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Analyzing Thermal Properties of Engine Cylinder Fins by Varying Slot Size and Material

Sachin Kumar Gupta[1], Harishchandra Thakur[2], Divyank Dubey[3]

sachin93gupta@gmail.com, harish@gbu.ac.in, divyank98@gmail.com

Abstract

Engine performance depends on various parameters such as types of material use for making engine, numbers of fins used, thickness of fins, and fins Shape which escort thermal effect on it. In this project our main aim is to analyses the thermal properties by using different types of materials for the fins with variable sizes slots to improve its performance and reduce its cost. The 3D modeling of engine with different slot sizes keeping fin size and number of fin same designed on Solidworks and the analysis on the ANSYS steady state. Presently Material used for manufacturing cylinder fin body is Aluminium Alloy A204 and we are comparing its performance using different material such as Aluminium alloy 6061, Aluminium alloy C443 and Aluminium alloy 2014 which having higher thermal conductivities. The result shows that 75mm slotted fins of Aluminium alloy 2014 having maximum heat transfer rate and also observed that as the slots size increase above 75mm there will decrease in heat transfer rate.

Keywords

Fin, Slots, Thermal analysis, Heat transfer

Introduction

In an IC engine during the fuel combustion only about 25 to 35 percent of chemical energy is converted into mechanical energy. 35 percent of the fuel energy lost in the environment and the remaining energy is removed through exhaustion' and radiation from the engine. Inside the IC Engine cylinder gases are burned at a temperature of about 2000^{o}C-2500^{o}C. In IC engine, during the combustion gases are produce at high temperature and pressure which exert direct forces to some parts of the engine, such as pistons, turbine blades, or a nozzle. Hot gases heat is absorb by the various parts of an engine like valve, cylinder head, and the cylinder wall piston.

Required of Cooling System in IC Engines:

A small amount of heat is converted into the mechanical power by an IC engine at the crankshaft. Thermal stresses leads to various loses due to the set up in the engine parts, engine valves twist because of overheating and reduces the strength of the materials used for piston and piston rings.

A fuel energy distribution of engine is given below:

- crank shaft useful work = 25 per cent
- cylinders walls loses = 30 per cent
- exhaust gases loses = 35 per cent
- friction Loss = 10 per cent

We can provide efficient cooling to improve the volumetric efficiency of an IC engine, but over cooling result decrease in overall efficiency.

Literature Review

Various IC Engines Cooling Method:

As the mechanical energy coming out from an engine is less than the heat energy generated due to combustion of fuel in the engine because of its inefficiency, this difference is removed through cooling process by intake air and exhaust hot gases to explicit engine cooling. For cooling process we can also use air or a liquid to remove the waste heat from an IC engine. For small or special purpose engines, air cooling makes for a lightweight and relatively simple system. The more complex circulating liquid-cooled engines also ultimately reject waste heat to the air, but circulating liquid improves heat transfer from internal parts of the engine.

Basic Principles:

Various methods are used to cool Engine either by using gaseous fluid flow (air) or by a liquid coolant run through a heat exchanger (radiator) to cool the heat engine. We cannot use water as a coolant due to the present of sedimentation in water which result the clogging of coolant passage and chemicals, such as salt, that chemically damage the engine. Thus, engine coolant flowed through heat exchanger i.e. radiator in vehicle that is cooled by the body of water.

Thermal Analysis:

Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. Several methods are commonly used – these are distinguished from one another by the property which is measured. Thermal Analysis is also often used as a term for the study of Heat transfer through structures and the analysis of heat transfer is done on ANSYS.

Aim of the Project

The main Aim of this project is to design and analyze cylinder head, providing with different rectangular slot by using different material like Aluminium alloy 204, aluminium Alloy 2014, Aluminium Alloy 6061 and Aluminium alloy C443 keeping the fin shape and thickness same as original fin.
Geometry of fins – rectangular having slots of 50mm, 75mm, 100mm
Thickness of fins – 2.35 mm

Materials- Aluminium alloy 204, Aluminium Alloy 2014, Aluminium Alloy 6061 and Aluminium alloy C443.

CFD Modeling and Simulation

Design of a model is making on Solidworks and its stimulation performed on ANSYS 14.5. ANSYS system of steady state Thermal analysis provides a convective transport of energy and the conductivity in solids. Some steps performing in CFD simulation of thermal analysis are:

- Modeling in Solidworks
- Import the geometry in ANSYS steady state thermal
- Generating mesh
- Set up the analysis by providing boundary conditions
- Control and monitor the solver to achieve a solution
- Visualize the results and create a report.

