Design And Thermal Analysis of Engine Cylinder Using Ansys Workbench

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Abstract- *The cylinder block forms the basic framework of the engine, it consists of engine cylinder which acts as bearing and guides the piston reciprocating in them. In order to cool the cylinder, fins are provided on the cylinder to increase the rate of heat transfer. The main purpose of using these cooling fins is to cool the engine cylinder by air. 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 this project work is to analyse the thermal properties using different materials by varying fin geometry and material. The engine cylinder dimensions are taken for 4-stroke TVS Victor engine. The 3D modelling software used is CATIA V5. Thermal analysis is done on the rectangular & circular cylinder fins in order to determine variation in temperature distribution and heat flux over time. Presently Material used for manufacturing cylinder fin body is Cast Iron. In this work, different materials like Copper, Aluminium alloy, steel and Titanium are considered for analysis. The results of the analysis show that among all the materials Aluminium alloy is best suitable material for engine cylinder because of its high heat transfer and temperature distribution when compared with other materials. Further, the circular fins increase the efficiency of the engine by reducing the weight of the engine.*

Keywords- Engine cylinder fins, thermal analysis of engine cylinder, design of cylinder fins.

I. INTRODUCTION

A heat engine is a machine, which converts heat energy into mechanical energy. The combustion of fuel such as coal, petrol, and diesel generates heat. This heat is supplied to a working substance at high temperature. By the expansion of this substance in suitable machines, heat energy is converted into useful work.

Combustion, also known as burning, is the basic chemical process of releasing energy from a fuel and air mixture. In an internal combustion engine (ICE), the ignition and combustion of the fuel occurs within the engine itself. The engine then partially converts the energy from the combustion to work. The engine consists of a fixed cylinder and a moving piston. The expanding combustion gases push the piston, which in turn rotates the crankshaft. Ultimately, through a system of gears in the powertrain, this motion drives the vehicle's wheels.

There are two kinds of internal combustion engines currently in production: the spark ignition gasoline engine and the compression ignition diesel engine. Most of these are four-stroke cycle engines, meaning four piston strokes are needed to complete a cycle. The cycle includes four distinct processes: intake, compression, combustion and power stroke, and exhaust.

Spark ignition gasoline and compression ignition diesel engines differ in how they supply and ignite the fuel. In a spark ignition engine, the fuel is mixed with air and then inducted into the cylinder during the intake process. After the piston compresses the fuel-air mixture, the spark ignites it, causing combustion. The expansion of the combustion gases pushes the piston during the power stroke.

II. EXPERIMENTAL

In this experimental work, TVS victor's engine cylinder is considered to carryout heat transfer analysis and results are tabulated. In internal combustion engines the combustion of fuels takes place inside the cylinder and the gases are formed and the temperature of gases are around 2300-2400°C and this is very high temperature and may results in burning of oil between the moving parts and may result in deformation of engine cylinder, therefore this temperature must be reduced to about 150-180°C at which the engine works at high efficiency, too much cooling is also not desirable because it decreases thermal efficiency.

Fig 2.1: TVS Engine Cylinder

TVS Victor Specification

- Bore Size: 51.00mm
- Material used: Cast iron

Powering the TVS Victor is an all-new 3-valve, single cylinder, 110cc engine, which pumps out 9.6PS of power and 9.4Nm of torque, and is coupled to a 4-speed gearbox. TVS claims a healthy mileage of 72kmpl from the Victor, which makes it powerful and efficient at the same time. In terms of mechanicals, the Victor doesn't break any benchmarks and has a conventional setup of telescopic front forks and a set of adjustable coil springs at the rear.

2.1 PROBLEM STATEMENT

In internal combustion engine combustions takes place inside the engine cylinder, hence the engine cylinder is main part in IC engine for efficiency so proper heat transfer should be takes place and proper engine cylinder should be design and proper material is used. Cast iron is used for engine cylinder in which the proper heat transfer will not takes place.

2.2 OBJECTIVES

1. To conduct a literature review on Engine cylinder and to set a stage for the study of modelling and analysis of thermal behaviour of cylinder body.
2. To carry out design relevant data for modelling in CAD software.
3. To design engine cylinder with rectangular and circular fins and with different materials.

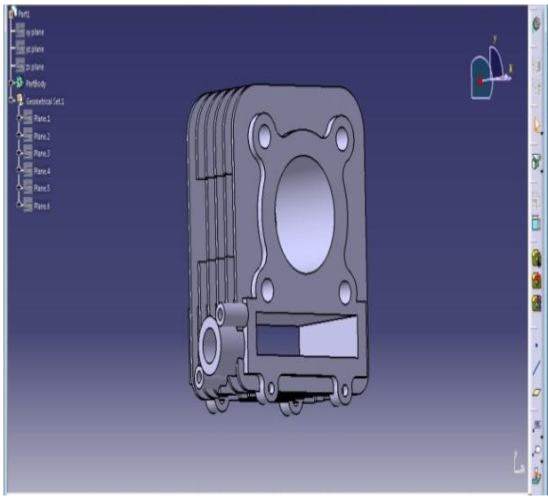


Fig 2.2: Designing Engine Cylinder Block

To conduct Finite element Analysis using ANSYS software and determine transient thermal properties of the proposed fin models.

