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DESIGN AND STATIC HEAT TRANSFER ANALYSIS ON ENGINE CYLINDER FINS

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Abstract- The major automobile component subject to high temperature variation and thermal stresses in engine cylinder. Fins are used on the surface of engine cylinder to increase the heat transfer rate. Heat rejection rate in engine cylinder fins can be enhanced by increasing its surface area. The objective of the present investigation is to examine the thermal properties by varying geometry, material and angle of cylinder fins using CATIA V5R21 and ANSYS15.0 work bench and the models are created by changing the geometry like rectangular, circular, angular and curved rectangular shaped fins. Static thermal analysis shows the distribution of temperature over the surface of the fins and the precise thermal simulation is very useful to identify the design parameters for improved life. The observations from the present investigation work, Aluminium Alloy 6061 showing higher temperature distribution compared to other Aluminium Alloy. 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 – Aluminium Alloy, ANSYS 15.0, Static heat transfer, Cylinder fins, Design and modeling.

1. INTRODUCTION

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine, the expansion of the high-temperature and pressure gases produced by combustion applies direct force to some component of the engine, such as pistons, turbine blades, or a nozzle. This force moves the component over a distance, generating useful mechanical energy [1].
All the heat produced by the combustion of fuel in the engine cylinders is not converted into useful power at the crankshaft. A typical distribution for the fuel energy is given: Useful work at the crank shaft is 25 per cent, Loss to the cylinders walls is 30 per cent, Loss in exhaust gases is 35 per cent and Loss in friction is 10 per cent. It is seen that the quantity of heat given to the cylinder walls is considerable and if this heat is not removed from the cylinders it would result in the pre-ignition of the charge. In addition, the lubricant would also burn away, thereby causing the seizing of the piston. Excess heating will also damage the cylinder material.
Keeping the above factors in view, it is observed that suitable means must be provided to dissipate the excess heat from the cylinder walls, so as to maintain the temperature below certain limits. However, cooling beyond optimum limits is not desirable, because it decreases the overall efficiency due to the following reasons:
Thermal efficiency is decreased due to more loss of heat to the cylinder walls. The vaporization of fuel is less; this results in fall of combustion efficiency [2]. Low temperatures increase the viscosity of lubrication and hence more piston friction is encountered, thus decreasing the mechanical efficiency.
Though more cooling is improves the volumetric efficiency, yet the factors mentioned above result in the decrease of overall efficiency. Thus it may be observed that only sufficient cooling is desirable and any deviation from the optimum limits will result in the deterioration of the engine performance[3].
Objectives of the work is to design engine cylinder fins by varying the geometry such as rectangular, circular, angular and curved at the edge shaped of the fins , and analysis of temperature of the proposed fin models element.

2. 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 V5 software.
Step 3: Model obtained in Step 2 is analysed using ANSYS 15.0 (static thermal–workbench), to obtain the temperature distribution and total heat flux
Step 4: Finally, we compare the results obtained from ANSYS for different materials and geometry.

Design and modeling: The present study is to design the engine cylinder with fins for an engine by changing the geometry such as rectangular, circular, curve shaped and angular fins as shown in figure1and Design parameters considered as shown in Table1.

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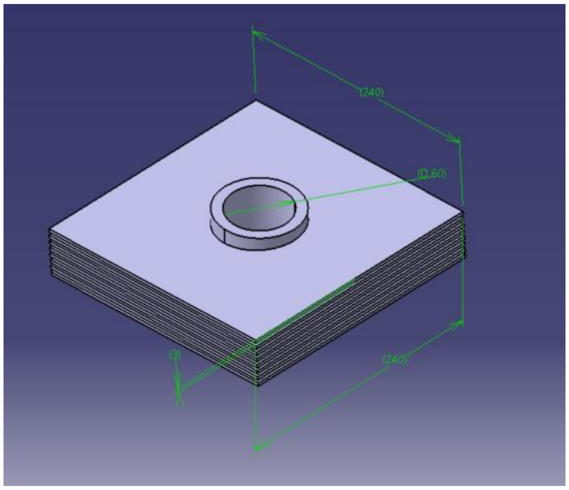
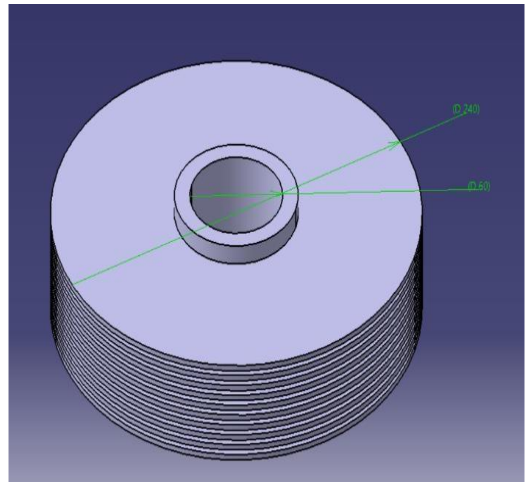
Table 1. Design parameters considered

