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HEAT TRANSFER ENHANCEMENT OF FIN BY VARYING ITS GEOMETRY AND MATERIAL

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Abstract- The Engine cylinder is one of the major automobile components, 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 fins, it is helpful to know the heat dissipation inside the cylinder. By increasing the surface area the heat dissipation rate increases. So designing such a large complex engine is very difficult.
The main aim of the present paper is to analyze the thermal properties by varying geometry, material and thickness of cylinder fins. The 3D models of the geometries are created in CREO software and its thermal properties are analyzed using ANSYS workbench by assuming steady state thermal conditions.
Material used for modeling cylinder fin is Aluminium alloy A204 with thermal conductivity of 150 W/mK and Aluminium alloy 7075 with thermal conductivity 130 W/m K and comparing the results and two geometries, rectangular and circular fins are modeled and comparing the results, also changing the thickness of the fin from 0.5 inches to 0.2 inches.
Keywords: Cylinder, High Temperatures and Thermal Stresses, Fins, CREO, ANSYS.

1. INTRODUCTION
Cylinder is the one of the major components in Engine, which is subjected to high temperature variations and thermal stresses. To cool the cylinder, fins are provided on the surface of the cylinder to increase the rate of heat transfer rate. Fins are Basically Mechanical structures which are used to cool various structures via the process of convection and conduction. Extended fins are well known for enhancing the heat transfer in IC engines. The construction of air cooling system is very simpler. Therefore it is important for an air-cooled engine to utilize the fins effectively to obtain uniform temperature in the Engine cylinder.

1.1 FINS:
In the study of heat transfer, 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, or 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 an object, however, increases the surface area and can sometimes be an economical solution to heat transfer problems.
For both modes of convective heat transfer i.e. natural and forced, fin is used to increase the rate of heat transfer from a surface to a fluid where heat transfer coefficient of surface and temperature difference between them is not possible to increase. Fins increase the surface area available for heat transfer. Fins are vastly used on the radiator surface, on the boiler water tubes, heat exchanger tubes and sometimes on electronic equipment..

2. LITERATURE SURVEY
"Masao YOSHIDA, Soichi ISHIHARA, Kohei NAKASHIMA: Air-Cooling Effects of Fins on a Motorcycle Engine"[1] The author had developed the experimental cylinder for an air-cooled engine and the effects of the number of fins, fin pitch and wind velocities on cylinder cooling were investigated. The major results obtained are, to increase the cylinder cooling, the cylinder should have a greater number of fins. At a lower speed the air flow separated on the fin surface at the leeward side and the temperature on the fin surface increased there. The higher temperature on the local fin surface makes cylinder bore a greater deformation, as a result, scuffing and increased lubricating oil consumption may occur.
"Pratima S. Patil, S.N. Belsare, Dr. S. L. Borse Analysis of internal combustion engine heat transfer rate to improve engine efficiency, specific power & combustion performance prediction" [2]This paper focuses on substantial difference of heat flux exists for various places in the cylinder of an engine.A substantial difference of heat flux exists for various places in the cylinder of an engine. Maximum heat flux in each part occurs when pressure in the cylinder is maximum. Heat flux on the intake valves is higher than other place of the cylinder. Heat flux on the cylinder head is more than piston and it has the lowest value on the cylinder liner.

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G.Raju, Dr. Bhramara Panitapu, S. C. V. Ramana Murty Naidu. “Optimal Design of an I C engine cylinder fin array using a binary coded genetic algorithm”.[3]This study also includes the effect of spacing between fins on various parameters like total surface area, heat transfer coefficient and total heat transfer .The aspect rations of a single fin and their corresponding array of these two profiles were also determined. Finally the heat transfer through both arrays was compared on their weight basis. Results show the advantage of triangular profile fin array. Heat transfer through triangular fin array per unit mass is more than that of heat transfer throughrectangular fin array. Therefore the triangular fins are preferred than the rectangular fins for automobiles, central processing units, aero-planes, space vehicles etc… where weight is the main criteria. At wider spacing, shorter fins are more preferred than longer fins. The aspect ratio for an optimized fin array is more than that of a single fin for both rectangular and triangular profiles.

