE DISTRIBUTION OF EXISTING
MODELS**

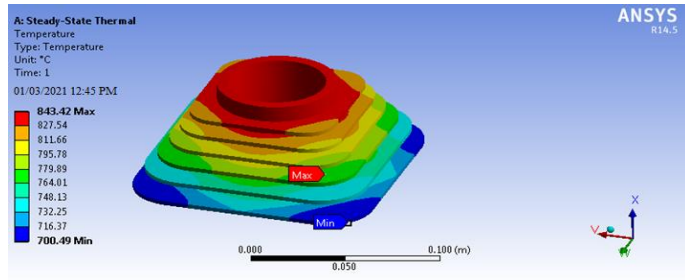


Figure 17 TEMPERATURE DISTRIBUTION ON AL2014

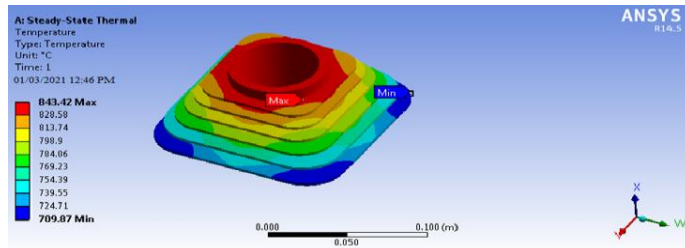


Figure 18 TEMPERATURE DISTRIBUTION ON AL6061

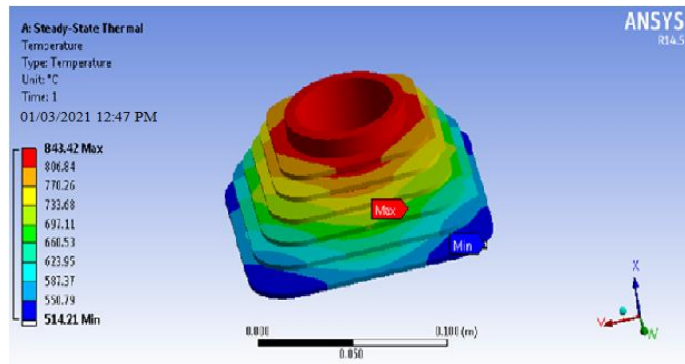


Figure 19 TEMPERATURE DISTRIBUTION ON GREY CAST IRON

Total Heat Flux of Existing Models:

WITH HOLES CYLINDER FINS:

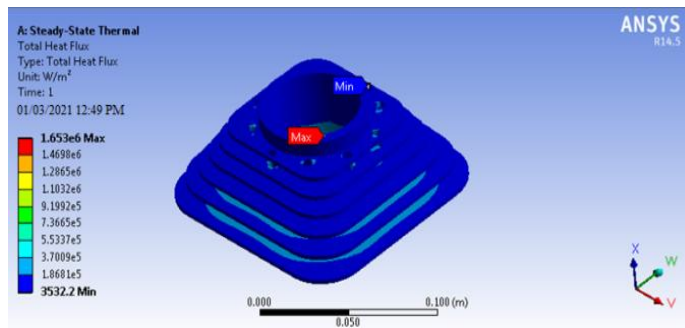


Figure 20 HEAT FLUX ON AL2014.

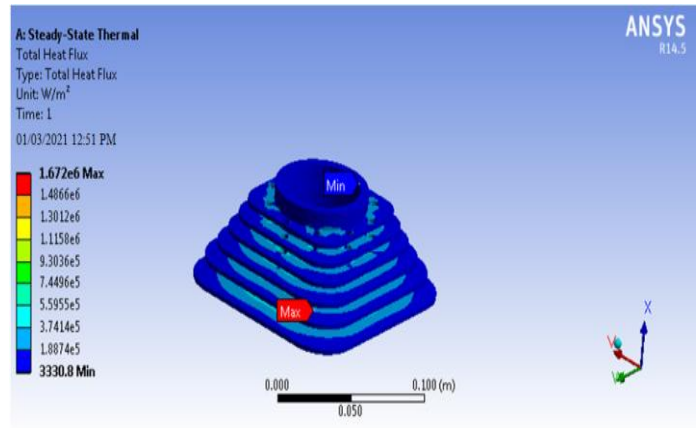


Figure 21 HEAT FLUX ON AL6061

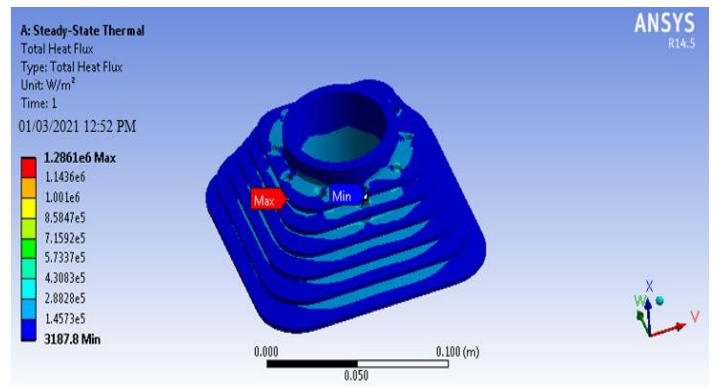


Figure 22 HEAT FLUX ON GREY CAST IRON

WITHOUT HOLES CYLINDER FINS:

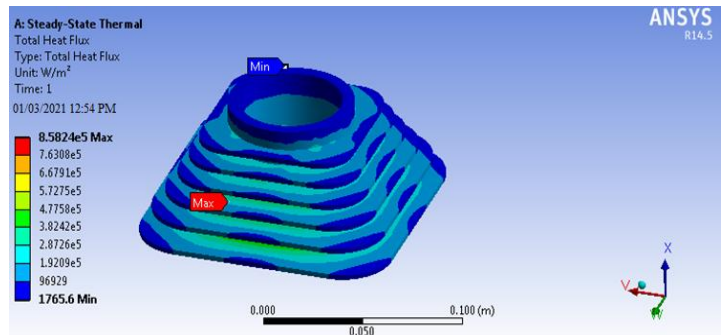


Figure 23 HEAT FLUX ON AL2014

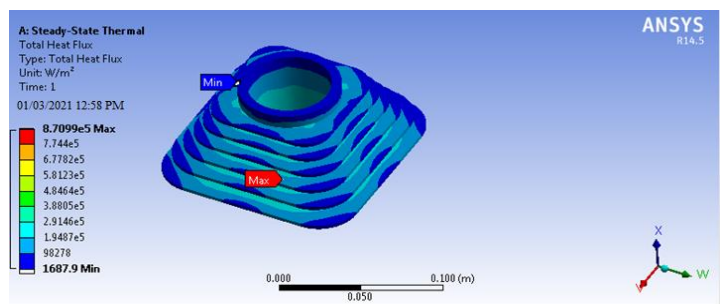


Figure 24 HEAT FLUX IN AL6061

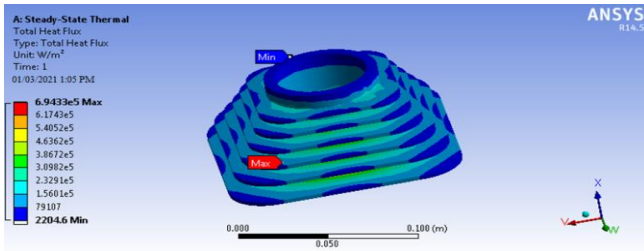


Figure 25 HEAT FLUX IN GREY CAST IRON GRAPHS BETWEEN WITH HOLES AND WITHOUT HOLES TEMPERATURE DISTRIBUTION CYLINDER FINS:

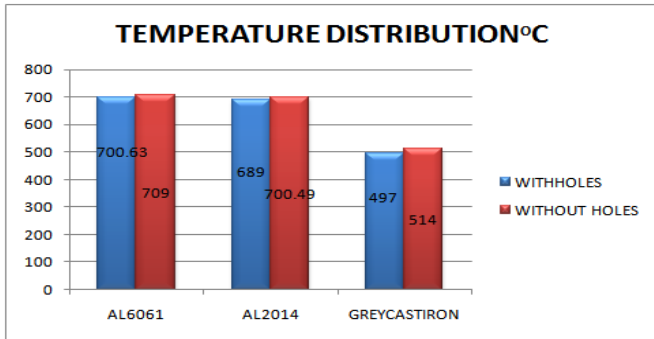


Figure 26 WITH HOLES AND WITHOUT HOLES TEMPERATURE DISTRIBUTION OF CYLINDER FINS

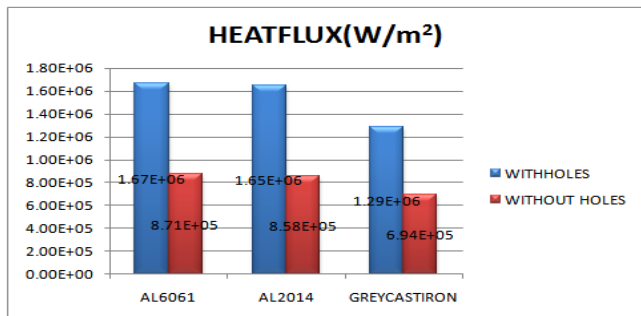


Figure 27 TOTAL HEATFLUX WITH AND WITHOUT HOLES

VIII CONCLUSION

Cylinder fins plays an important role in heat transfer ,Design and analysis done with different geometry and with different materials Design of cylinder block. The fins geometry and cross sectional area affects the heat transfer coefficient In this present work, cylinder block created in 3D software CATIA two different designs with and without holes taking specifications Honda shine 125cc in which perpendicular fins are mounted. After that modifications is done in engine cylinder block fins, with and without holes. There is a scope of improvement in heat transfer of air-cooled engine cylinder fin,. finally concluded the suitable design and material for the cylinder fins on these materials grey cast iron,Al2014,Al6061

materials, finally concluded the al6061 is suitable for cylinder fins because of better heat flux rate .

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