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Thermal Analysis of Engine Cylinder Fins by Varying Its Geometry Shape and Material

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Abstract:

The fins are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. An engine is subjected to high temperatures and to reduce it, fins are provided. In this work, the design of engine cylinder fins is carried out by using SOLIDWORKS designing software and thermal analysis of the designed engine fins with the ANSYS. By doing thermal analysis on engine cylinder fins, it shows the heat dissipation rate from the cylinder. In this project, the cylinder fins were designed by changing the geometry shape of fins for four materials, Al 7075 alloy, AL 6082 alloy, Al 2014,cast iron and thermal analysis were done to investigate the heat dissipation rate. Mostly the heat transfer rate depends on thermal conductivity. Hence in this paper an attempt has been made to find out the thermal analysis of cylinder block with fins for different material by using ANSYS software.

Keywords — **Engine cylinder fins, Thermal conductivity, Steady state analysis.**

I. INTRODUCTION

Fins are external surface that are used enhance the heat transfer from the engine surface to reduce the metal temperature in IC engine. 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. 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. [1-9]

An engine cooling system is a system integral with the engine. It carries away excess heat from the engine with the help of a flowing fluid. Cooling is needed because high temperatures damage engine materials and lubricants and becomes even more important in hot climates. Internal-combustion engines burn fuel hotter than the melting temperature of engine materials, and hot enough to set fire to lubricants. Engine cooling removes energy fast enough to keep temperatures low so the engine can survive. [10-16]

Fins are extensions on exterior surfaces of objects that increase the rate of heat transfer from the object by increasing convection. This is achieved by increasing the surface area of the body, which in turn increases the heat transfer rate. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. 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. The cylinder is facilitated with metal fins covering the outside of the Cylinder Head and cylinders which increase the surface area that air can act on the fins. The heat generated by an air-cooled engine is released directly into the air. Fins are most commonly used in heat exchanging devices such as radiators for in cars, heat exchangers in power plants etc., In IC engine the power generation of high ranged temperatures which cause heat up and over-heating problem effect the engine to cease and some. Improper conditions of disaster may occur to the engine. To prevent over-heating and heat up problem fins are provided. Fins basically increase the rate of

heat transfer by increasing the area where cooler air can pass. As the air passed over and through the fins, the engine heat dissipated into air. Fins of IC engines must have optimistic behavior regarding to the design and manufacturing of an engine. Hence there will be many barriers available for convection. An air-cooled engine has the fins which gives greater surface in selecting the correct fins for the correct component.[17-22]

II. MATERIALS AND METHODS

The analyzation of the project is done by varying the materials of fins. Present used material for cylinder fin body is Cast iron which has less thermal conductivity. Our aim is to change the material for fin body by analyzing the fin body with other materials and compare its results. The geometry details of the cylinder fins gathered from comparing three different types of 100cc bikes. We are replacing the cast iron with Aluminum alloy 7075, Aluminum alloy 6082 and Aluminum alloy 2014. Aluminum alloys is a predominant metal in aluminum. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminum is used for wrought products, for example rolled plate, foils and extrusions. aluminum alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. Aluminum alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

III. DESIGN AND MODELLING

SOLIDWORKS uses a 3D design approach. As you design a part, from the initial sketch to the final result, you create a 3D model. From this model, you can create 2D drawings or mate components consisting of parts or subassemblies to create 3D assemblies. You can also create 2D drawings of 3D assemblies. When designing a model using SOLIDWORKS, you can visualize it in three dimensions, the way the model exists once it is manufactured.