Magarajan U. , Thundil karrupa Raj R. , Elango T. “ Numerical study on heat transfer I C Engine cooling by extended fins using CFD” [4]In this study, heat release of an IC engine cylinder cooling fins with six numbers of fins having pitch of 10 mm and 20 mm are calculated numerically using commercially available CFD tool Ansys Fluent. The IC engine is initially at 150 and the heat release from the cylinder is analyzed at a wind velocity of 0 km/h. It is observed from the CFD result that it takes 174.08 seconds (pitch=10mm) and 163.17 seconds (pitch =20mm) for ethylene glycol domain to reach temperature of 423 K to 393 K for initially.

The 12 experiment results shows that the value of heat releases by the ethylene glycol through cylinder fins of pitch 10mm and 20mm are about 28.5W and 33.90 W.

Mr. N. Phani Raja Rao, Mr. T. Vishnu Vardhan. “Thermal Analysis of Engine Cylinder Fins By Varying Its Geometry and Material.” [5]

The principle implemented in the project to increase the heat dissipation rate by using the invisible working fluid nothing but air. The main aim of the project is to varying geometry, material. In present study, Aluminium alloy 6061 and magnesium alloy are used and compared with Aluminium Alloy A204. **-** The various parameters (i.e., shape and geometry of the fin) are considered in the study, shape (Rectangular and Circular), thickness (3 mm and 2.5 mm). 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 weight of the fin body is also reduced when Magnesium alloy is used. 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. By using circular fins the weight of the fin body reduces compare to existing engine cylinder fins.

3. MODELLING AND ANALYSIS

3.1 The MODELING OF CYLINDER FIN

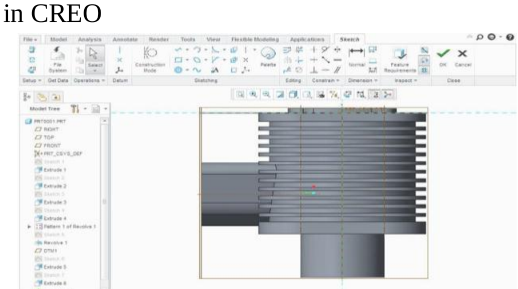
Cylinder along with fin was modeled in CREO software. The dimensions of the cylinder along with fin were taken from commercially available bike data sheet. Fins with different geometries (circular and rectangular) were modeled using CREO software.

3.2. Modeling Of Rectangular And Circular Cylinder Fin In Creo

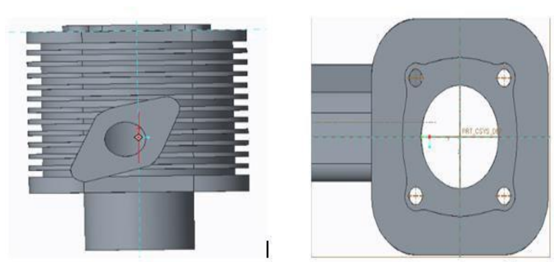
Existing Model Specifications

Engine model	:	Yamaha RX 100.
Engine type	:	Four-stroke, single cylinder, and air cooled,
Displacement volumes	:	98C.C.
Fin shape	:	Rectangular with curves at corner
Engine Dimensions		
Cylinder outer diameter	:	8 inches
Cylinder inner diameter	:	3.5 inches
Height	:	9.5 inches
Fin thickness	:	0.5 inches and 0.2 inches
Distance between fins	:	inches