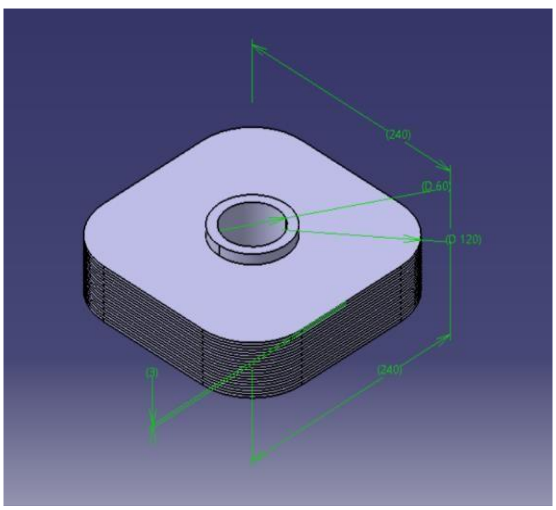
Thickness of the fin	3 mm
Gap between 2 fins	2.5 mm
Cylinder diameter	60 mm



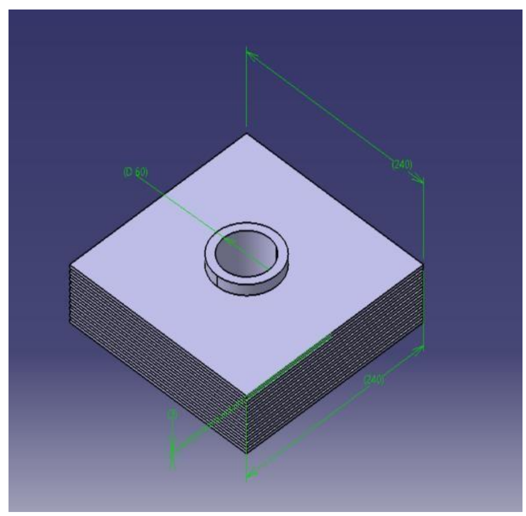
a). Angular fins



b). Circular fin



c). Rectangular curved edge fins



d). Rectangular fins

Figure 1 illustrates the design of all four geometries using CATIA V5R21

Analysis:The following table 2 shows which are used and the material for each fin, and the heat input data which are necessary for analysis in the ANSYS and table 3 shows the boundary conditions for the analysis[4].

Table 2. Material properties thermal conductivity

Materials	Thermal Conductivity (W/m K)	Heat transfer coefficient (W/m2 0C)	Density (g/cc)	Specific heat (J/kg K)
Aluminium 6061	167	20	2.7	897
Aluminium 204	156	20	2.75	880
Aluminium 2014	160	20	2.8	870
Aluminium C443	146	20	2.69	900

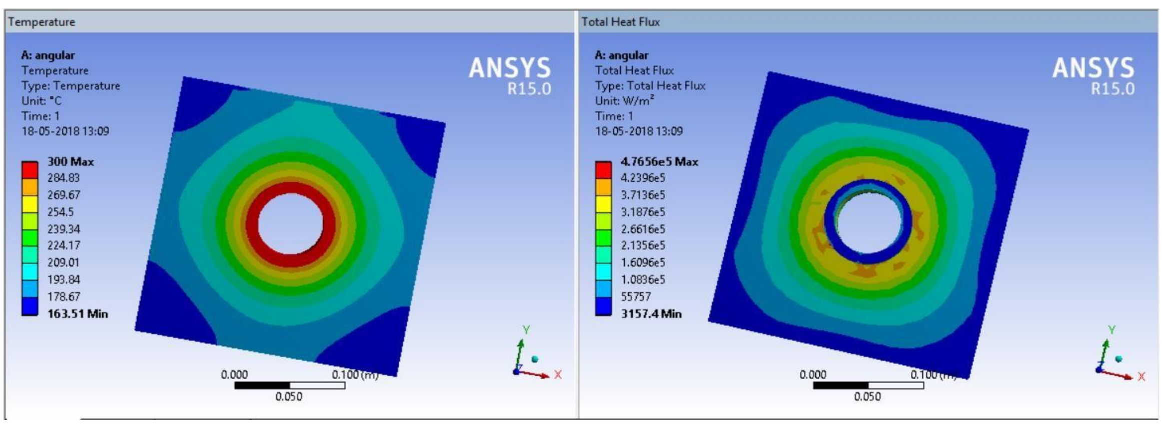
Table 3. Boundary conditions

Engine cylinder temperature	300 0C
Film coefficient	20W/m2 K
Ambient temperature	25 0C