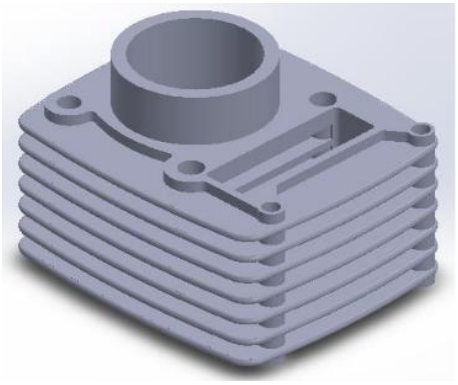

Fig. 1. Cylinder fin without slot

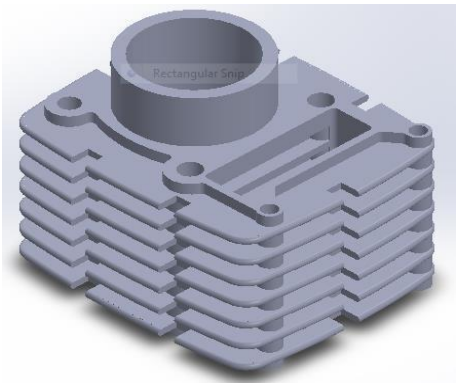

Fig. 2. Cylinder fin with slot

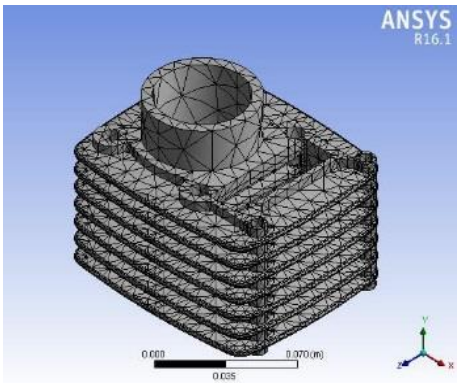

Fig. 3. Cylinder fin without slot meshing

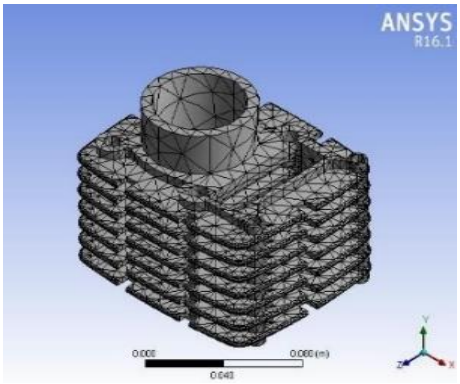

Fig. 4. Cylinder fin with slot meshing

TABLE I
DIFFERENT PROPERTIES OF VARIOUS MATERIALS

Materials	Density g/cm3	Thermal conductivity w/m-k	Specific heat capacity j/kg-k
Aluminum alloy 7075	2.8	130	870
Aluminum alloy 6082	2.71	160	900
Aluminum alloy2014	2.80	150	870
Cast iron	6.85	52	460

IV. ANALYSIS

ANSYS Mechanical and ANSYS Multi physics software are non-exportable analysis tools incorporating pre-processing (geometry creation, meshing) solver and post-processing modules in a graphical user interface. These are general purpose finite element modelling packages for numerically solving mechanical problems, including static/dynamic structural analysis (both linear and non-linear) heat transfer and fluid problems, as well as acoustic and electric magnetic problems.

Inner side temperature = 1500 ^{0}C

Ambient temperature = 22 ^{0}C

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

V. RESULTS AND DISCUSSION

The fin materials are analyzed by using ansys in following figure 5 and 6.

Aluminum Alloy 2014: Aluminum alloy 2014 is often used in the aerospace industry. It is easily machined in certain tempers, and among the strongest available aluminum alloys, as well as having high hardness. However, it is difficult to weld, as it is subject to cracking 2014 is the second most popular of the 2000-series aluminum alloys, after aluminum alloy.

Aluminum Alloy 6082: Aluminum alloy 6082 is the wrought aluminum-magnesium-silicon family (6000 or 6xxx series). It is one of the more popular alloys in its series (alongside alloys 6005, 6061, and 6063), although it is not strongly featured in ASTM (North American) standards. It is typically formed by extrusion and rolling, but as a wrought alloy it is not used in casting. It can also be forged and clad, but that is not common practice with this alloy. It cannot be work hardened, but is commonly heat treated to produce tempers with a higher strength but lower ductility.

Aluminum Alloy 7075: An aluminum alloy with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other aluminum alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use. Its ability to be highly polished, 7075 is widely used in mould tool manufacturing. This alloy has been further refined into other 7000 series alloys for this application, namely 7050 and 7020.

