HCTL Open International Journal of Technology Innovations and Research (IJTIR)
http://ijtir.hctl.org
Volume 14, April 2015
e-ISSN: 2321-1814, ISBN (Print): 978-1-62951-946-3

Thermal Analysis of Variable Size of Rectangular Slotted Curve Fins

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 used for making engine, numbers of fins, type of fins, thickness of fins and fins shape which escort thermal effect on it. The 3D Modelling of engine with different shape, number of fin done on Solidworks and the analysis performed on the ANSYS steady state. In this research we want to improve engine performance by changing its fins into interrupted curved fins having rectangular slots with variable slot sizes. Presently material used for manufacturing cylinder fin body is Aluminium Alloy A204 which has thermal conductivity of 150W/mk. In this paper we replace Aluminium Alloy A204 with Aluminium Alloy 2014, Aluminium Alloy 6061 and Aluminium alloy C443. In this study, result shows that 75mm slotted fins made up of Aluminium 2014 material having maximum heat flux and minimum fin surface temperature of IC engine.

Keywords

IC engine, slotted fin, interrupted wavy fins, thermal analysis

Introduction

Combustion of an IC engines can best transform about 25 to 35 percentage of the chemical energy of the fuel into mechanical energy. About 35 percent of the heat generated is lost in to the atmosphere and the remaining heat remove through exhaustion' and radiation from the engine. Inside the IC Engine cylinder the burning temperature of gases is about 2000^{o}C-2500^{o}C. In IC engine, the high-temperature and pressure gases produced by combustion applies direct forces to some parts of the engine, such as pistons, turbine blades, or a nozzle The engine parts like cylinder head, cylinder wall piston and the valve absorb this heat from the hot gases.

Prerequisite of Cooling System in IC Engines:

Only some part of heat produced during the combustion of fuel in the IC engine cylinders is converted into mechanical power at the crankshaft. These loses may occur due to the Thermal stresses set up in the engine parts, Engine valves warp (twist) due to overheating, Reduces the strength of the materials used for piston and piston rings and many more factors which leads heat loses in the IC Engine.

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

For improving the volumetric efficiency of an IC engine we can provide efficient cooling to it, but over cooling resulting in the decrease in overall efficiency.

Literature Review

IC Engines Cooling Method:

Mechanical energy generated by converting heat energy from heat flow, much as a water wheel extracts mechanical power from a flow of mass falling through a distance. Due to the Engine inefficiency more heat energy entered in the engine than coming out as mechanical energy, this difference must be removed. This waste energy is removed through the cooling process by intake air, hot exhaust gases and explicit engine cooling.

Basic Principles:

Engine are cooled by various methods either by using gaseous fluid flow (air) or by a liquid coolant run through a heat exchanger (radiator) to cool the heat engine. We can be use water as a coolant but the drawback is that due to the present of sedimentation in water it clogs the coolant passage, or chemicals, such as salt, that chemically damage the engine. Thus, engine coolant flowed through heat exchanger that is cooled by the body of water.

Thermal Analysis:

Thermal analysis is a field of material 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. Many of the basic engineering data for modelling such systems comes from measurements of heat capacity and thermal conductivity.

Aim of the Project

The main aim of the project is to design and analyse cylinder with fins, keeling the fin curve with same area as the original fin have with different rectangular slot by using the material aluminium alloy 204,aluminium 2014, aluminium 6061 and aluminium alloy c443.

Geometry of fins – Curve having slots of 50mm, 75mm, 100mm
Thickness of fins – 2.35 mm
Materials- Aluminium alloy A204, Aluminium Alloy 2014, Aluminium Alloy 6061 and Aluminium alloy C443.

CFD Modeling and Simulation

The Model is design 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:

1. Modelling in Solidworks
2. Import the geometry in ANSYS steady state thermal
3. Generating mesh
4. Set up the analysis by providing boundary conditions
5. Control and monitor the solver to achieve a solution
6. 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 and its modification of fin shapes engines are modelled in 3D modelling software Solidworks. Present used material for fin body is Aluminium alloy A204 and we are replacing it with Aluminium alloy 2014 and Aluminium alloy C443. The shape of the fin is rectangular we have changed it into curve shape having different slot having 50mm, 75mm, 100mm size and thickness of 2.35mm. In this we design a cylinder having curve fins with 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

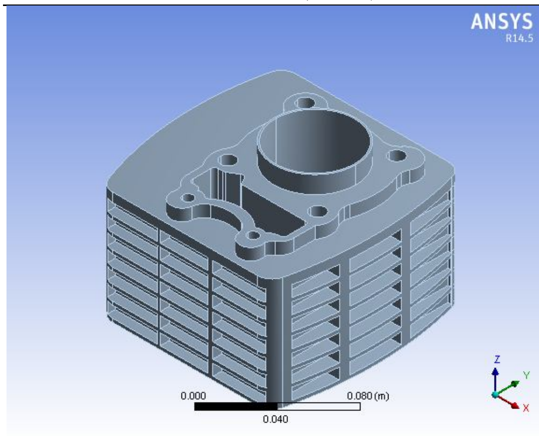
Create Mesh for the Geometry

In steady state thermal analysis our next step is to generate mesh in the design using efficient mesh generation techniques, meshes were created with high contact sizing relevance. The total number of elements and nodes are 6564 and 13678 respectively.