III. LITERATURE SURVEY

1. Mr. N. Phani Raja Rao, Mr. T. Vishnu Vardhan : By changing the shape of the fin from rectangular to circular weight of the fin reduced thereby increase the heat transfer rate & efficiency of fin
2. Optimization of Engine Cylinder Fins of Varying Geometry and Material by P.Harish, B.Ramakrishna Reddy , G.S.Md.Waseem Akram : By observing the thermal analysis results, thermal flux is more for Aluminum alloy than other Materials and also by using Aluminum alloy its weight is less, so using Aluminum alloy is better.

IV. RESULT AND DISCUSION

3.1 Heat Transfer Analysis of IC Engine Cylinder With Fins

Temperature and heat transfer analysis of engine cylinder with rectangular fins & Titanium, Mild steel, Copper, Aluminium, Cast Iron materials are used.

HEAT TRANSFER ANALYSIS FOR TITANIUM

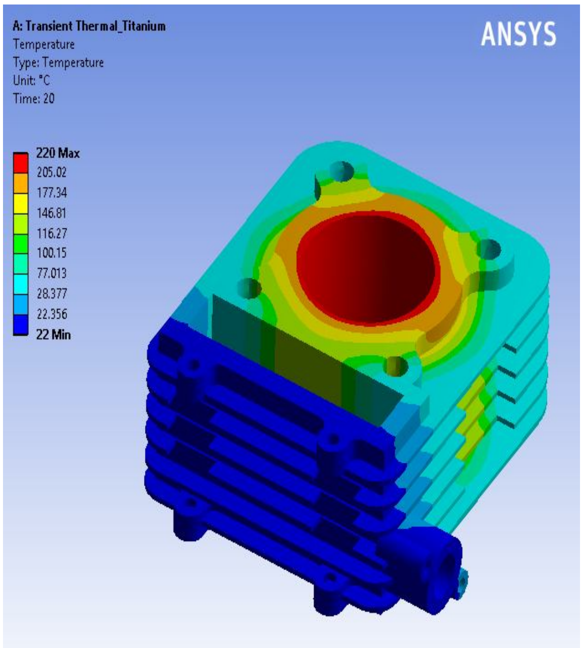


Fig 3.1 Temperature distribution In Engine Cylinder with Rectangular Fins

The Figure 3.1 shows Transient Thermal Analysis for Titanium material with rectangular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 22 o C

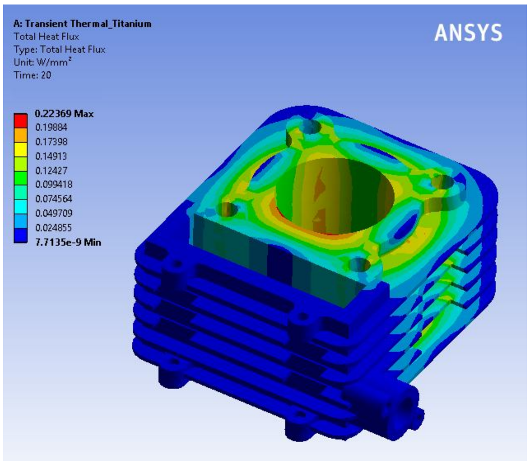


Fig 3.2 Heat Flux distribution In Engine Cylinder With rectangular Fins

The Figure 3.2 shows Transient Thermal Analysis for Titanium material with rectangular fins and from figure we can see that maximum heat flux is 0.22369 W/mm2 & minimum heat flux is 7.7135e-9 W/mm2 .

HEAT TRANFER ANALYSIS FOR MILD STEEL

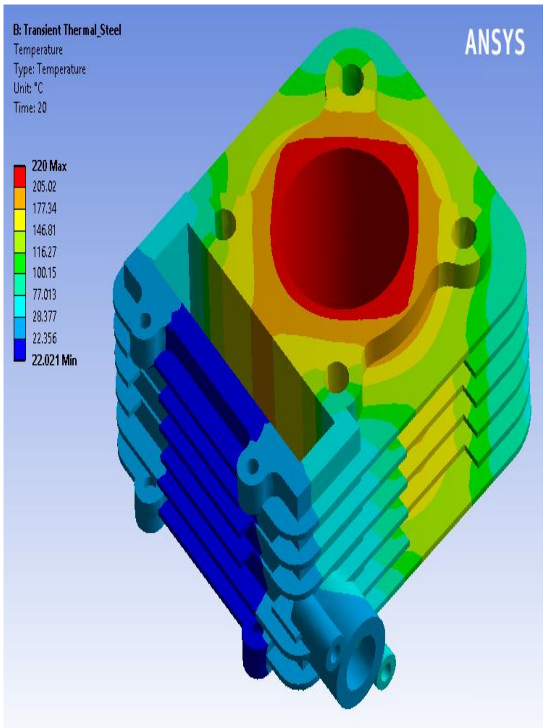


Fig 3.3 Temperature distribution In Engine Cylinder With rectangular Fins

The Figure 3.3 shows Transient Thermal Analysis for Titanium material with rectangular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 22.021 o C.