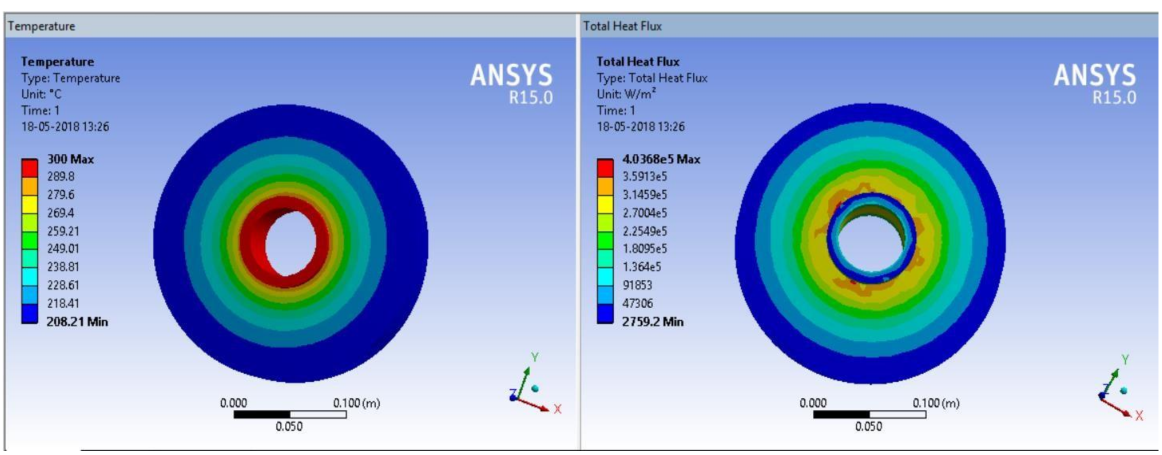
3. RESULT AND DISCUSSION

Static heat transfer Analysis: Static heat transfer analysis determines the temperature and other thermal quantities .The temperature distribution 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 or static 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-structures are static heat transfer analysis interaction problems, and so on involving transient heat transfer analysis[5]. In all type of applications, transient heat transfer analysis and static heat transfer analysis can be either linear or non-linear. Material properties such as thermal conductivity, specific heat or temperature depending convective coefficients or radiation effects can result in non-linear analysis that require an iterative procedure to achieve accurate solutions[6]. Temperature distributions and total heat flux of modified engine fins with unlike metal alloys are shown in Figures.

