

**DESIGN AND OPTIMIZATION OF ENGINE CYLINDER FINS BY VARYING
GEOMETRY AND MATERIAL WITH THERMAL ANALYSIS**

**M.RAJESH¹, ASSISTANT PROFESSOR, S.RAHAMATHULLAH², ASSOCIATE PROFESSOR, DR.
G NAGA MALLESWARA RAO³,
PROFESSOR
DEPARTMENT OF MECHANICAL ENGINEERING, GATES INSTITUTE OF TECHNOLOGY
GOOTY: ANDHRA PRADESH INDIA
CORRESPONDING AUTHOR: E-
MAIL: MADRIRAJESH@GMAIL.COM, SHAIK.RTH@GMAIL.COM**

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 cylinder to increase the rate of heat transfer. The main aim of the Paper is to analyze the thermal properties by varying geometry, material (Cu and Al alloy 6082), distance between the fins and thickness of cylinder fins. The Fins models are created by varying the geometry circular and also by varying thickness of the fins for both geometries. The 3D modeling software used is Pro/Engineer & UniGraphics. Thermal analysis is done on the cylinder fins to determine variation temperature distribution over time. The analysis is done using ANSYS. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder. The principle implemented in this Paper is to increase the heat dissipation rate by using the invisible working fluid, nothing but air. All the materials are showing linear distribution of temperature alongside the length of fins. Also, the circular fins increase the efficiency of the engine by reducing the weight of the engine

Keywords- Engine cylinder, Fins, FEM, Optimization, Material, Heat dissipation,

I. INTRODUCTION

The internal combustion engine is an engine in which the combustion of a fuel takes place in a combustion chamber. Here, the expansion of the high-temperature and high-pressure gases produced by combustion applies direct force to component of the engine, such as piston, turbine blades, or a nozzle. This force transfers the component over a distance, generating useful mechanical energy. Air cooled engines are replaced by water cooled engines which are more efficient, but all two wheelers uses Air cooled engines, because Air-cooled engines are lighter weight and lesser space requirement. The heat produced during combustion in IC engine should be retained at higher level to increase thermal efficiency, but to prevent the thermal damage some heat should remove from the engine.

In Internal engine combustion engines, combustion of air - fuel mixture takes place inside engine

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cylinder and hot gases are produced. The temperature of gases will be around 2300 – 500°C. The high temperature may result into burning of oil film between moving parts and may result into seizing or welding. Hence, this temperature must be reduced to increase the efficiency of the engine. It has been observed from the literature that the heat dissipative effects of the fins used in engine by changing geometry and material have not been reported. The present investigation work aims to investigate heat dissipative effect of fins made up of Aluminium 6061, Aluminium 2014 and Aluminium Alloy C443 and also, modifying its geometry.

II. BACKGROUND INFORMATION
DESIGN AND MODELLING

The present study is to design the engine cylinder with fins for a 150cc engine by changing the geometry such as rectangular, circular & curve shaped (parabolic) and angular fins. Table 1 show that different materials and geometry chosen for present study and material properties are given in the Table 2

Table.1. Different materials and geometry chosen for analysis

Type of Fins	Material of the fin
Rectangular	Aluminium Alloy 6061
Circular	Aluminium Alloy 204
Angular	Aluminium Alloy 2014
Curved	Aluminium Alloy C443

Table.2. Material properties thermal conductivity

Materials	Thermal Conductivity (W/mK)	Heat transfer coefficient (W/m ² k)	Density (g/cc)	Melting Point (K)
Aluminium 6061	167	25	2.7	855
Aluminium 204	156	25	2.75	820
Aluminium 2014	160	25	2.8	780
Aluminium C443	146	25	2.69	847

Figure 1 to 4 illustrates the design of all four geometries and it is designed using SOLIDWORKS. The cylinder diameter of 50 mm and height of 53 mm have been chosen for the present analysis. The fin thickness is 2.5 mm and gap between fins is 7.5 mm. Figure - 5 to 8 shows the engine cylinder is designed with different fin geometries.