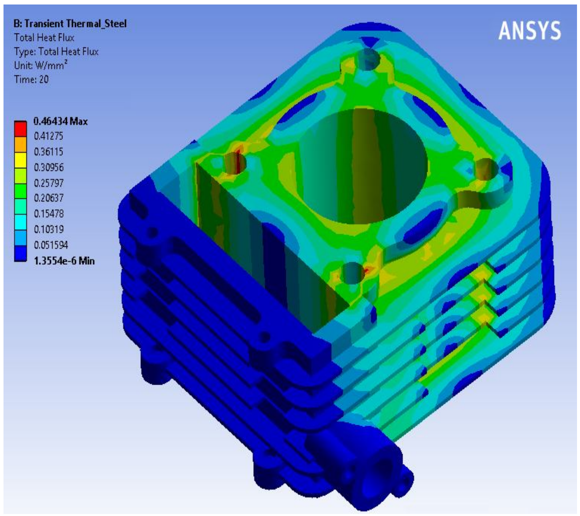


Fig 3.4 Heat Flux distribution In Engine Cylinder With rectangular Fin

The Figure 3.4 shows Transient Thermal Analysis for Titanium material with rectangular fins and from figure we can see that maximum heat flux is 0.46434 W/mm2 & minimum heat flux is 1.3554e-9 W/mm2 o C.

HEAT TRANSFER ANALYSIS FOR ALUMINIUM

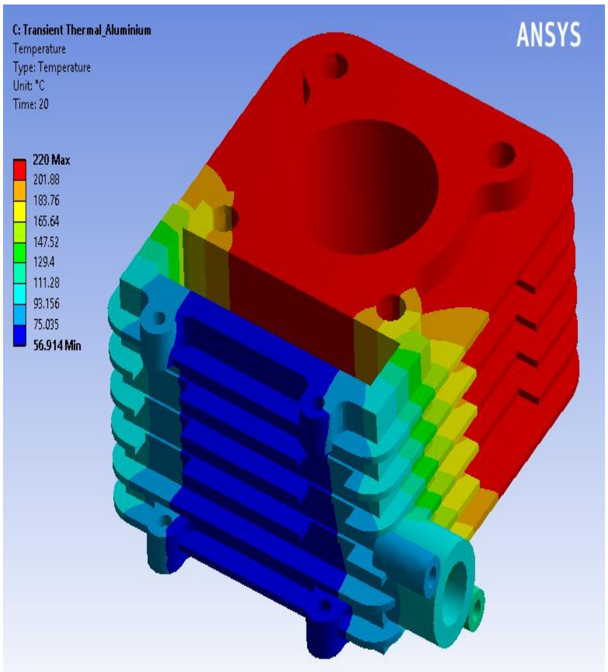


Fig 3.5 Temperature distribution In Engine Cylinder With rectangular Fins

The Figure 3.5 shows Transient Thermal Analysis for Titanium material with rectangular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 56.914o C.

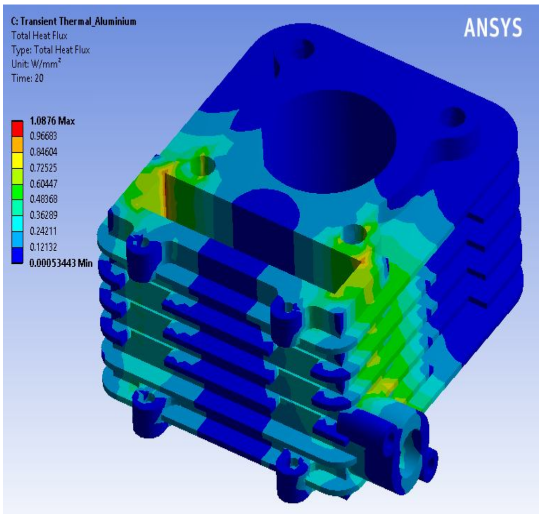


Fig 3.6 Heat Flux distribution In Engine Cylinder With rectangular Fins

The Figure 3.6 shows Transient Thermal Analysis for Titanium material with rectangular fins and from figure we can see that maximum heat flux is 1.0876 W/mm2 & minimum heat flux is 0.00053443 W/mm2 .