Create Geometry

In this project we have designed a cylinder fin body used in 115cc Bajaj Caliber Motorcycle modeled in 3D modeling software Solidworks. Present used material for fin body is Aluminium alloy 204 and we are replacing it with Aluminium alloy 2014 and Aluminium alloy C443. The shape of the fin is rectangular having different slot of 50mm, 75mm, 100mm size and thickness of 2.35mm. In this we design a cylinder having different slotted sizes keeping the fin thickness same as the original cylinder fin as shown in fig 1.

Material Used	Thermal Conductivity(W/mK)	Specific Heat (J/g ºC)	Density (g/cc)
Aluminium 2014	192	0.88	2.8
Aluminium 6061	180	0.896	2.7
Aluminium Alloy A204	120	0.963	2.8
Aluminium Alloy C443	142	0.936	2.69

Table 1: different properties of various materials

Create Mesh for the Geometry

Our next step is to generating mesh in steady state thermal analysis. The design using efficient mesh generation techniques, meshes were created with high contact sizing relevance. The total number of elements and nodes are 17167 and 32125 respectively.

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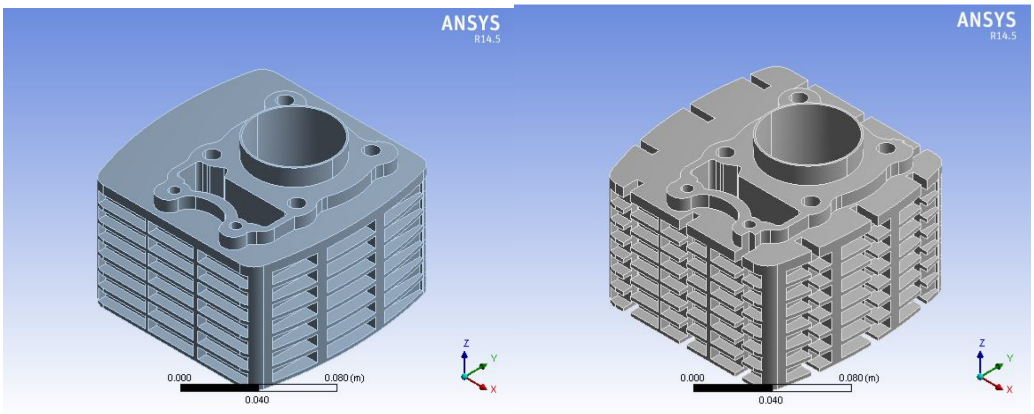
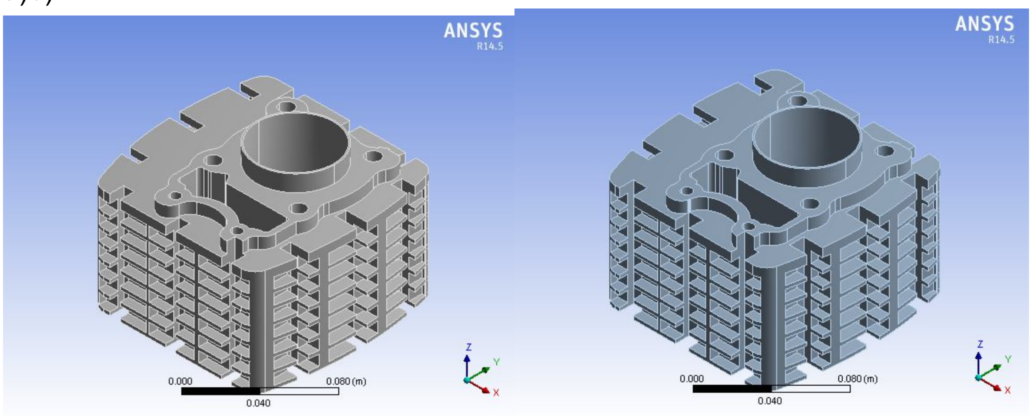
Analysis Setup

After meshing of geometry and boundary condition has been applied. Analysis performed in ANSYS steady state thermal. We provided temperature of 558K to the inner side of the cylinder of the engine.
Film Coefficient – 25 W/m^2 K and
Bulk Temperature – 313K.



a)b)