Figure.1. Engine cylinder with angular fins

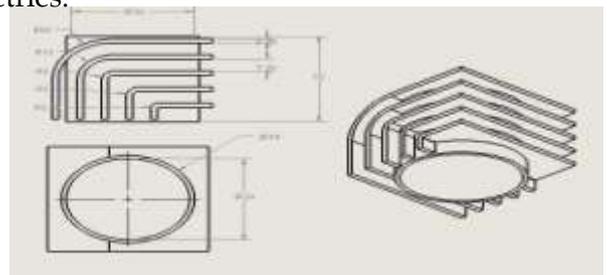


Figure.2. Engine cylinder with curved fins

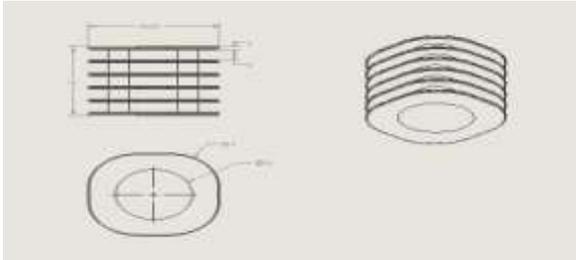


Figure.3.Engine cylinder with circular fins

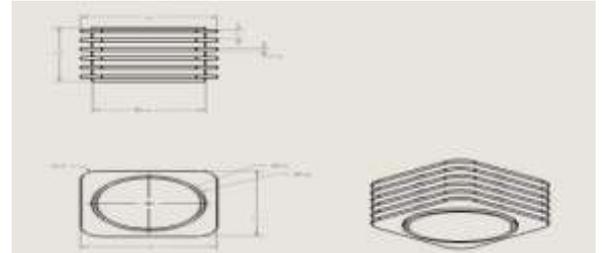


Figure.4.Engine cylinder with rectangular fins

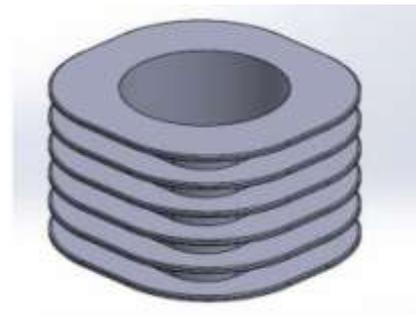


Figure.5.Cylinder fin with rectangular geometry Figure.6.Cylinder fin with circular geometry



Figure.7.Cylinder fin with angular geometry

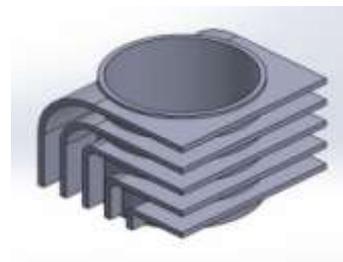


Figure.8.Cylinder fin with curved geometry

III. MAIN RESULT

Finite Element Analysis (FEA): Finite Element Analysis uses a system of points called nodes and they make a grid called a mesh. This mesh is programmed to cover the material and structural properties which define how the structure will react to loading conditions. Nodes are allocated at a certain density all over the material depending on the anticipated stress levels of a particular area. Created geometries were meshed carefully using FLUENT in **Ansys** workbench. Thermal analysis was carried out to determine the temperature and other thermal quantities and the boundary

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conditions were given as follows.

Model : k- ϵ

Inlet velocity : 30 (m/s)

Inlet temperature : 1100°C

Outer temperature : Ambient temperature (pressure outlet)

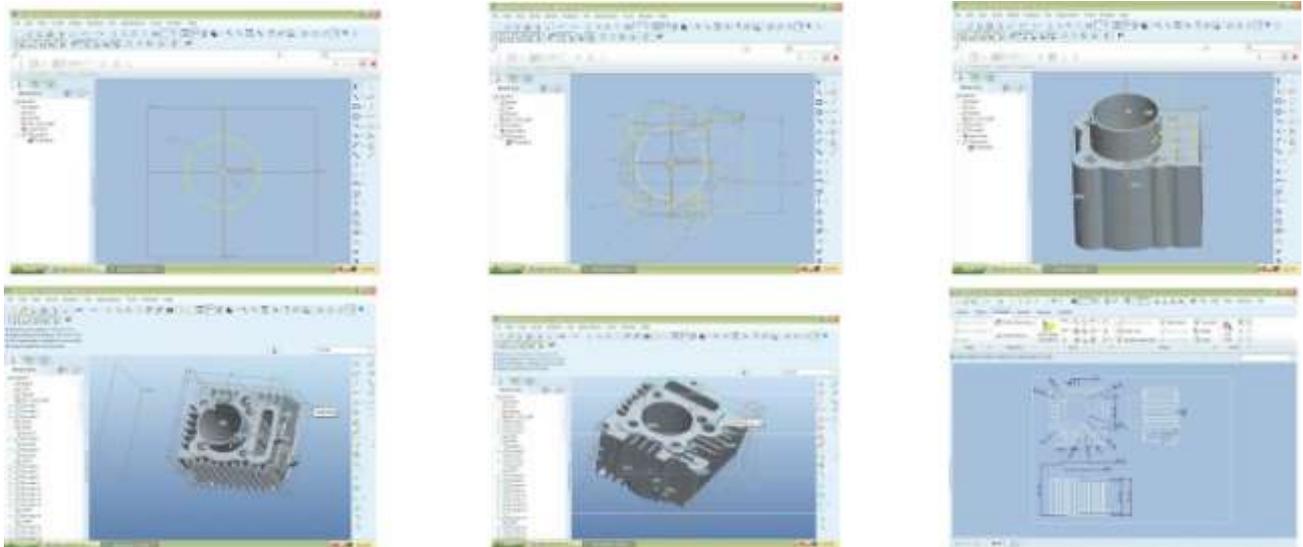
Analysis is also done by varying the materials of fins. Present used material for cylinder fin body is Cast Iron. Our aim is to change the material for fin body by analyzing the fin body with other materials and also by changing the geometry distance between the fins and thickness of the fins.