HEAT TRANSFER ANALYSIS FOR COPPER

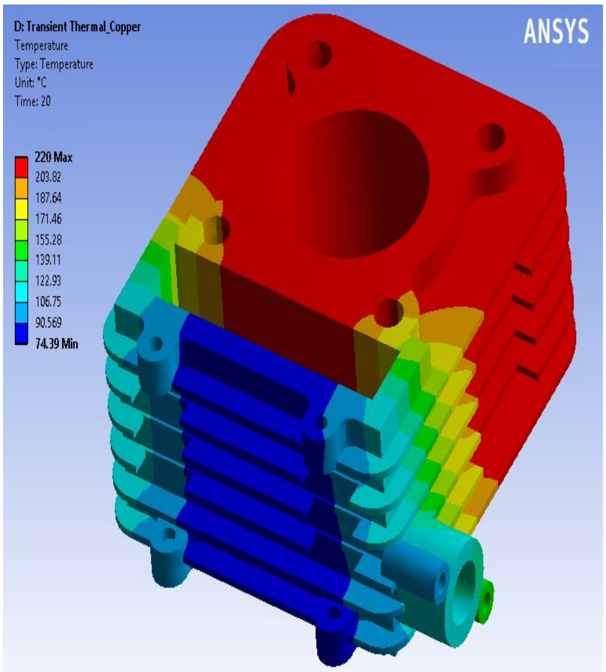


Fig 3.7 Temperature distribution In Engine Cylinder With rectangular Fins

The Figure 3.7 shows Transient Thermal Analysis for Copper material with rectangular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 74.39 o C

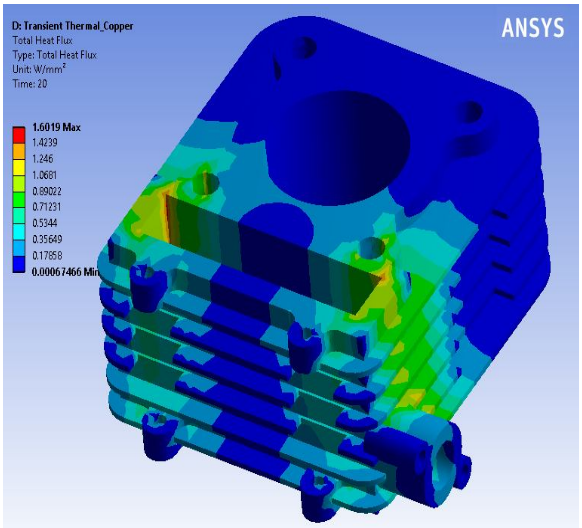


Fig 3.8 Heat Flux distribution In Engine Cylinder With rectangular Fins

The Figure 3.8 shows Transient Thermal Analysis for Copper material with rectangular fins and from figure we can see that maximum heat flux is 1.6019 W/mm2 & minimum heat flux is 0.00067466 W/mm2 .

HEAT TRANSFER ANALYSIS FOR CAST IRON

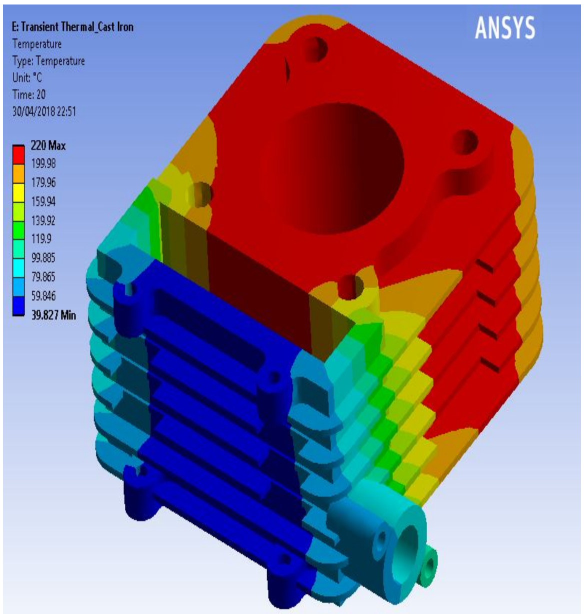


Fig 3.9 Temperature distribution In Engine Cylinder With rectangular Fins

The Figure 3.9 shows Transient Thermal Analysis for Cast Iron material with rectangular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 39.827 o C.

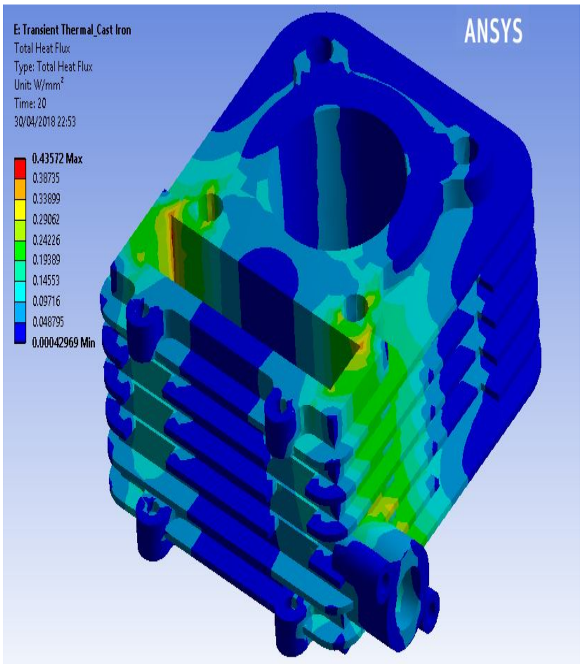
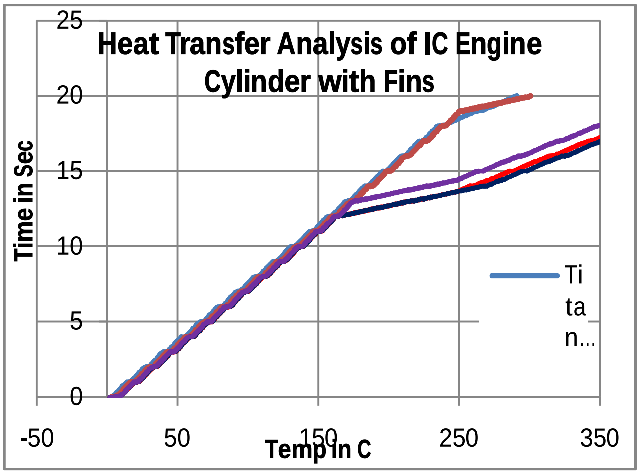


