Performance Analysis of Cylinder Cooling of an Air Cooled Engine

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Abstract- **Engine life and effectiveness can be improved with effective cooling. The cooling mechanism of the air cooled engine is mostly dependent on the fin design of the cylinder head and block. The heat is conducted through the engine parts and convected to air through the surfaces of the fins. Insufficient removal of heat from engine will lead to high thermal stresses and lower engine efficiency. As the air-cooled engine builds heat, the cooling fins allow the air to move the heat away from the engine. Low rate of heat transfer through cooling fins is the main problem in this type of cooling. In the present work, an attempt is made to optimize the circumferential fins of rectangular and triangular geometrical profile on the basis of temperature distribution. The fin body is modeled using solid works and steady state thermal analysis carried out by Ansys. The results obtained from the Ansys analysis are compared with the experimental outcomes.**

Keywords- **circumferential fins, Heat transfer, steady state thermal analysis.**

I. INTRODUCTION

Most internal combustion engines [1] are fluid cooled using either air or a liquid coolant run through a heat exchanger (radiator) cooled by air. In air cooling system, heat is carried away by the air flowing over and around the cylinder. Here fins are cast on the cylinder head and cylinder barrel which provide additional conductive and convective surface. We know that 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 2300-2500°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 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.

Extended surfaces or fins [2] are widely used in many engineering applications which include, but are not limited to, air conditioning, refrigeration, automobile and chemical processing equipment. The primary objective of using fins is to enhance the heat transfer between the base surface and its convective environment.

As per the literature survey [3], it is established that Effectiveness of the circumferential fin with material aluminum alloy 6061 is better than the fin with material aluminum alloy A204,which is used as fin material for I.C. Engines.

Hence, circumferential fin of various profiles with material aluminum alloy 6061 is used in the henceforth work.

II. ENGINE SPECIFICATION

Table 1: Engine Specification

No of cylinders	1
bore	57.3mm
stroke	57.8mm
Piston displacement	149.2 cm^3
Compression ratio	9.1:1
Fuel used	petrol
Engine position	vertical

III. EXPERIMENTAL APPARATUS AND METHODS

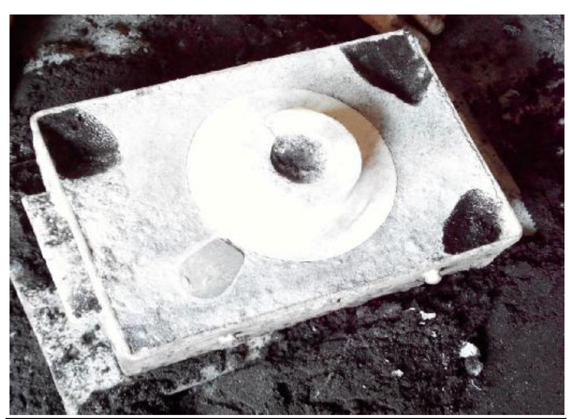

Figure 1: casting of cylinder with circumferential fin.

Fig 1 shows the casting of experimental cylinder with circumferential fin of rectangular and triangular profile with material Aluminum Alloy 6061.

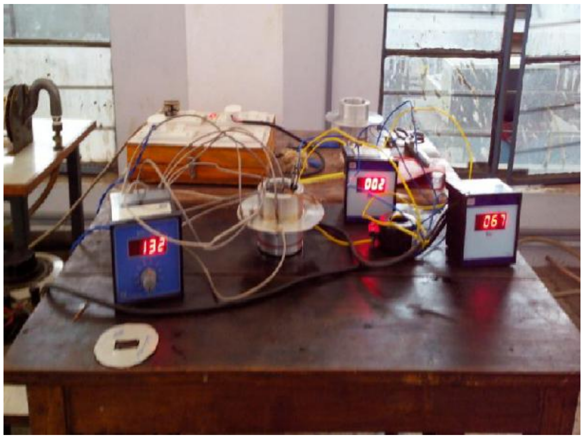

Figure 2: experimental setup at MJCET.

Fig 2 shows the experimental setup consist of the following components:

1. Casted experimental cylinder with annular fin
2. SAE 40 lubricating oil
3. 500 watts electric heater
4. Ammeter
5. Voltmeter
6. Dimmerstat
7. Temperature indicator
8. k-type thermocouples
9. Wooden cap.

In order to perform the experiment, we prepared an experiment cylinder with single fin consist of lubricating oil SAE40. The 500w electric heater is immersed in the oil which is controlled by dimmer stat. To measure the rate of heat transfer, ammeter and voltmeter is used. To measure the temperature at various locations on experimental cylinder, k-type thermocouples connected to temperature indicator is used. To avoid the heat loss, wooden cap is placed on the top of the cylinder. Hence from the above experimental setup, the rate of Heat transfer and Temperature distribution is measured and evaluated.

IV. FINITE ELEMENT MODELING AND ANALYSIS

In the present work solid model of engine cylinder with different circumferential fin profiles like rectangular, and triangular are prepared by using SOLIDWORKS. After modeling it has been imported in Ansys Work Bench with suitable extension for assigning boundary conditions. The below figure shows the geometry model of engine cylinder. Thickness of the fin in rectangular profile is 3mm and length of the fin is 35mm, where as for triangular fin the thickness at the base of the cylinder is 3mm and total length of the fin is 35mm.

