

Thermal Analysis of Engine Fins with Different Geometries

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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. We know that, 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 the present paper is to analyze the thermal properties by varying geometry of cylinder fins using Ansys work bench. The 3D model of the geometries are created using SOLIDWORKS 2016 and its thermal properties are analyzed using Ansys workbench R 2016. The variation of temperature distribution over time is of interest in many applications such as in cooling. The accurate thermal simulation could permit critical design parameters to be identified for improved life. Presently Material used for manufacturing cylinder fin body is Aluminium Alloy AA 6061 which has thermal conductivity of 160 – 170 W/mk. presently analysis is carried out for cylinder fins using this material.

KEYWORDS: Dissipation, Thermal conductivity, cylinder, fins, Solid works 2016, Aluminium Alloy 6061

I. INTRODUCTION

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 it seizing or welding of 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 efficient 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. To avoid overheating, and the consequent ill effects, the heat transferred to an engine component (after a certain level) must be removed as quickly as possible and be conveyed to the atmosphere. It will be proper to say the cooling system as a temperature regulation system. It should be remembered that abstraction of heat from the working medium by way of cooling the engine components is a direct thermodynamic loss.

1.1 Natural cooling

It is a building design approach that focuses on heat gain control and heat dissipation in a building in order to improve the indoor thermal comfort with low or nil energy consumption. This approach works either by preventing heat from entering the interior (heat gain prevention) or by removing heat from the building (natural cooling). Natural cooling utilizes on-site energy, available from the natural environment, combined with the architectural design of building components (e.g. building envelope), rather than mechanical systems to dissipate heat. Therefore, natural cooling depends not only on the architectural design of the building but how it uses the local site natural resources as

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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heat sinks (i.e. everything that absorbs or dissipates heat). Examples of on-site heat sinks are the upper atmosphere (night sky), the outdoor air (wind), and the earth/soil.

1.2 ENGINE FINS

Most modern internal combustion engines are cooled by a closed circuit carrying liquid coolant through channels in the engine block and cylinder head, where the coolant absorbs heat, to a heat exchanger or radiator where the coolant releases heat into the air (or raw water, in the case of marine engines). Thus, while they are not ultimately cooled by the liquid, because of the liquid-coolant circuit they are known as water-cooled. In contrast, heat generated by an air-cooled engine is released directly into the air. (Direct Cooled Engine) Typically this is facilitated with metal fins covering the outside of the Cylinder Head and cylinders which increase the surface area that air can act on. Air may be force fed with the use of a fan and shroud to achieve efficient cooling with high volumes of air or simply by natural air flow with well-designed and angled fins. In all combustion engines, a great percentage of the heat generated (around 44%) escapes through the exhaust, not through either a liquid cooling system or through the metal fins of an air-cooled engine (12%). About 8% of the heat energy finds its way into the oil, which although primarily meant for lubrication, also plays a role in heat dissipation via cooler.

II. PROBLEM DEFINITION

In the present paper investigation on thermal issues on automobile fins were carried out. Investigation yields the temperature behavior and heat flux of the fins due to high temperature in the combustion chamber. Ansys work bench is utilized for analysis. The analysis is done for different models of fins that are commercially available now a days and a comparison is thus established between them. Also the material is changed so that better heat transfer rate can be obtained.

2D Layout of Cylinder Fins:

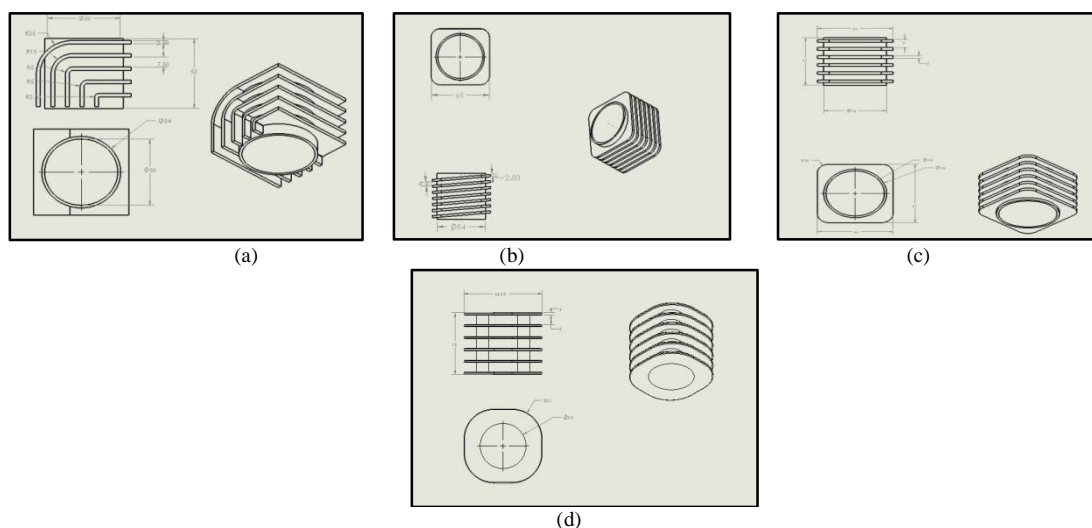


Fig. 1. 2D Layout of Cylinder Fins, (a) Engine Cylinder with Angular Fins (b) Engine Cylinder with Curved Fins (c) Engine Cylinder with Rectangular Fins (d) Engine Cylinder with Cylindrical Fins

III. MODELLING AND ANALYSIS OF CYLINDER FIN

Cylinder along with fin was modelled in Solid works. The dimensions of the cylinder along with fin were taken from commercially available bike data sheet. Fins with different geometries (circular, Curved, Angular and rectangular) were modelling using Solid works Software

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 5, May 2016

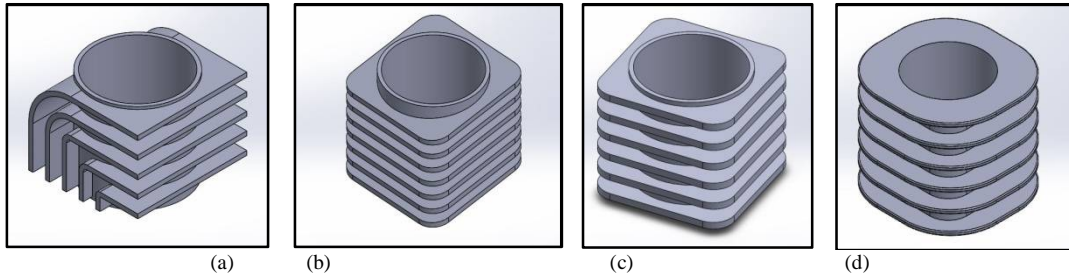


Fig. 2. 3D Layout of Cylinder Fins, (a) Engine Cylinder 3D model with Angular Fins (b) Engine Cylinder 3D model with Curved Fins (c) Engine Cylinder 3D model with Rectangular Fins (d) Engine Cylinder 3D model with Cylindrical Fins

3.1 Analysis In Ansys Workbench:

Analysis of the cylinder fin for different geometries was carried out in ansys workbench. The basic model was generated using Pro-E and that model is imported to ansys work bench. Meshing is done in Ansys work bench.

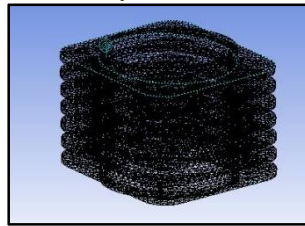


Fig 3. (a) Meshed view of the engine with rectangular fins

Transient thermal analysis was carried out. Transient thermal analyses determine temperatures and other thermal quantities that vary over time. The variation of temperature distribution over time is of interest in many applications such as with cooling of electronic packages or a quenching analysis for heat treatment. Also of interest are the temperature distribution results in thermal stresses that can cause failure. In such cases the temperatures from a transient thermal analysis are used as inputs to a static structural analysis for thermal stress evaluations. In the present study as the fins undergo temperature variation along time so transient thermal analysis was carried out. Boundary conditions were given in terms of temperature as follows,

Maximum temperature = 1500 °C, Minimum temperature = 140° C

Materials that are used for present analysis are aluminium 6061.

Boundary condition	Square Aluminum	Circular Aluminum	Curved Aluminum	Angular Aluminum
Engine temperature (K)	1200	1200	1200	1200
Heat transfer coefficient (W/m ² K)	1000	1500	1700	1500
Ambient temperature (K)	300	300	300	300
Velocity (m/s)	20	20	20	20
Pressure (Atm)	1	1	1	1

Table 1: Preparation for CFD

IV. ANALYZED RESULTS OF VARIOUS STRUCTURES ENGINE FINS

Thus the above mentioned steps are followed for analysing the different structures of designs which is created and its characteristics are differentiated for different model and its results are as follows