Fig 3.10 Heat Flux distribution In Engine Cylinder With rectangular Fins

The Figure 3.10 shows Transient Thermal Analysis for Cast Iron material with rectangular fins and from figure we can see that maximum heat flux is 0.43572 W/mm2 & minimum heat flux is 0.00042969e-9 W/mm2. We can observe heat flux is

Graph 3.1: Heat transfer analysis of engine cylinder with rectangular fin



Following are the investigation and results got for Circular blades appeared in figures Temperature and heat transfer analysis of engine cylinder with circular fins & Titanium, Mild steel, Copper, Aluminium, Cast Iron materials are used.

HEAT TRANSFER ANALYSIS FOR TITANIUM

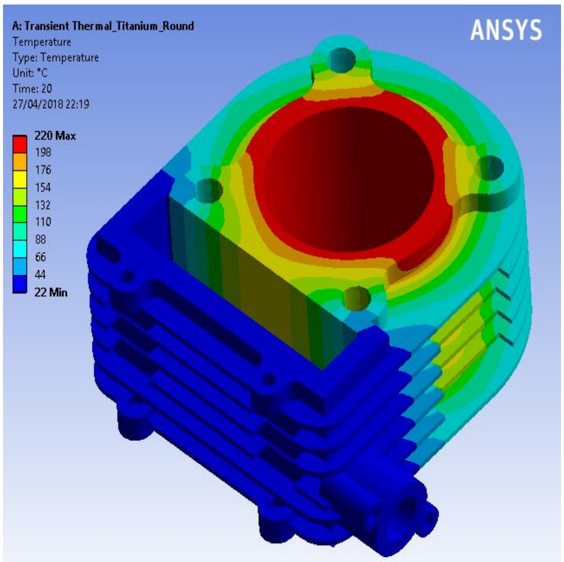


Fig 3.11 Temperature Distribution in Engine Cylinder with Circular Fins

The Figure 3.11 shows Transient Thermal Analysis for Cast Titanium Material with Circular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 22 o C.

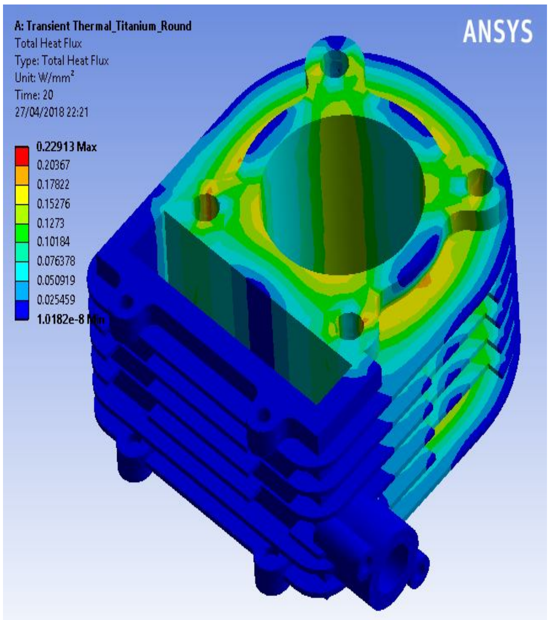


Fig 3.12 Heat Flux Distribution in Engine Cylinder with Circular Fins

The Figure3.12 shows Transient Thermal Analysis for Titanium Material with Circular fins and from figure we can see that maximum heat flux is 0.22913 W/mm2 & minimum heat flux is 1.10182e-9 W/mm2.