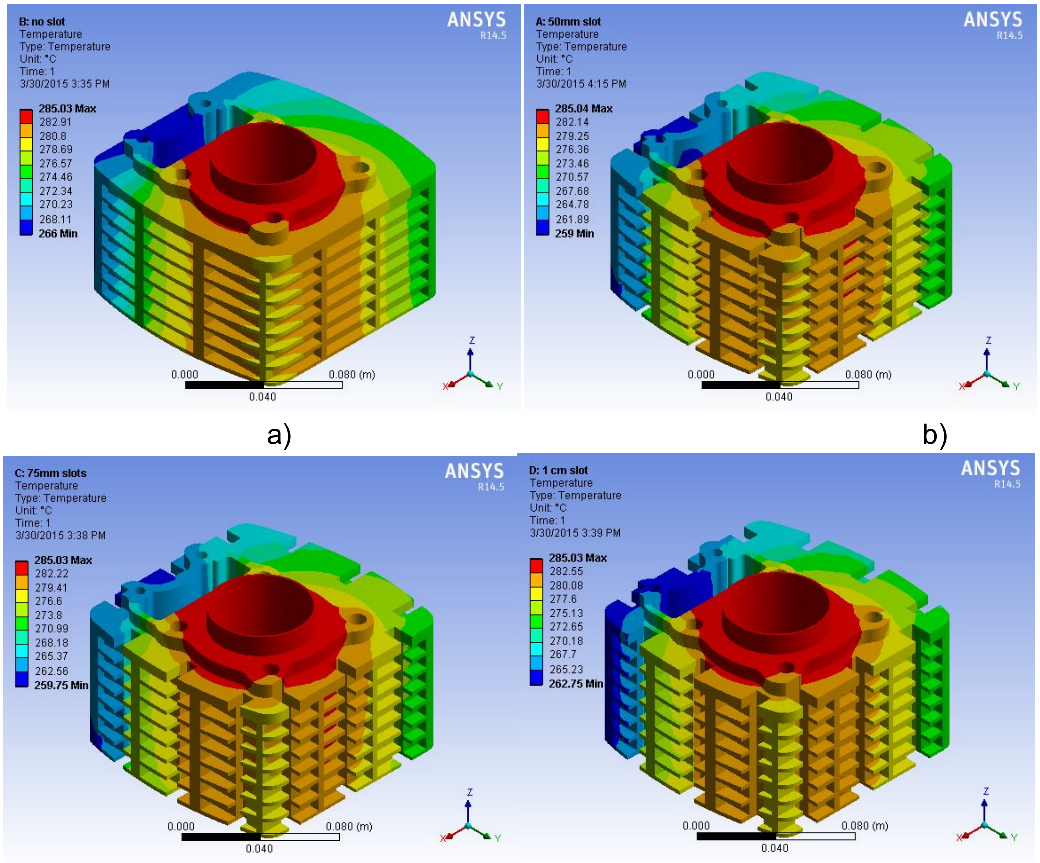


c) d)

Figure 1: Design of a) Bajaj Caliber Engine b) 50mm slot fin c) 75mm slot fin d) 100mm slot fin.

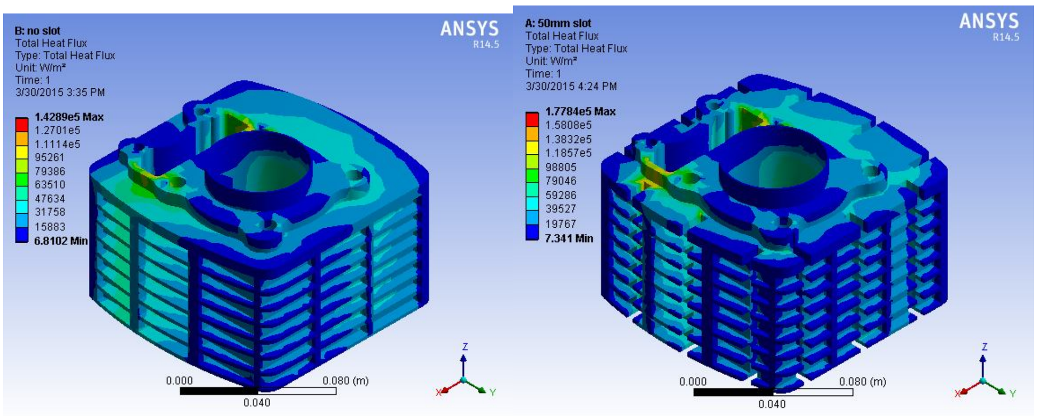
Visualizing the Results

The results were examined, when the solver terminated. Temperature contour and heat flux contour of various fin surfaces of engine cylinder as well as parameters and changes in other parameters can also be predicted by computational analysis. Fig.2 shows the temperature distribution over the convective surface area of the engine fin having different rectangular slot size. It can be seen that the larger perforated fin are pumping out the more heat from the base. The top ends of the fins are cooled faster.



a) b) c) d)