Geometry of fins - Original model and Modified Model

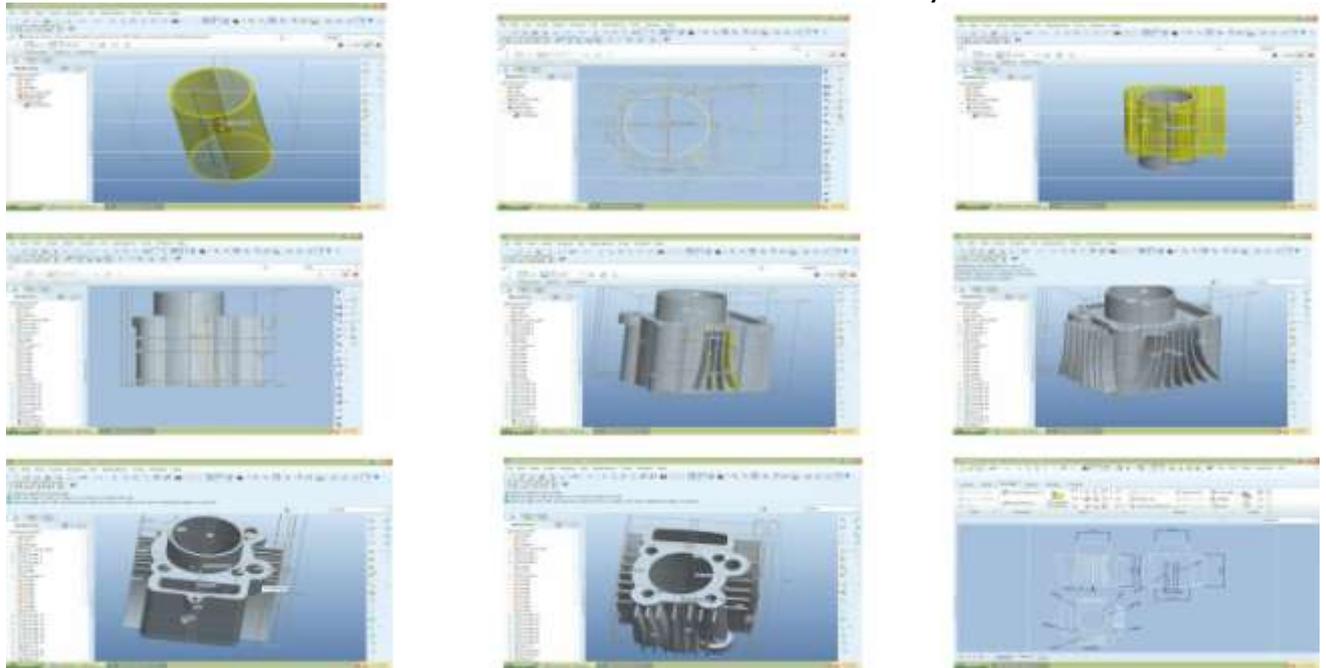
For Original Model - Thickness of fins - 2mm and Distance between the fins - 7.5mm