HEAT TRANSFER ANALYSIS FOR MILD STEEL

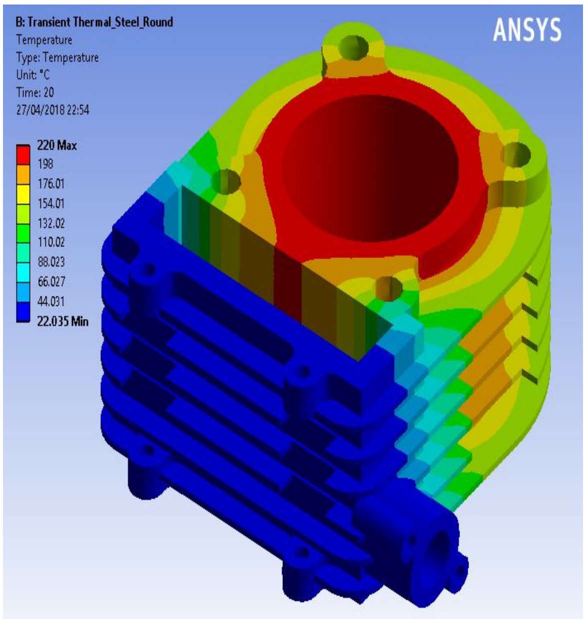


Fig 3.13 Temperature Distribution in Engine Cylinder with Circular Fins

The Figure 3.13 shows Transient Thermal Analysis for Cast Mild Steel with Circular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 22.035 o C

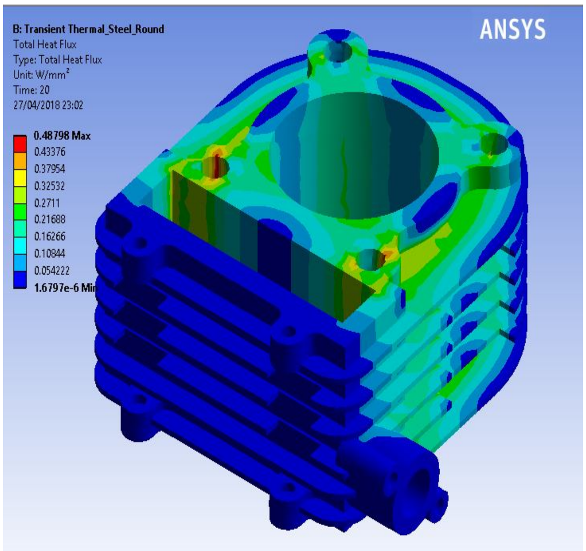


Fig 3.14 Heat Flux Distribution in Engine Cylinder with Circular Fins

The Figure 3.14 shows Transient Thermal Analysis for Mild Steel with Circular fins and from figure we can see that maximum heat flux is 0.48798 W/mm2 & minimum heat flux is 1.6797e-9 W/mm2.

HEAT TRANSFER ANALYSIS FOR ALUMINIUM

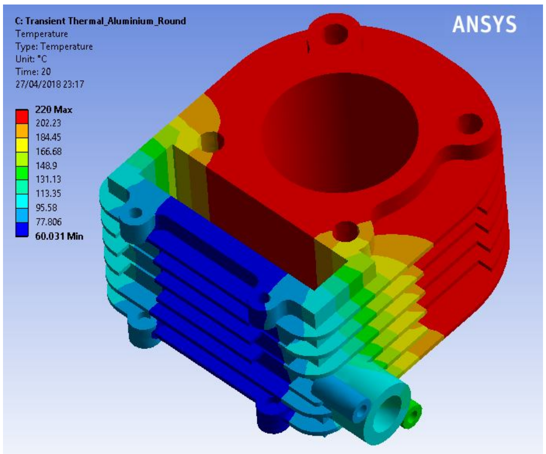


Fig 3.15 Temperature Distribution in Engine Cylinder with Circular Fins

The Figure3.15 shows Transient Thermal Analysis for Cast Aluminium Material with Circular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 60.031 o C.

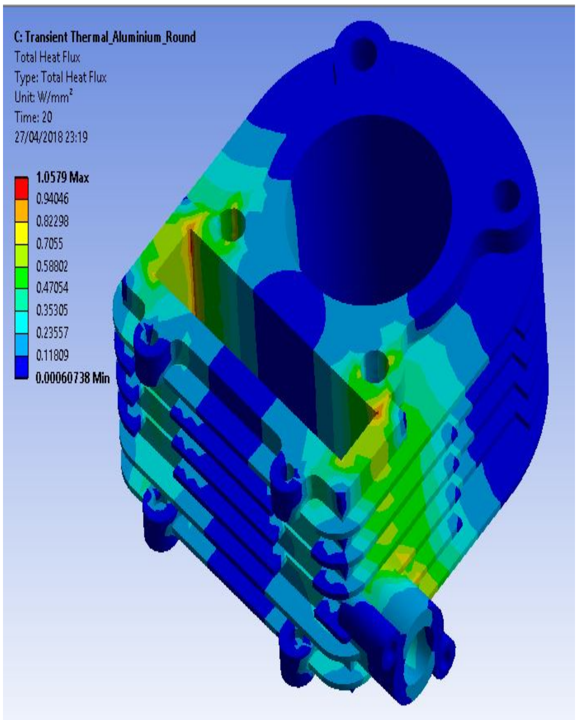


Fig 3.16 Heat Flux Distribution in Engine Cylinder with Circular Fins

The Figure 3.16 shows Transient Thermal Analysis for Aluminium Material with Circular fins and from figure we can see that maximum heat flux is 1.0579 W/mm2 & minimum heat flux is 0.00060738e-9 W/mm2.