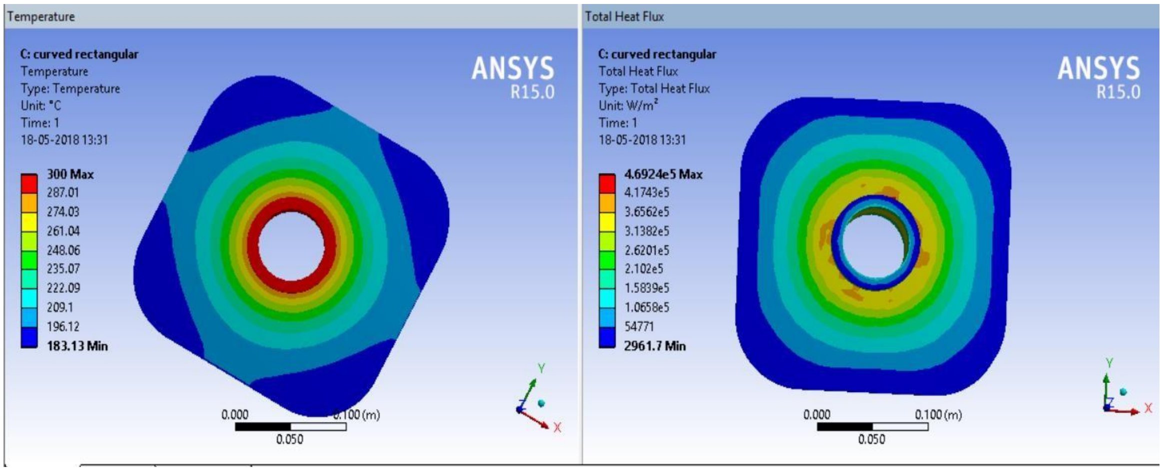
For aluminium alloy 6061



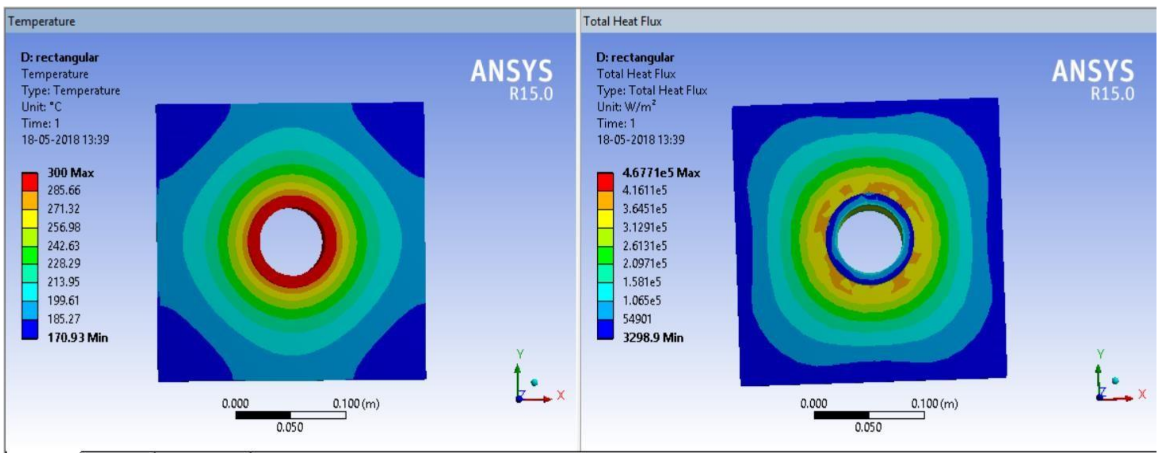
a). Angular fin



b). Circular fin



c). Curved edge fin

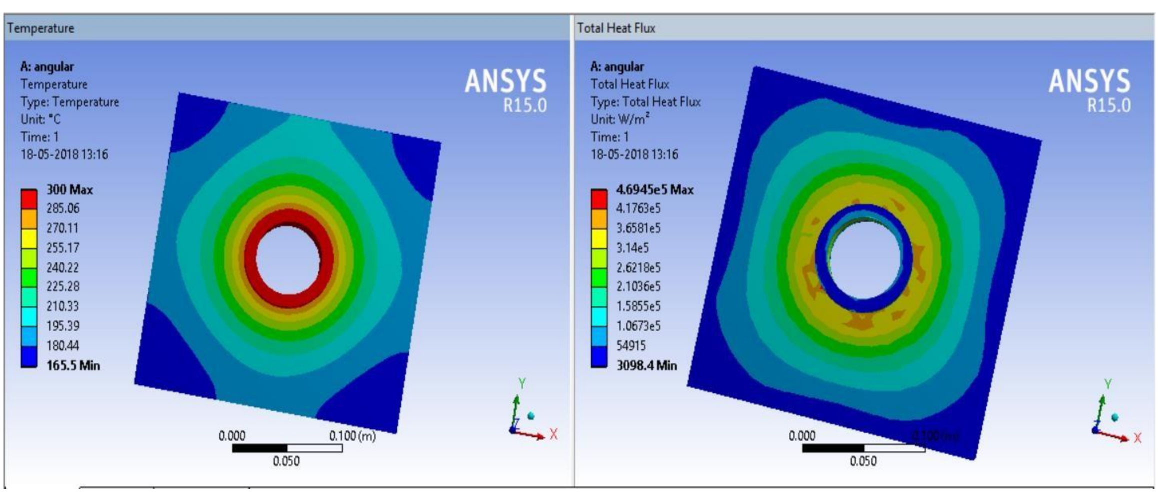


d). Rectangular fin

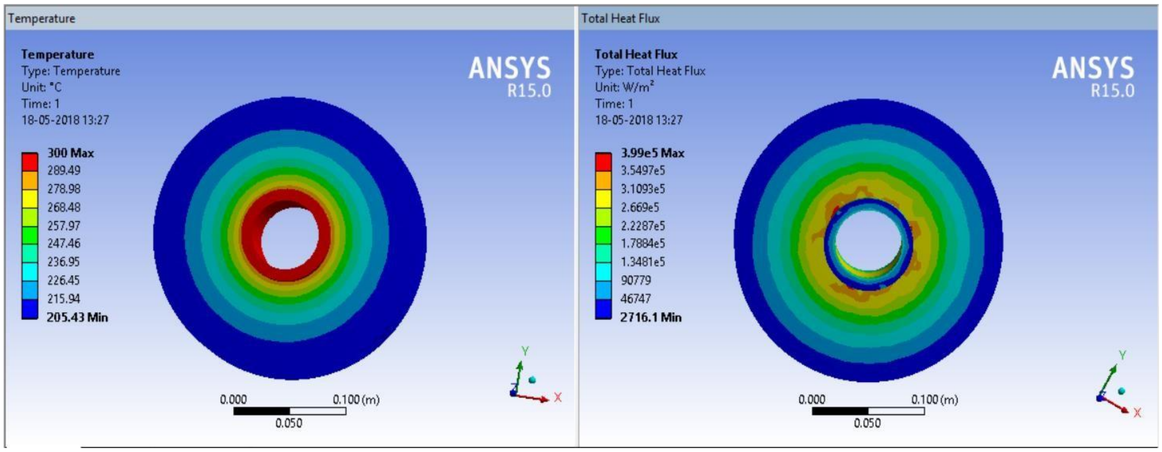
Figure. 2 Temperature distribution and total heat flux of modified engine fins with aluminium alloy 6061

It is observed from the Figure.2, the circular fins shows good temperature distribution and total heat flux along the fin length, since it has more surface area than other fins.