Cast Iron: Cast iron tends to be brittle, except for malleable cast irons. With its relatively low melting point, good fluidity, castability, excellent machinability, resistance to deformation and wear resistance, cast irons have become an engineering material with a wide range of applications and are used in pipes, machines and automotive industry parts, such as cylinder heads, cylinder blocks and gearbox cases. It is resistant to damage by oxidation.

VI. COMPARISON OF RESULTS

The output values of fins with different materials are analyzed using Ansys software. The output values of those models are compared in following table II and III.

TABLE III
COMPARISON OF CYLINDER FIN WITHOUT SLOT

Material		Temperature °c	Total heat flux W/m^2	Directional heat flux W/m^2
Aluminium alloy 7075	Min	1374.6	855.33	-1.28e+05
	Max	1500	8.12e+05	5.30e+05
Aluminium alloy 6082	Min	1396.7	887.29	-1.28e+05
	Max	1500	8.22e+05	5.37e+05
Aluminium alloy 2014	Min	1390.3	877.76	-1.28e+05
	Max	1500	8.19e+05	5.35e+05
Cast iron	Min	1216.7	701.28	-1.28e+05
	Max	1500	7.39e+05	4.82e+05

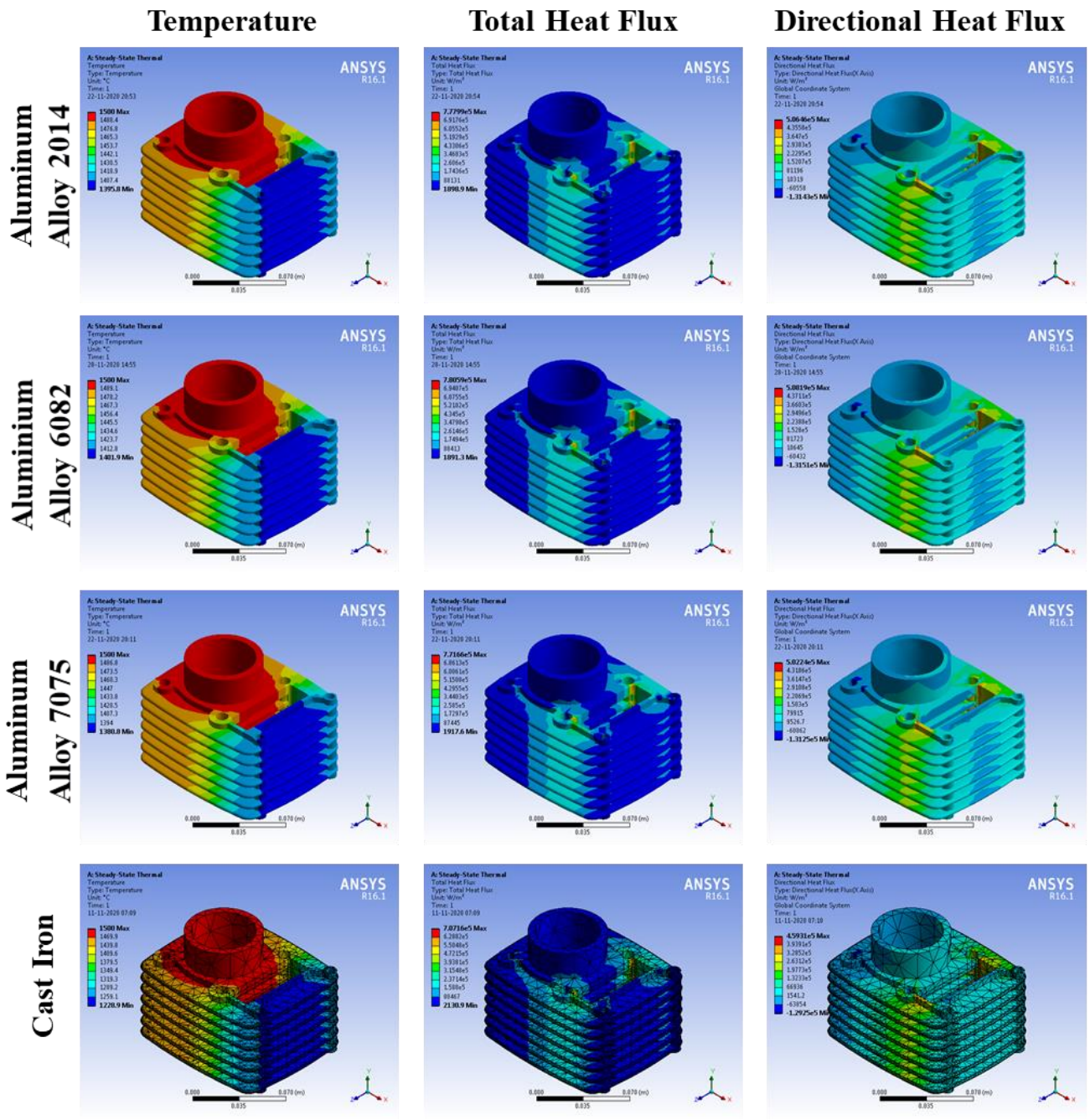

Fig. 5. Analysis results of cylinder fin without slots

TABLE IIIII
CYLINDER FIN WITH SLOT RESULTS

Material		Temperature °c	Total heat flux W/m^2	Directional heat flux W/m^2
Aluminium alloy 7075	Min	1380.8	1917.6	-1.31e+05
	Max	1500	7.72e+05	5.02e+05
Aluminium alloy 6082	Min	1401.9	1891.3	-1.32e+05
	Max	1500	7.81e+05	5.08e+05
Aluminium alloy 2014	Min	1395.8	1898.9	-1.31e+05
	Max	1500	7.78e+05	5.06e+05
Cast iron	Min	1228.9	2130.9	-1.29e+05
	Max	1500	7.07e+05	4.59e+05