For modified model - Thickness of fins - 1.5mm and Distance between the fins for combustion side 9.65mm and for opposite side 4.23 mm Materials - Cast Iron, Copper and Aluminum alloy 6082

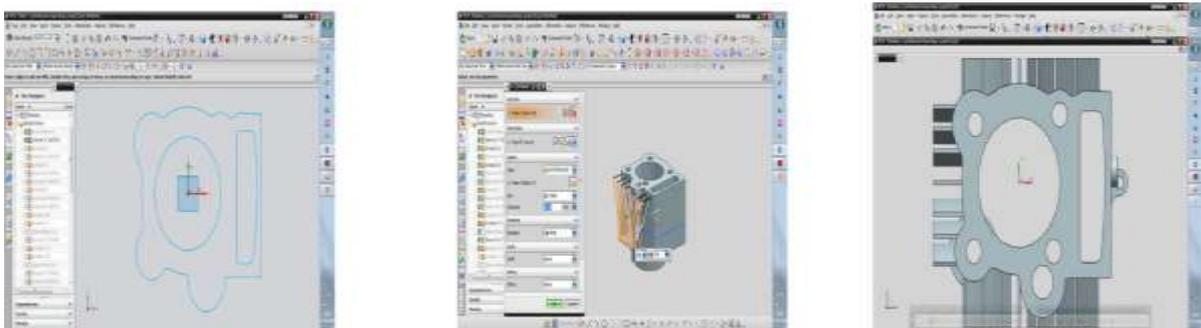
MODELS OF CYLINDER FIN BODY - ORIGINAL FIN BODY IN Pro/E



MODIFIED MODEL OF FIN BODY IN Pro/E



DESIGN OF MODIFIED FINS IN UNIGRAPHICS



RESULTS Transient heat transfer Analysis: Transient heat transfer analysis determines the temperature and other thermal quantities which vary over time. The deviation of temperature distribution over time is of prime interest in many applications such as with cooling of electronic components or a quenching analysis for heat treatment. Also, the temperature variation results in thermal stresses that can cause failure. In such cases the temperatures from a transient heat transfer analysis are used as input to a structural analysis for thermal stress evaluation. Heat transfer application such as heat treatment problem, electronic package design, engine blocks, nozzles, pressure vessels, fluid-structure interaction problems, and so on involving transient heat transfer analysis. In all type of applications, transient heat transfer analysis can be either linear or

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non-linear. Material properties such as thermal conductivity, specific heat or temperature depending convective coefficients or radiation effects can result in non-linear analyses that require an iterative procedure to achieve accurate solutions. Temperature distributions of modified engine fins with unlike metal alloys are shown in Figure.

Temperature distributions of modified engine fins with aluminium alloy 6061:

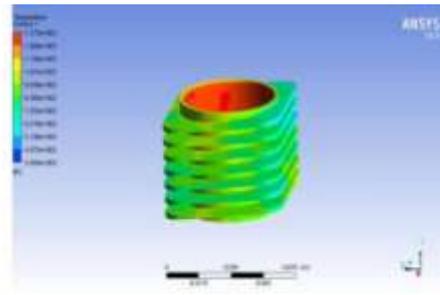
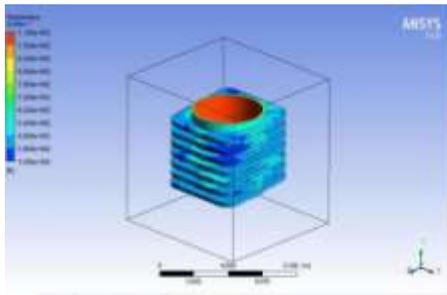


Figure.9.Temperature flow around rectangular fin Figure.10.Temperature flow around angular fin

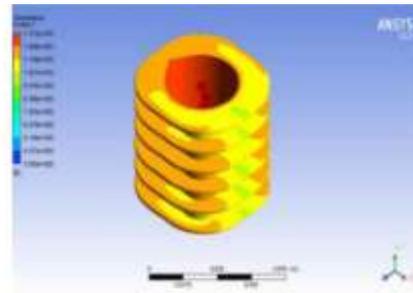
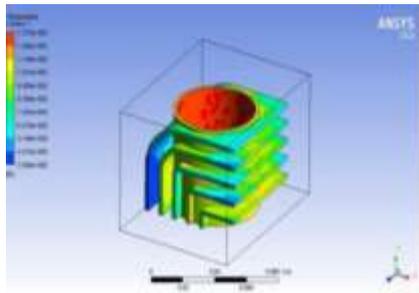


Figure.11.Temperature flow around curved fins Figure.12.Temperature flow around circular fins

It is observed from the Figure 9 to 12, the circular fins showing good temperature distribution along the fin length. Also, the angular fins are showing good distribution of heat compared to that of rectangular and curved fins.