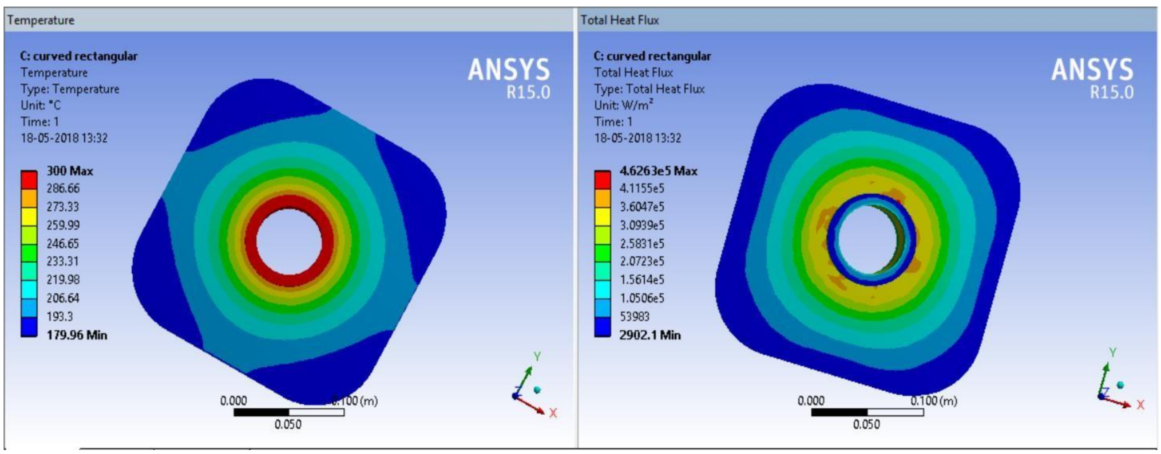
For aluminium alloy 204:



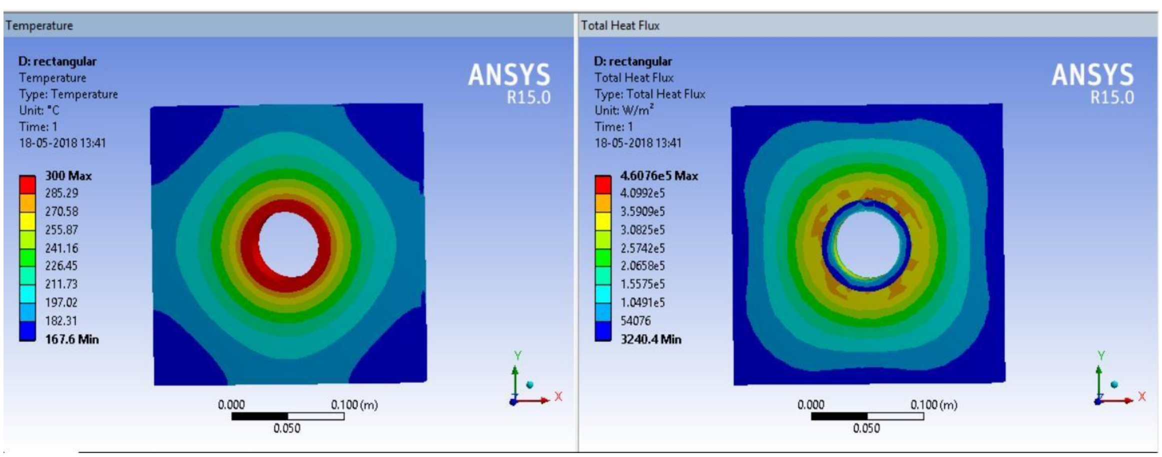
a). Angular fin



b). Circular fin



c). Curved edge fin

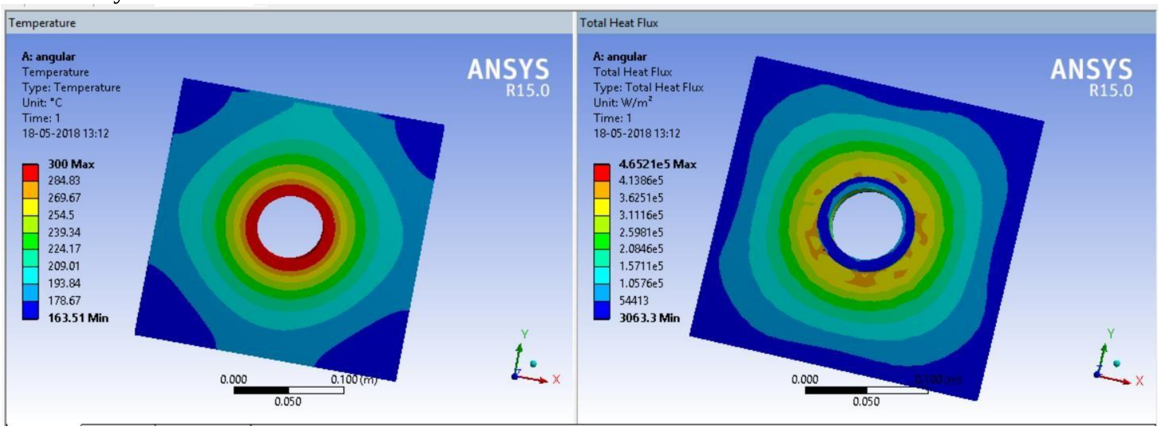


d). Rectangular fin

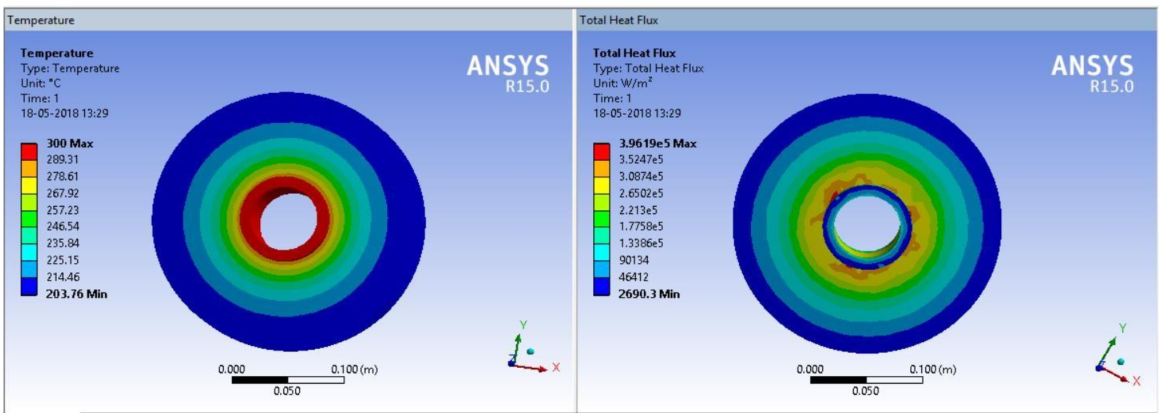
Figure.3 Temperature distribution and total heat flux of modified engine fins with aluminium alloy 204:

It is observed from the figures.3, the circular fins shows good temperature distribution and total heat flux along the fin length since it has more surface area than other geometry.