4.1 Temperature Flow

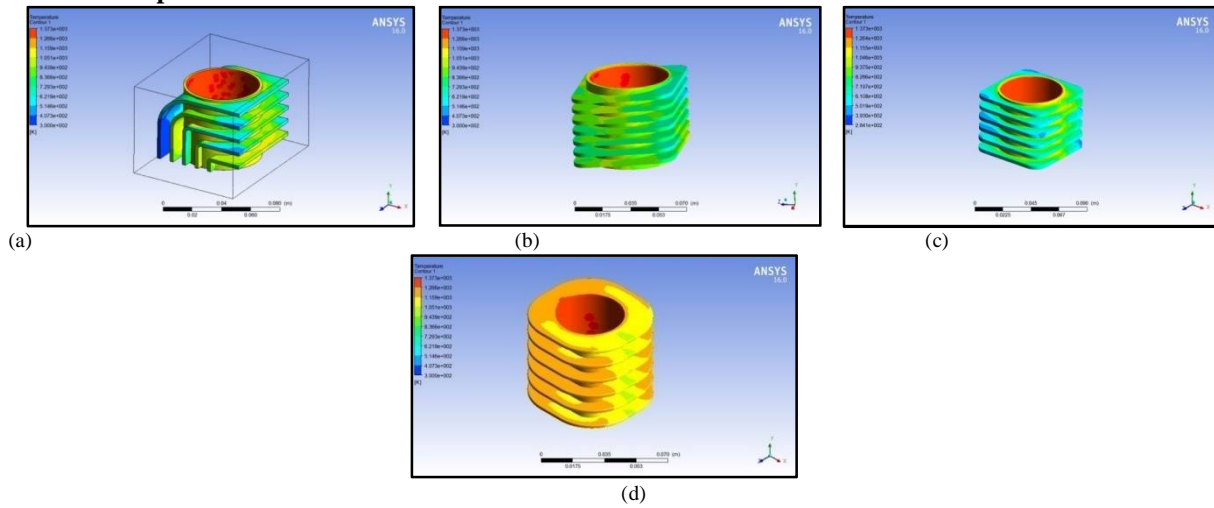


Fig. 4 Temperature Flow: (a) Angular Engine Fins (b) Curved Engine Fins (c) Circular Engine Fins (d) Rectangular Engine Fins

4.2 Stream Line Flow

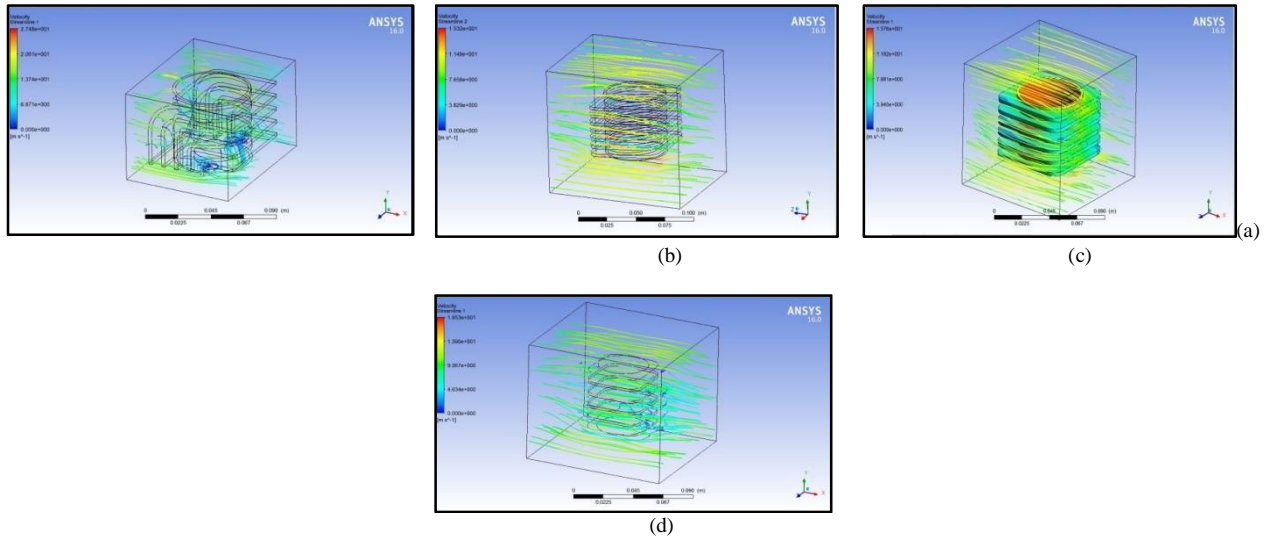
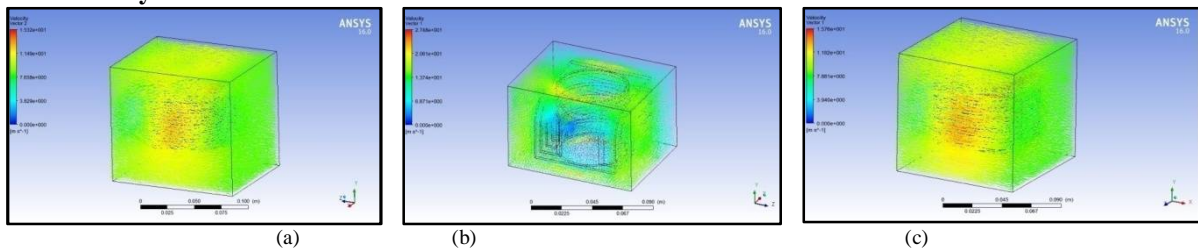
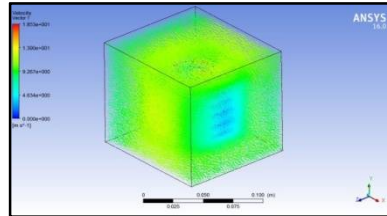