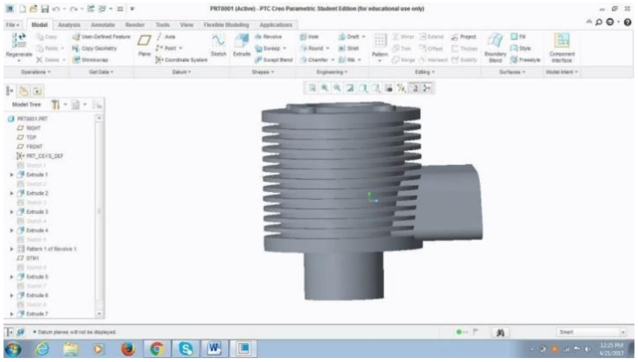
Modeling in CREO

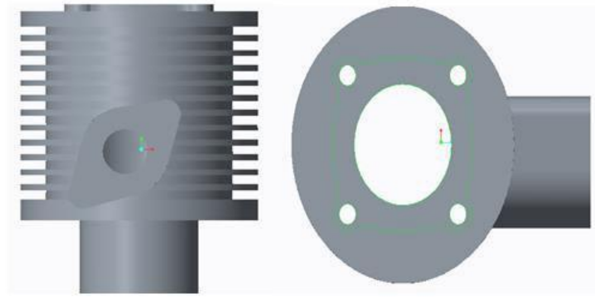


Modeling of rectangular fin



Side & Top view of rectangular fin





Modeling of circular fin

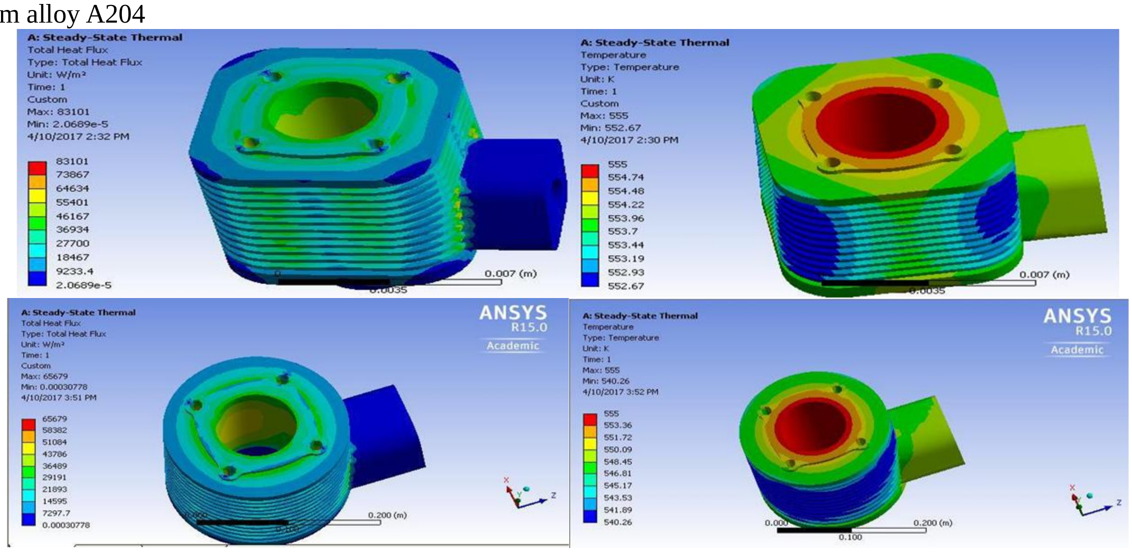
Side & Top view of circular fin

3.3 Analysing Engine Cylinder Fin In Ansys :

Applying Boundary Conditions inside the cylinder and convection at tip of the fin with film coefficient of 25 W/ K and ambient temperature of 313 K is applied. In the present paper temperature of 555 K is taken as base temperature and applied it

Solution Information:Solution of Rectangular and Circular Fins Obtained are :