Temperature distributions of modified of engine fins with aluminium alloy 2014:

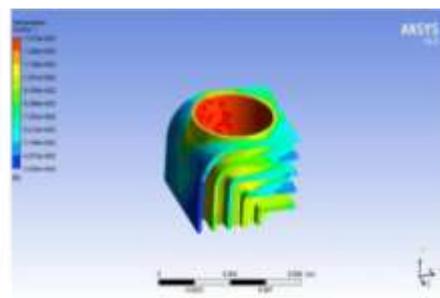
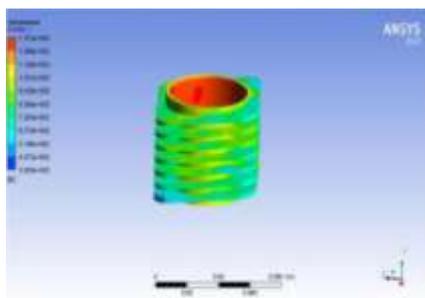


Figure.13.Temperature flow around Angular fins Figure.14.Temperature flow around curved fins

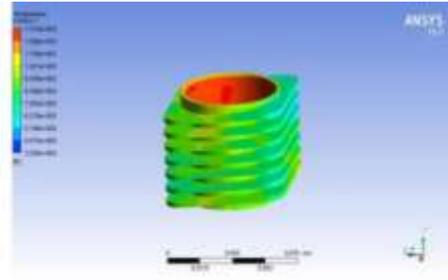
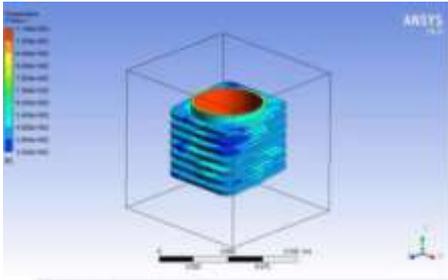


Figure.15. Temperature flow around circular fins Figure.16. Temperature flow around rectangular fins

It is observed from the Figure 13 to 16, the circular fins showing good temperature variation along the fin length. Also, the angular fins are showing good distribution of heat compared to that of rectangular and curved fins.

Temperature distributions of modified of engine fins with aluminium alloy 204:

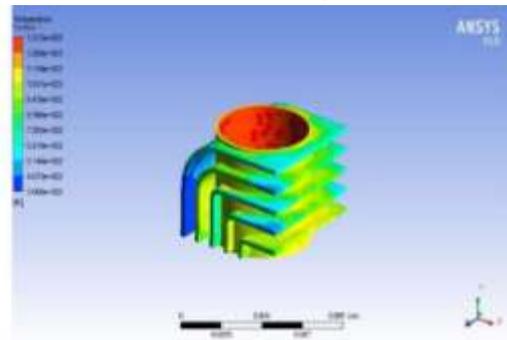
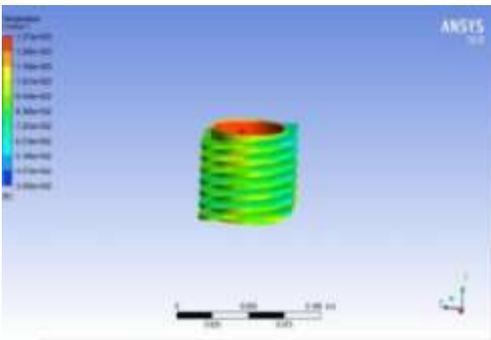


Figure.17. Temperature flow around curved fins Figure.18. Temperature flow around angular fins