HEAT TRANSFER ANALYSIS COPPER

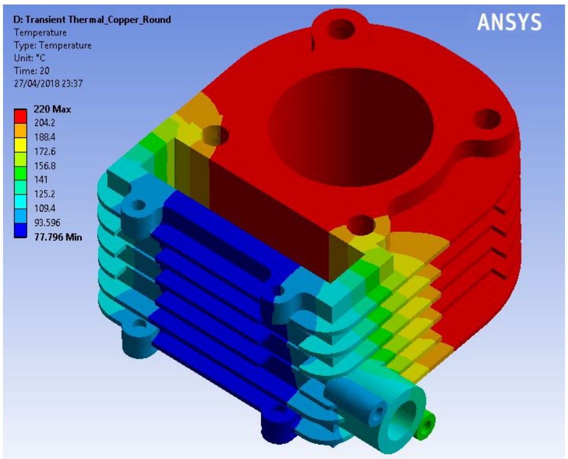


Fig 3.17 Temperature Distribution in Engine Cylinder with Circular Fins

The Figure 3.17 shows Transient Thermal Analysis for copper Material with Circular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 77.796 o C.

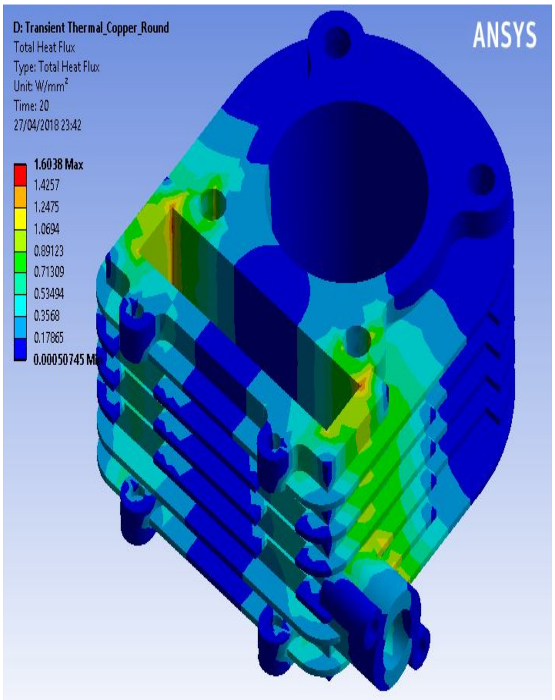


Fig 3.18 Heat Flux Distribution in Engine Cylinder with Circular Fins

The Figure 3.18 shows Transient Thermal Analysis for Copper Material with Circular fins and from figure we can see that maximum heat flux is 1.6038 W/mm2 & minimum heat flux is 0.00050745e-9 W/mm2

HEAT TRANSFER ANALYSIS FOR CAST IRON

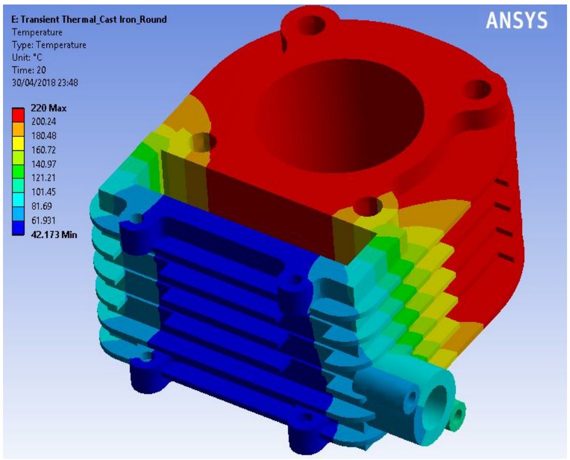


Fig 3.19 Temperature Distribution in Engine Cylinder with Circular Fins

The Figure 3.19 shows Transient Thermal Analysis for Cast Iron Material with Circular fins and from figure we can see that maximum temperature is 220 o C & minimum temperature is 42.173 o C. We can observe temperature is maximum at centre & minimum at outer side of cylinder walls.