Figure 2: Temperature contour a) Bajaj Caliber plane fin b) 50mm slot fin c) 75mm slot fin d) 100mm slot fin Engine having Aluminium alloy 2014 material



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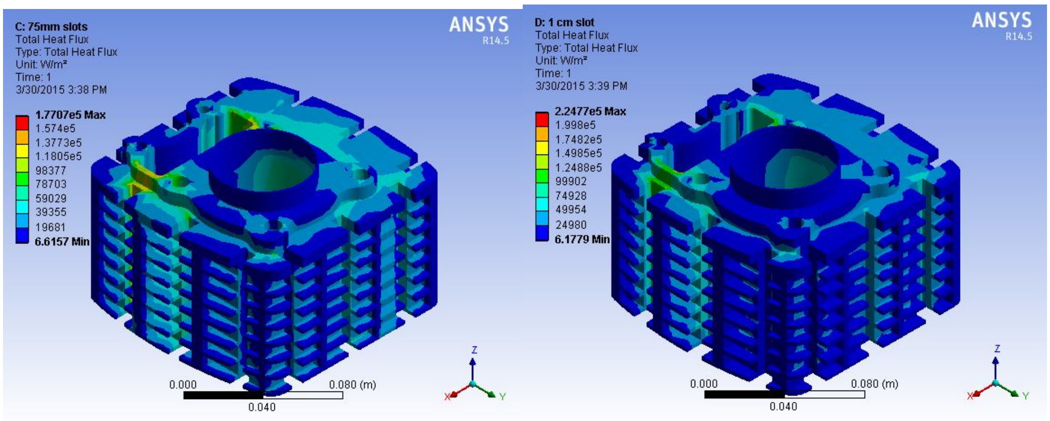


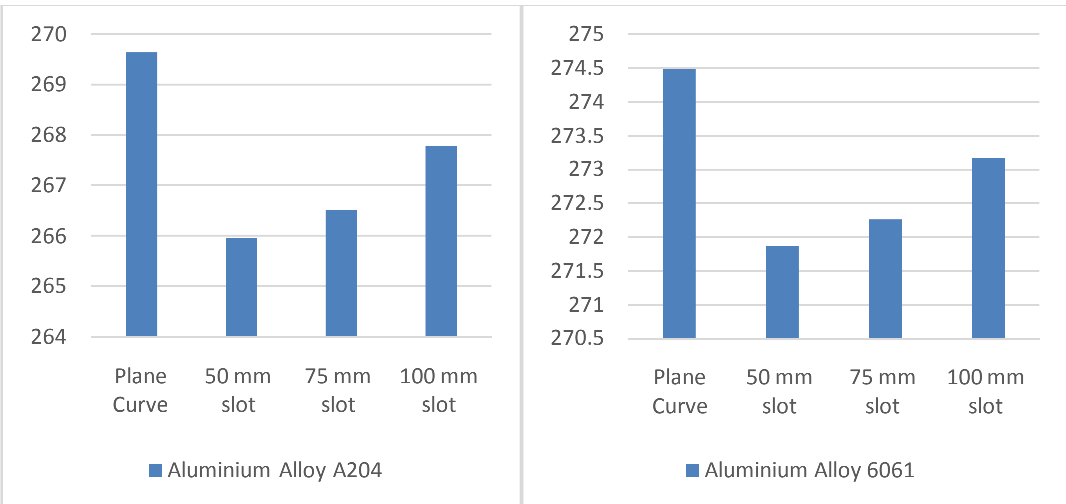
c) d)

Figure 3: Heat flux a) Bajaj Caliber plane fin b) 50mm slot fin c) 75mm slot fin e) 100mm slot fin Engine having Aluminium alloy 2014 material

Results and Discussion

We have done thermal analysis on the fin body by varying materials, geometry and slot sizes. Now a day's material used for fin body of IC engine is Aluminium alloy A204. We are replacing older material with Aluminium alloy 6061, Aluminium Alloy C443 and Aluminium Alloy 2014. The shape of the fin remains the same with variable slots sizes.

The default thickness of fin is 2.35mm. By slotting the weight of the fin body reduces thereby increasing the heat transfer rate but excess increase in slot sizes leads to decrease in heat transfer. By observing the analysis results we have compared fin surface temperature of various sized slotted fins for different materials as shown in fig 4. Heat flux through the engine is compared for different fins and materials as shown in fig 5.