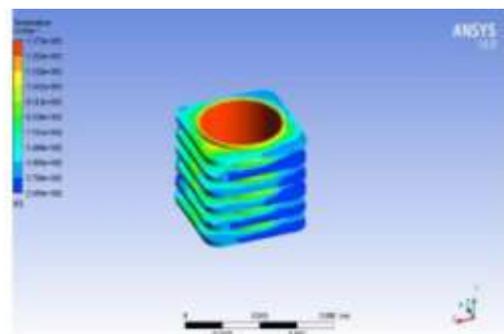
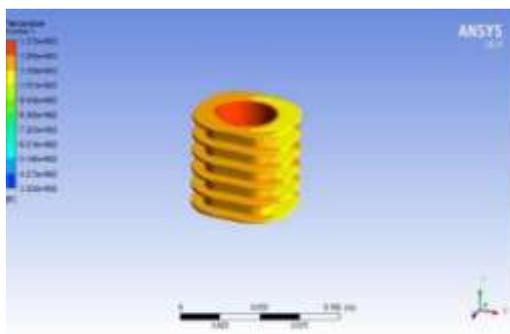


Figure.19. Temperature flow around circular fins Figure.20. Temperature flow around rectangular fins

Figure17 to 20 illustrates the transient temperature distribution of engine fins with different geometries. It is noted that the circular fins are showing good temperature distribution along the length of the fins.

Temperature distributions of modified of engine fins with magnesium alloy C443:

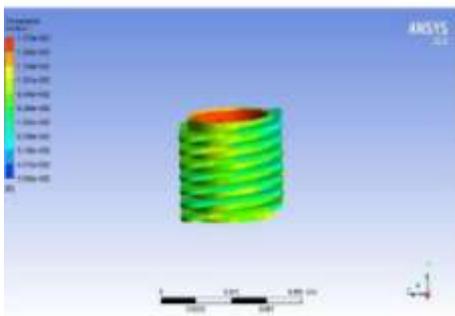


Figure.21. Temperature flow around angular fins

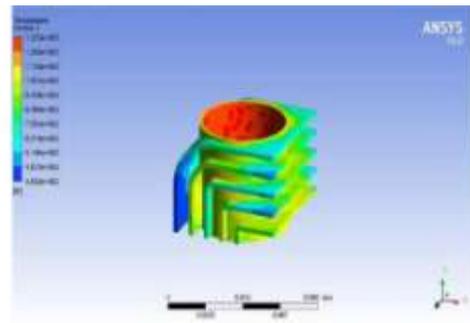


Figure.22. Temperature flow around curved fins

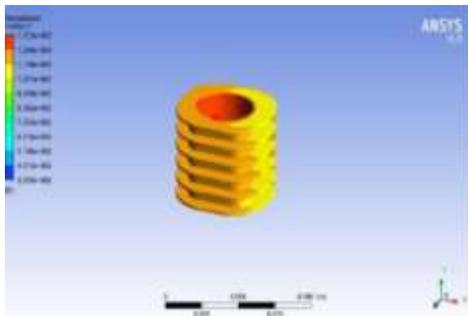


Figure.23. Temperature flow around circular fins

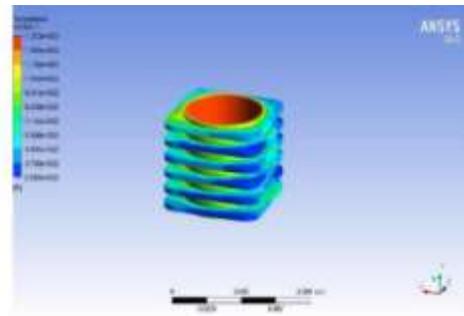


Figure.24. Temperature flow around rectangular fins

It has been observed from the Figure 21to 22, the temperature is spread throughout the area in the circular fins therefore better heat transfer rate is obtained from the circular fins.

Temperature distribution through the circular fins for different alloys: It is observed from the transient temperature analysis the circular fins showing good temperature distribution along the fin length. Figure 5 illustrates the temperature distribution of circular fins with different alloys. It is seen from the figure the Aluminium Alloy 2014 showing 17 % higher temperature distribution compared to that of Aluminium Alloy 204. All the materials are showing linear distribution of temperature along the length of fins. Also, the circular fins increases the efficiency of the engine by reducing the weight of the engine.

IV. CONCLUSION

In this present research we have designed cylinder fin body used in 100cc motorcycle. We have replaced the engine fins with different materials such as Aluminium 6061, A2014, C443. The various geometries of fins used are angular, curved and circular instead of rectangular fins. The

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observations from the present research work are, Aluminium 2014 Alloy showing 17 % higher temperature distribution compared to that of Aluminium Alloy 204 due to its material composition and higher thermal conductivity. All the materials are showing linear distribution of temperature along the length of fins and the circular fins increase the efficiency of the engine by reducing the weight of the engine. Also, observed that the engine with curved fins is shown better efficiency due to its less weight.

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