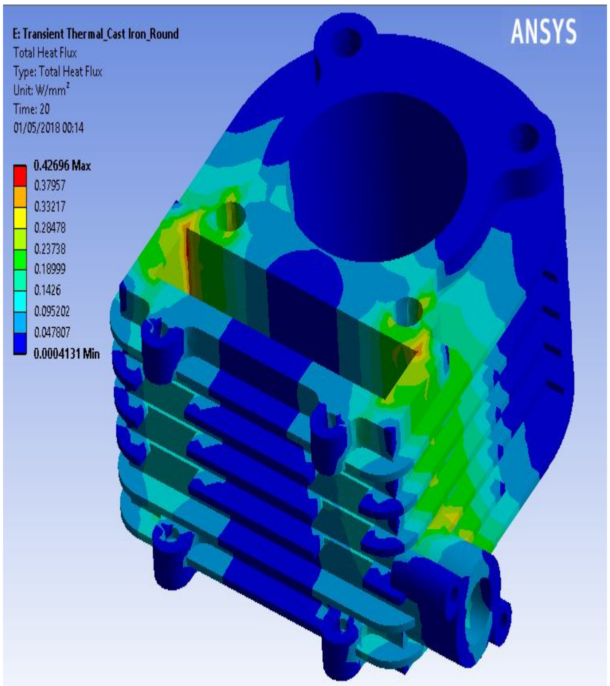
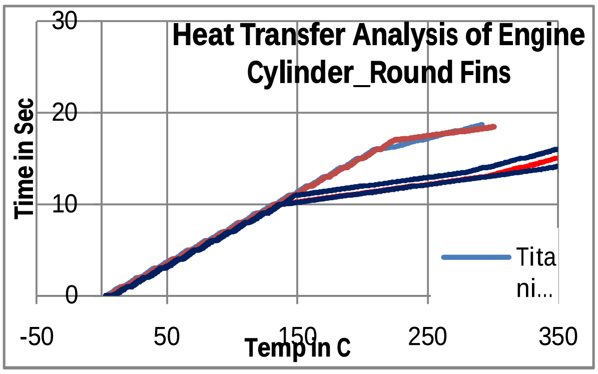


Fig 3.20 Heat Flux Distribution in Engine Cylinder with Circular Fins

The Figure 3.20 shows Transient Thermal Analysis for Cast Iron Material with Circular fins and from figure we can see that maximum heat flux is 0.42696 W/mm2 & minimum heat flux is 0.0004131e-9 W/mm2. We can observe heat flux is maximum at centre and minimum at outer side of cylinder walls.

Graph3.2: Heat transfer analysis of engine cylinder with circular fin



3.2Summary of the Results

Table 3.1: Summary of results

Fin Types	Titanium		Copper		Mild Steel		Aluminium	
	Temperature oC	Heat Flux W/mm2	Temperature oC	Heat Flux W/mm2	Temperature oC	Heat Flux W/mm2	Temperature oC	Heat Flux W/mm2
Rectangular	220 max	0.22369 max	220 max	1.6019 max	220 max	0.4643 max	280 max	1.0876 max
	22 min	7.7135e-9 min	74.394 min	0.00067466 min	22 min	13.55 min	56.914 min	0.00053443 min
Circular	220 max	0.22913 max	220 max	1.6058 Max	220 max	0.48798 max	220 max	1.0579\max
	22 min	1.0182e-8 min	77.796 min	0.00050745 min	22.035 min	1.6797e-6 min	60.031 min	0.00060738 min

It is observed from the table 3.1 the circular fins showing good temperature distribution along the fin length. Also, the circular fins are showing good distribution of heat compared to that of rectangular.

It has been observed from the Figures the temperature is spread throughout the area in the circular fins therefore better heat transfer rate is obtained from the circular fins.

SCOPE FOR FUTURE WORK

1. Further work can be carried out on curved fins & Transient heat transfer analysis can be done.
2. The distance between fins can be varied and thermal behaviour can be predicted
3. The thickness of the fin can be varied and thermal efficiency of material can be checked.
4. Alternative materials like material matrix material may be explored for thermal analysis.

REFERENCES

[1] N. Phani Raja Rao analysed the thermal properties by varying geometry, material and thickness of cylinder fins.
[2] Bassam A/K Abu-Hijleh investigated numerically the problem of laminar natural.
[3] Prof. R.B.Gupta, 1998, “Automobile engineering,” Satya Prakashan, Incorporating, Tech India Publications.
[4] Wang,Q., Cao,Y., and Chen,G., 1996b “Piston assembly design for improved thermal tribological performance.” Tribology transactions, vol.39 pp.483- 489Compression Ignition Engines, Sadhana Vol. 29, Part 3, pp 275-284.
[5] Lienhard, J.H.,IV, and Lienhard,J.H.,V, 2004, A Heat Transfer Textbook Phlogistan, Cambridge, MA.
[6] Kern,D.Q., and A.D.Kraus, 1972, “Extended Surface Heat Transfer”, McGraw-Hill Book Company, New York.
[7] Gardner, K. A., 1945, “Efficiency of Extended Surfaces,” ASME, J. Heat Transfer, 67, 621- 631.

[8] Badr, H. M., 1983, "A Theoretical Study of Laminar Mixed Convection From a Horizontal Cylinder in a Cross Stream," Int. J. Heat Mass Transfer, 26, pp. 639-653.
[9] Saitoh, T., Sajik, T., and Maruhara, K.,1993, "Benchmark Solutions to Natural Convection Heat Transfer Problem Around a Horizontal Circular Cylinder," Int. J. Heat Mass Transfer, 36 pp. 1251-1259.
[10] Gardner, K. A., 1945, "Efficiency of Extended Surfaces," ASME, J. Heat Transfer, 67, 621- 631