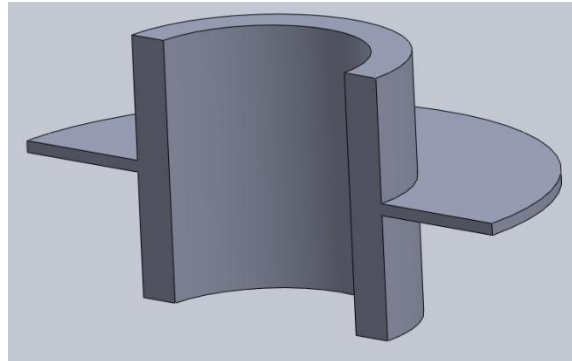

Figure 3: solid works model of circumferential fin of rectangular geometry

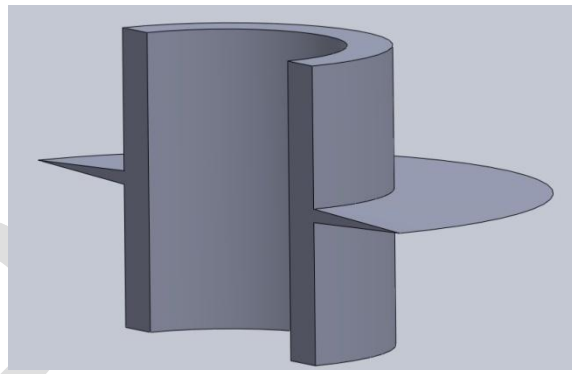

Figure 4: solid works model of circumferential fin of triangular geometry

A. Boundary Conditions

Steady state thermal Analysis Boundary conditions:

1. Inside wall temperature-160^{0}C
2. Thermal conductivity K-173 w/mk
3. convective heat transfer coefficient h-10w/m^{2}k
4. Ambient temperature-34^{0}C

V. RESULTS AND DISCUSSIONS

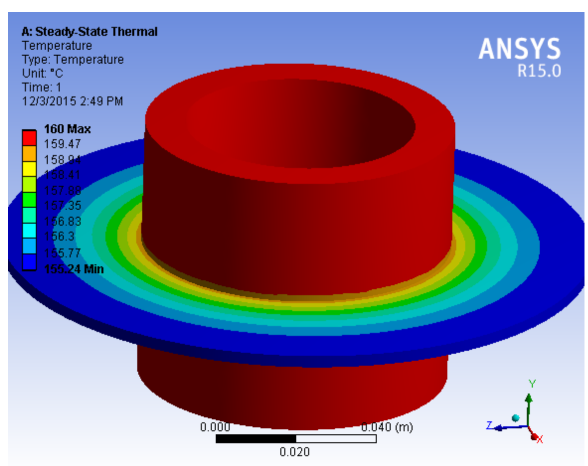

Figure 5: Temperature distribution - circumferential fin of rectangular profile

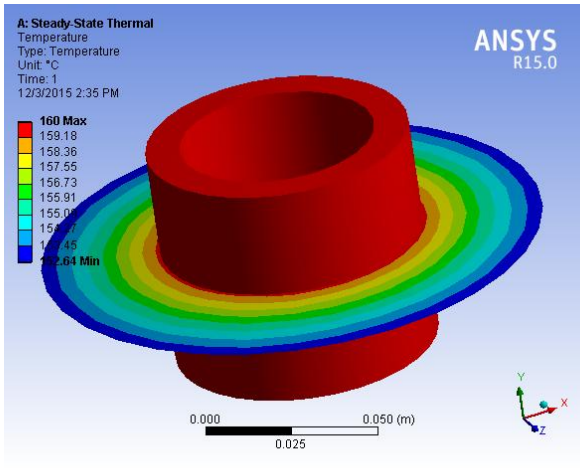

Figure 6: Temperature distribution - Circumferential fin of triangular profile

Circumferential fin	Experimental Results		
	Temperature at the fin base (°C)	Temperature at the fin tip (°C)	Temperature Difference (°C)
Rectangular profile	159	153	6
Triangular profile	159	150	9

Circumferential fin	Ansys Results		
	Temperature at the fin base (°C)	Temperature at the fin tip (°C)	Temperature Difference (°C)
Rectangular profile	159.47	155.2	4.27
Triangular profile	159.18	152.64	6.54

Due to increased rate of heat dissipation, the temperature difference at the root and tip of the triangular profile fin is increased by 50%

VI. CONCLUSIONS

The following conclusions are made after comparisons

1. Temperature at the tip of the circumferential fin with triangular profile is lower than rectangular profile for the given same boundary conditions, hence triangular profile fins are preferred than rectangular profile fins
2. By using triangular profile fins, the weight of the fin body reduces.
3. Hence for cooling cylinder block of I.C. Engine, circumferential fins of triangular profile with material aluminum alloy 6061 is preferred and recommended based on this research work.

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