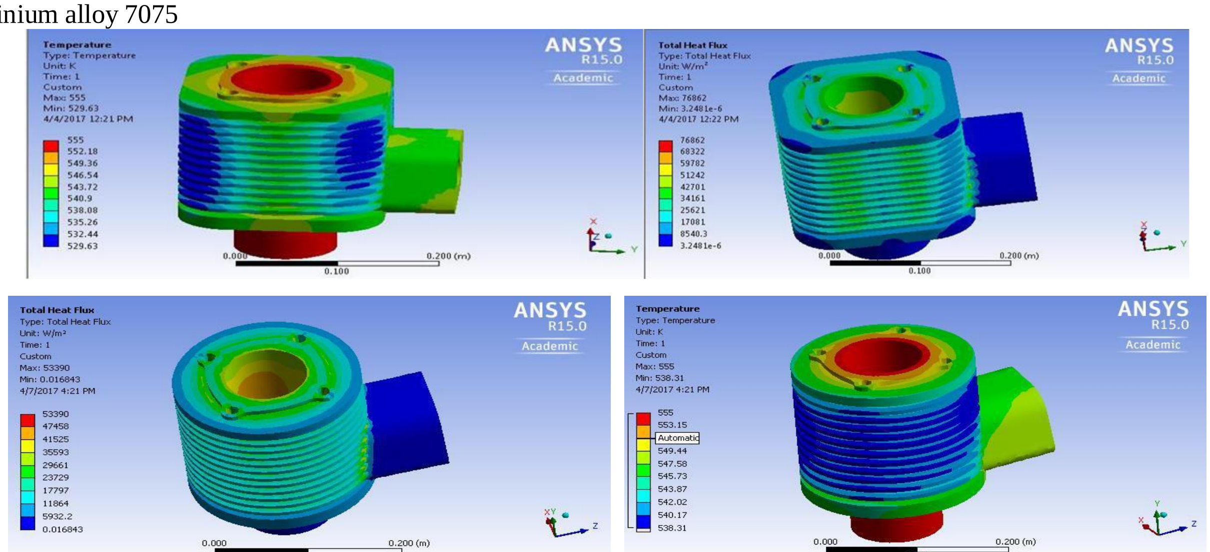
Aluminium alloy A204



Total Heat Flux

Temperature Distribution

Aluminium alloy 7075



Total Heat Flux

Temperature Distribution

4. THEORETICAL CALCULATIONS

4.1 Total Heat Flux

Heat Transfer(Q):

$$Q = N \times \sqrt{hPKA} \times T\infty \times \frac{\left(\sinh(mL) + \frac{h}{mk}\, cosh(mL)\right)}{cosh(mL) + \frac{h}{mk}\, sinh(mL)}$$

4.2 Heat Flux (Q):

$q = \frac{Q}{N}$ W/

4.3 Boundary Conditions

Boundary conditions for designed model is given as follow

Base temperature (T) : 555 K
Heat transfer coefficient (h) : 25 W/ k
Ambient temperature (T∞) : 313 K

4.4 Temperature Distribution:

We are considering the fin tip as convective type. The temperature distribution at the end (or) tip of the fin can be calculated by using below formula.

$$T_{tip} = T_{\infty} + \frac{T_0 - T_{\infty}}{\cosh(mL) + [\frac{h}{m \times k} \times \sinh(mL)]}$$

5. RESULTS

In this project, an engine cylinder with rectangular and circular fins is modeled in CREO software and steady state thermal analysis is done using ANSYS software. The results for total heat flux and temperature distribution obtained in ANSYS are compared with theoretical calculations as shown below.

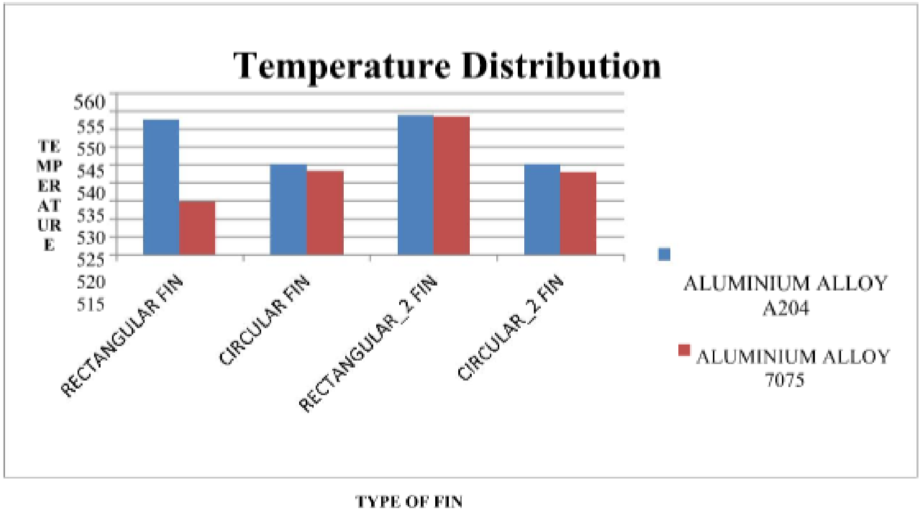
GEOMETRY	MATERIAL	TOTAL HEAT FLUX (W/ (Practical)	TOTAL HEAT FLUX (W/ (Theoretical)
RECTANGULAR FIN	ALUMINIUM ALLOY A204	83101	79436.67
	ALUMINIUM ALLOY 7075	76862	79177.94
CIRCULAR FIN	ALUMINIUM ALLOY A204	65679	69765.94
	ALUMINIUM ALLOY 7075	53390	68237.44
RECTANGULAR_2FIN	ALUMINIUM ALLOY A204	97689	134771.98
	ALUMINIUM ALLOY 7075	100110	132766.03
CIRCULAR_2 FIN	ALUMINIUM ALLOY A204	66414	82387.6
	ALUMINIUM ALLOY 7075	63265	81875