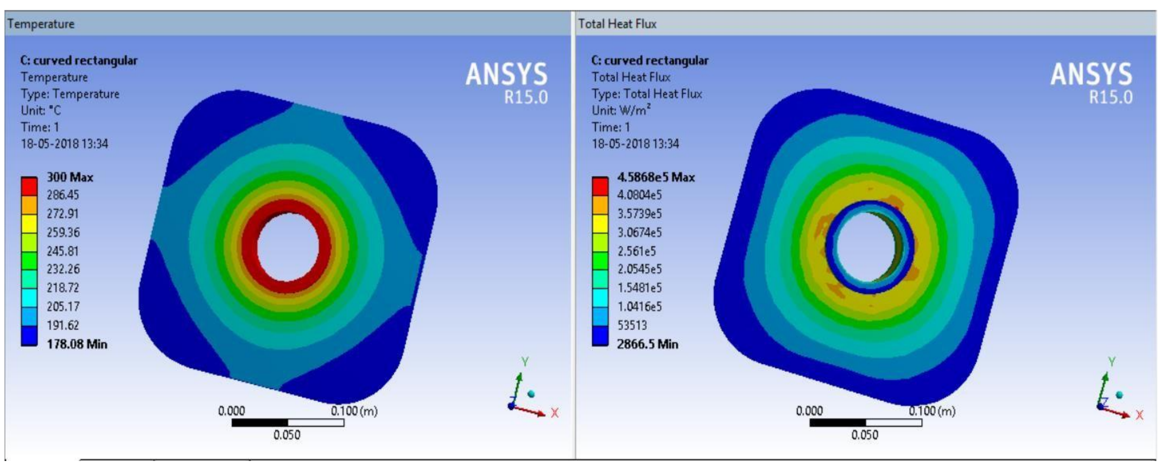
For aluminium alloy 2014



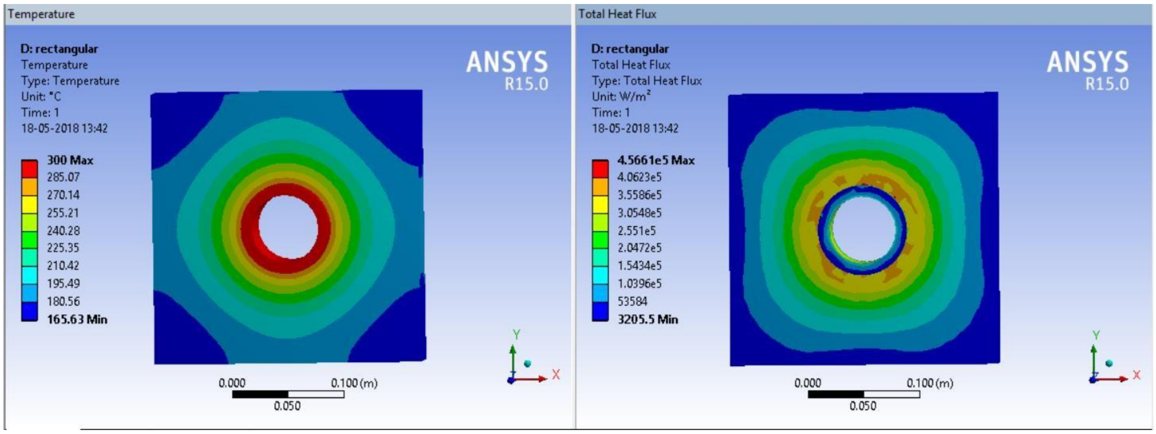
a). Angular fin



b). Circular fin



c). Curved edge fin

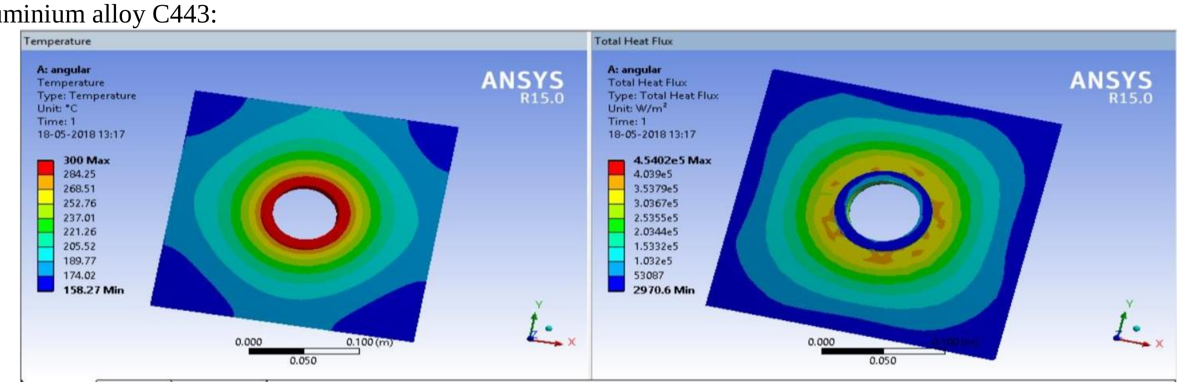


d). Rectangular fin

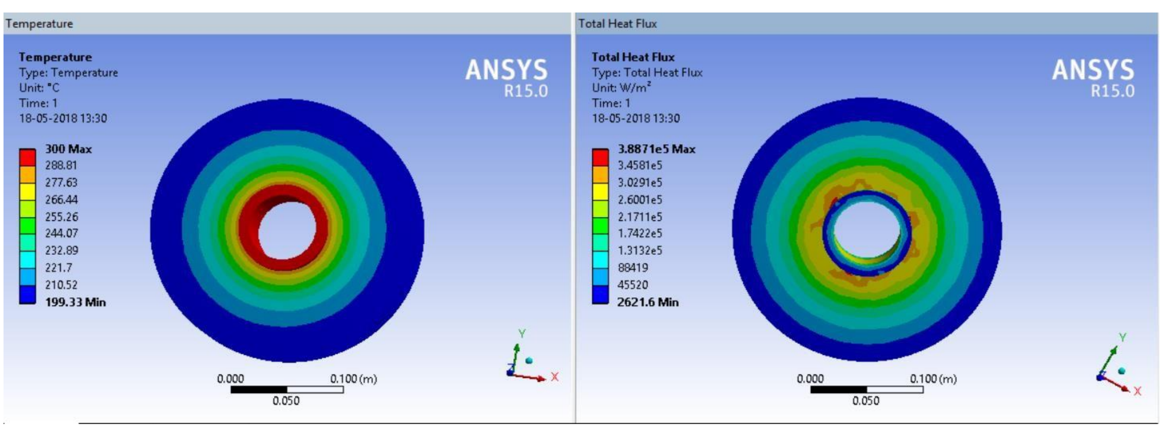
Figure.4 Temperature distribution and total heat flux of modified engine fins with aluminium alloy 2014:

It is observed from the figures 4, the circular fins shows good temperature distribution and total heat flux along the fin length.