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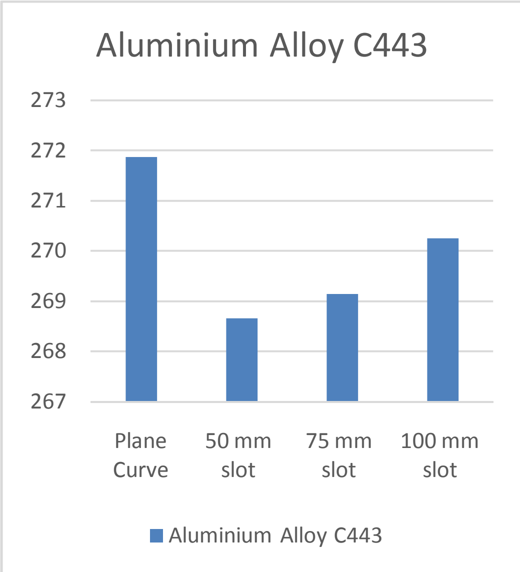
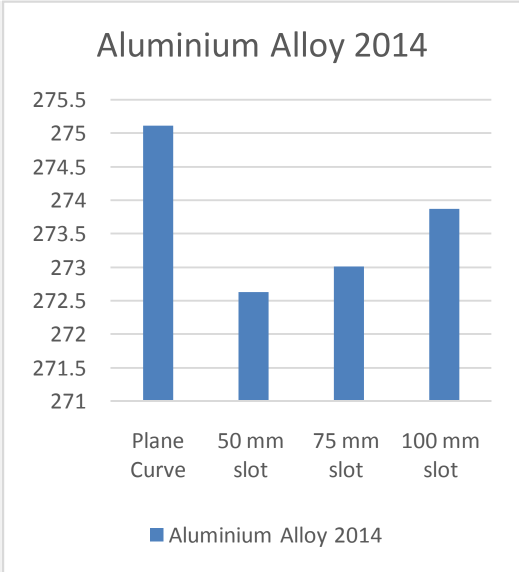


c)



d)

Figure 1: Average temperature of various fin surfaces having different material

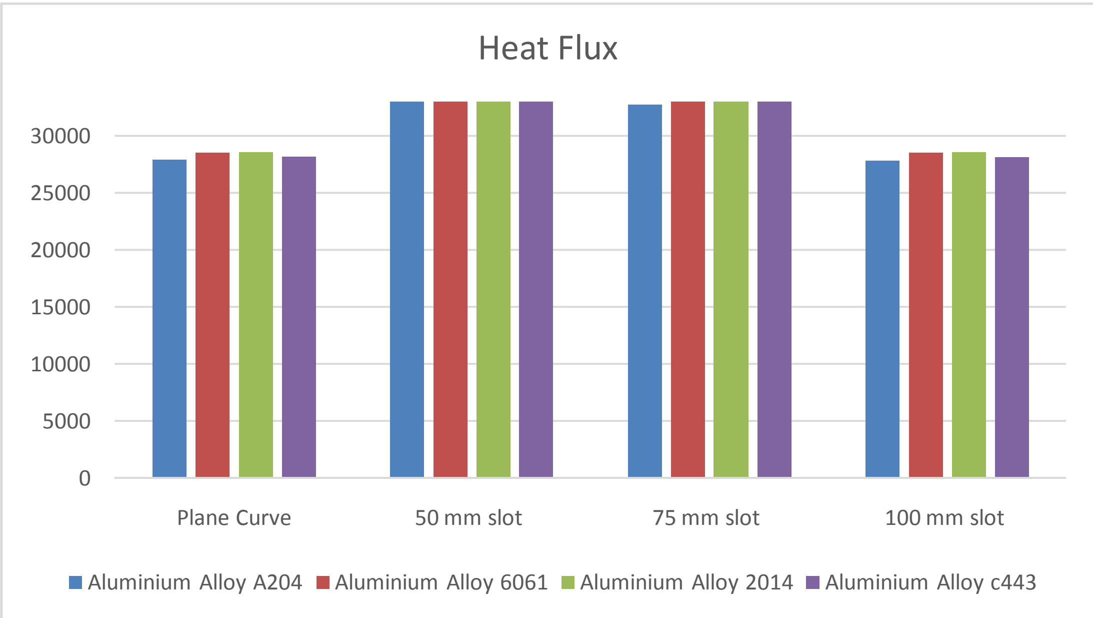


Figure 2: Comparison of Heat flux through the engine cylinder for different fins and material

Conclusion

From the investigation the following conclusion has been made:

- The cost of engine decreases due to reduce in the material requirement of cylinder.
- 75mm slotted fins have maximum heat transfer within different material slotted fin.
- The minimum surface provided for 75mm for fin surface temperature.
- 75mm slotted fin engine of Aluminium 2014 material have maximum heat transfer.
- As the slots size increase above 75mm heat transfer decreases.

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