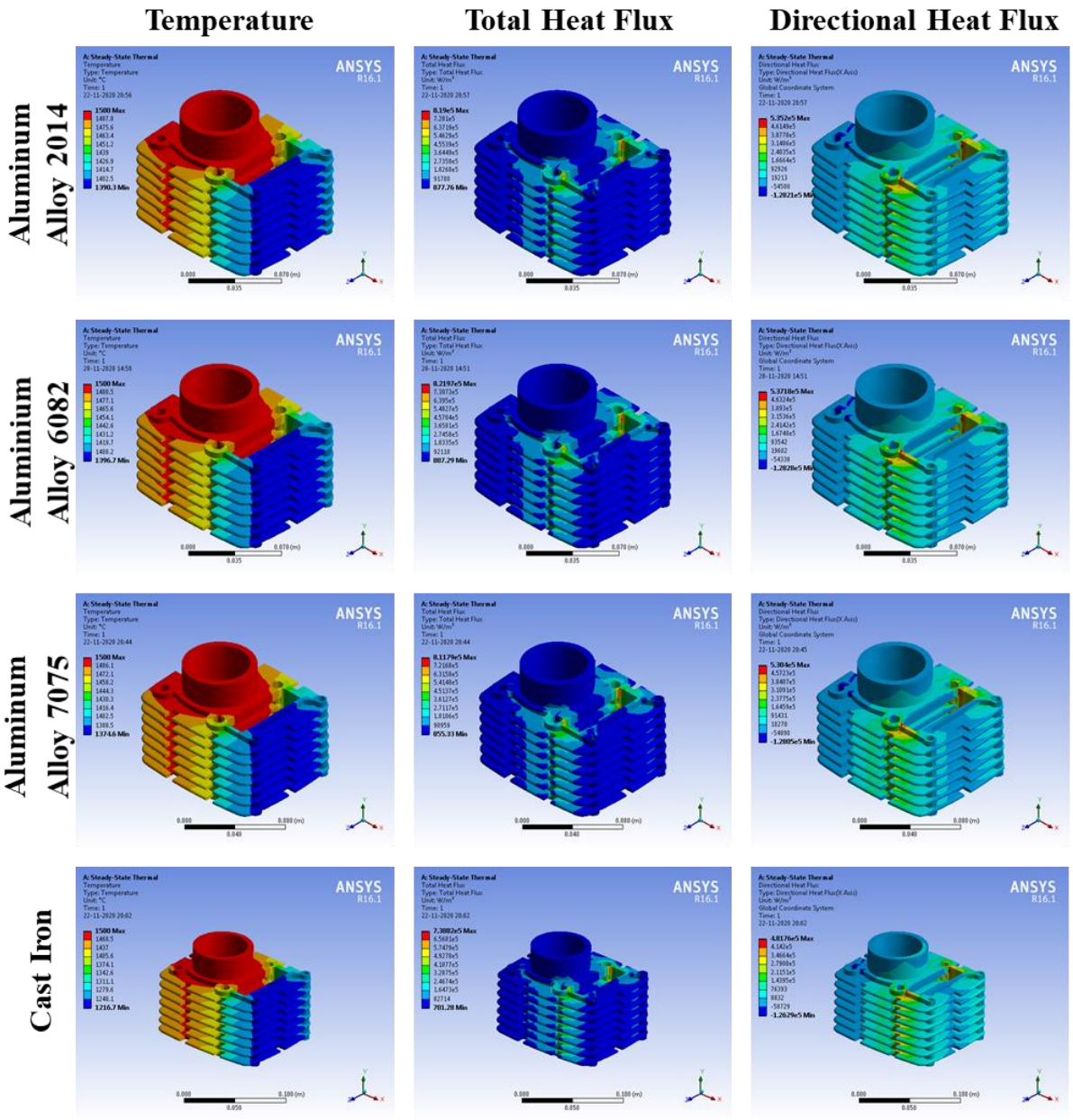

Fig. 6. Analysis results of cylinder fin with slots

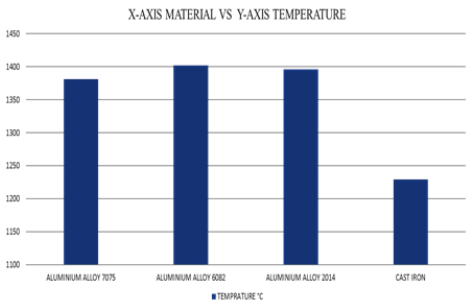

Fig. 7. Temperature of engine cylinder without slot

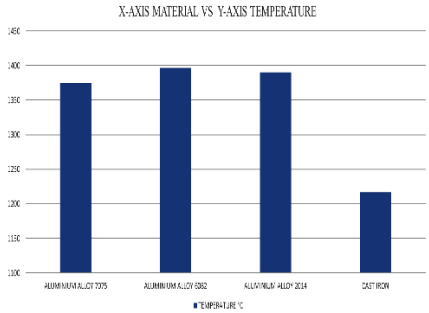

Fig. 8. Temperature of engine cylinder with slot

VII. CONCLUSION

Presently used material of Aluminum alloy in cylinder fin analyzed with different grade of alloy like Aluminum alloy 7075, Aluminum alloy 6082, and Aluminum alloy 2014 and also cast iron. A slot size of 7.5mm provided in the fin to increase the heat transfer rate in cylinder which also compares with normal cylinder fin and also the thickness 3mm. By reducing the thickness and shape of the fin reduces the weight thereby increase the efficiency.

In this project thermal analysis of engine cylinder fin has been undergone to improve the heat transfer rate. The design of cylinder fin is undergone by SolidWorks 14.0 and the analysis of cylinder fin performed by ANSYS 16.1.

By comparing the results of cylinder fin with various material conclude the Aluminum alloy 6082 conduct more heat with efficient than the aluminum alloy 7075, Aluminum alloy 2014 and cast iron and also the cylinder fin with slot increase more heat transfer than the normal cylinder fin.

VIII. FUTURE SCOPE

Aluminum alloy material has high strength, good conductivity and low density properties hence several research has been taken to improve conductivity and strength with weight ratio. The above project can be widely used where heat transfer is require and have space constrain. It can used in air cooled engine and other engine used in different industries, machine etc. where space is not constrain and there is requirement of high heat transfer rate. Therefore, this project may also be applied for heat exchanger used power plants, radiators and automobile etc.

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