Fig. 5 Stream Line Flow: (a) Angular Engine Fins (b) Curved Engine Fins (c) Circular Engine Fins (d) Rectangular Engine Fins

4.3 Velocity flow

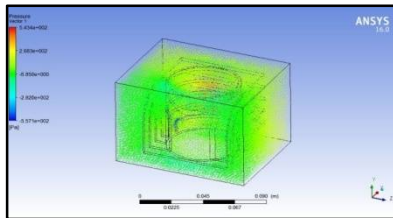




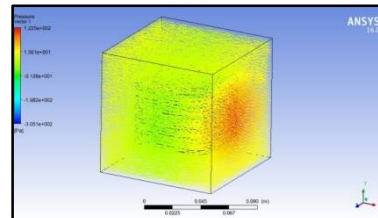
(d)

Fig. 6 Velocity Flow: (a) Angular Engine Fins (b) Curved Engine Fins (c) Circular Engine Fins (d) Rectangular Engine Fins

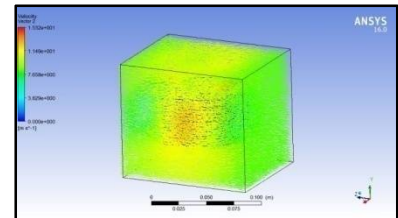
4.4 Pressure Distribution



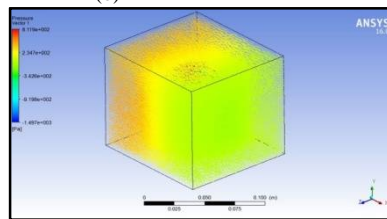
(a)



(b)



(c)



(d)

Fig. 7 Pressure Flow: (a) Angular Engine Fins (b) Curved Engine Fins (c) Circular Engine Fins (d) Rectangular Engine Fins

4.5 Result comparison

Engine Fins	Max / Min	Temperature Flow	Streamline flow	Velocity flow	Pressure Distribution
Angular Fins	Minimum	3.000e ⁺⁰⁰²	0	0	1.353e ⁺⁰⁰²
	Maximum	1.373e ⁺⁰⁰³	1.532e ⁺⁰⁰¹	1.532e ⁺⁰⁰¹	1.064e ⁺⁰⁰²
Curved Fins	Minimum	3.000e ⁺⁰⁰²	0	0	5.571e ⁺⁰⁰²
	Maximum	1.373e ⁺⁰⁰³	2.748e ⁺⁰⁰¹	2.748e ⁺⁰⁰¹	5.434e ⁺⁰⁰²
Circular Fins	Minimum	3.000e ⁺⁰⁰²	0	0	1.497e ⁺⁰⁰³
	Maximum	1.373e ⁺⁰⁰³	1.853e ⁺⁰⁰¹	1.853e ⁺⁰⁰¹	8.119e ⁺⁰⁰²
Rectangular Fins	Minimum	2.841e ⁺⁰⁰²	0	0	3.051e ⁺⁰⁰²
	Maximum	1.373e ⁺⁰⁰³	1.576e ⁺⁰⁰¹	1.576e ⁺⁰⁰¹	1.225e ⁺⁰⁰²

Table 2 Comparison of various dimensions fins

V. CONCLUSION

Design of fin plays an important role in heat transfer. There is a scope of improvement in heat transfer of air cooled engine cylinder fin if mounted fin's shape varied from conventional one. Contact time between air flow and fin (time between air inlet and outlet flow through fin) is also important factor in such heat transfer. Wavy fin shaped cylinder block can be used for increasing the heat transfer from the fins by creating turbulence for upcoming air. Improvements in heat transfer can be compare with all the four model of the engine fins geometry by CFD Analysis and its flow

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

characteristics are studied for all the geometries it is found that the curved fins provide better result when compared with all the other geometries.

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International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016



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