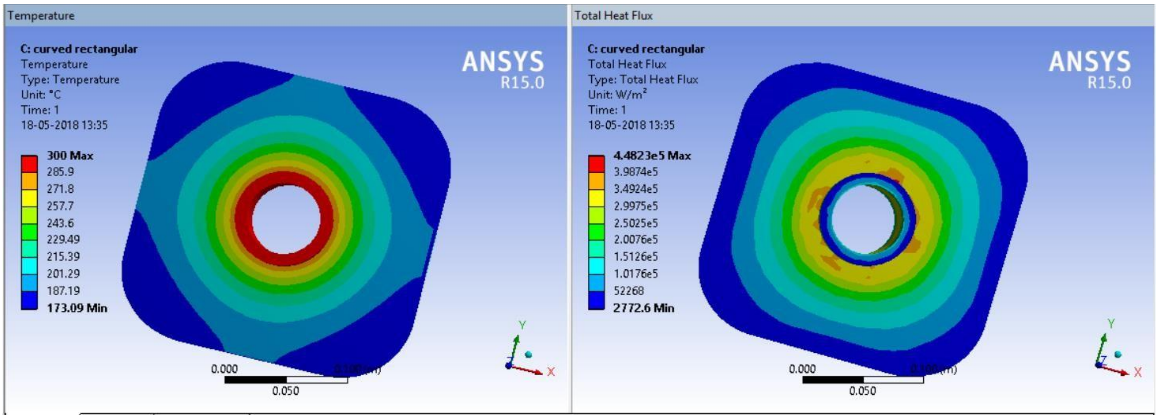
For aluminium alloy C443:



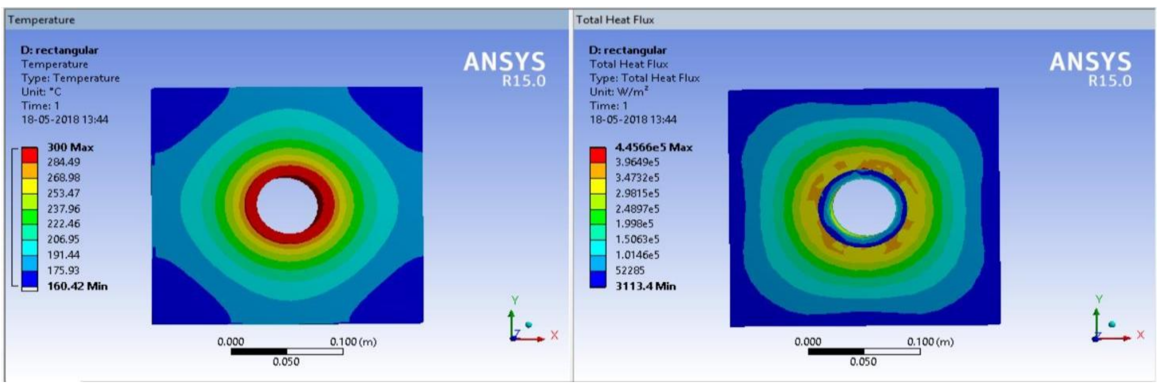
a). Angular fin



b). Circular fin



c). Curved edge fin



d). Rectangular fin

Figure.5 Temperature distribution and total heat flux of modified engine fins with aluminium alloy C443:

It is observed from the figures 5, the circular fins shows good temperature distribution and total heat flux along the fin length. Since the surface area of the circular fin is more than any other fin geometry.

Finally we observed from table 4, the static temperature analysis that the circular fins showing good temperature distribution and total heat flux along the fin length. It is seen from the figure of the Aluminium Alloy 6061 is showing higher temperature distribution and total heat flux compared to that of other Aluminium Alloy like 204, C443 and 2014. All the materials are showing linear distribution of temperature along the length of fins. Also, the circular fins increase the efficiency of the engine by reducing the weight of the engine.

Table 4 Temperature and total heat flux (minimum) far from the heated surface of the cylinder

Material of circular fin	Temperature (0C)	Total heat flux (W/m2)
Aluminium 6061	208.21	2759.2
Aluminium 2014	205.43	2716.1
Aluminium 204	203.76	2690.3
Aluminium C443	199.33	2621.6

4. CONCLUSIONS

The observations from the present work are:

Aluminium Alloy 6061 shows higher temperature distribution compared to that of other aluminium Alloy like C443, 2014 and 204 due to its material composition, density and higher thermal conductivity.

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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