Comparison of Total Heat Flux

GEOMETRY	MATERIAL	TOTAL HEAT FLUX (W/ (Practical)	TOTAL HEAT FLUX (W/ (Theoretical)
RECTANGULAR FIN	ALUMINIUM ALLOY A204	552.67	542.46
	ALUMINIUM ALLOY 7075	529.63	540.44
CIRCULAR FIN	ALUMINIUM ALLOY A204	540.26	552.5
	ALUMINIUM ALLOY 7075	538.31	542.35
RECTANGULAR_2FIN	ALUMINIUM ALLOY A204	553.87	528.77
	ALUMINIUM ALLOY 7075	553.7	525.27
CIRCULAR_2 FIN	ALUMINIUM ALLOY A204	540.26	542.03
	ALUMINIUM ALLOY 7075	538.13	537.85

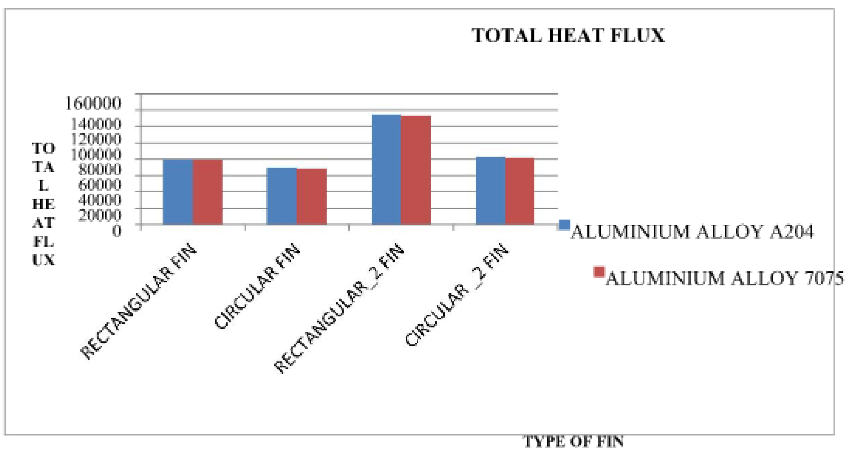
Comparison of Temperature Distribution

5.1. Temperature Distribution Graph



From the graph it is observed that temperature distribution is more in rectangular fin compared to circular fin.

5.2 Total Heat Flux Graph



From the graph it is observed that total heat flux is more in rectangular fin compared to circular fin.

6. CONCLUSIONS

In present work, an engine cylinder with rectangular and circular fins are modeled in CREO software and steady state thermal analysis is done by using ANSYS software. These fins are used for air cooling systems for two wheelers.

In present study, Aluminium alloy A204 is compared with Aluminium alloy 7075. The various parameters (i.e., geometry and thickness of the fin) are considered in the study. It is observed that Aluminium alloy A204 shows better results than Aluminium alloy 7075 due to its material composition and higher thermal conductivity.

It is observed that the total heat flux is more in rectangular shape fins compared to circular shape fins.

Also it is observed that, by reducing the thickness of the fin from 0.5 inches to 0.2 inches the total heat flux and temperature distribution are increasing.

7. REFERENCES

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[2] "Pratima S. Patil, S.N. Belsare, Dr. S. L. Borse Analysis of internal combustion engine heat transfer rate to improve engine efficiency, specific power & combustion performance prediction".

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[4] Magarajan U. , Thundil karrupa Raj R. , Elango T. " Numerical study on heat transfer I C Engine cooling by extended fins using CFD".

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