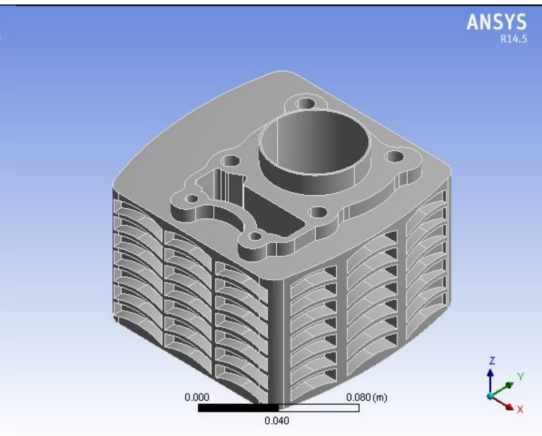
Analysis Setup

After creating mesh in the design we apply boundary condition to analysis the result in ANSYS workbench. 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.

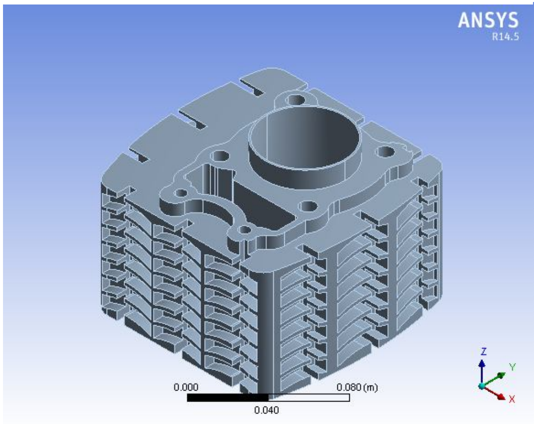
HCTL Open International Journal of Technology Innovations and Research (IJTIR)
http://ijtir.hctl.org
Volume 14, April 2015
e-ISSN: 2321-1814, ISBN (Print): 978-1-62951-946-3



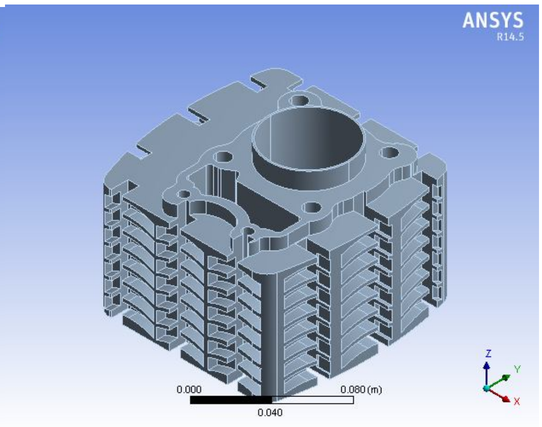
A)



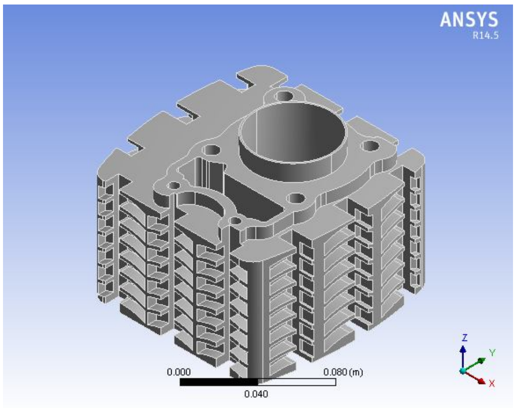
B)



C)



D)



E)

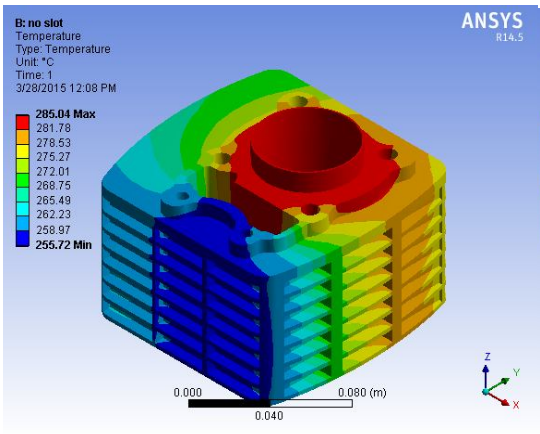
Figure 1: Design of A) Bajaj Caliber Engine B) Solid Curved fin C) 50mm slot fin D) 75mm slot fin E) 100mm slot fin

Visualizing the Results

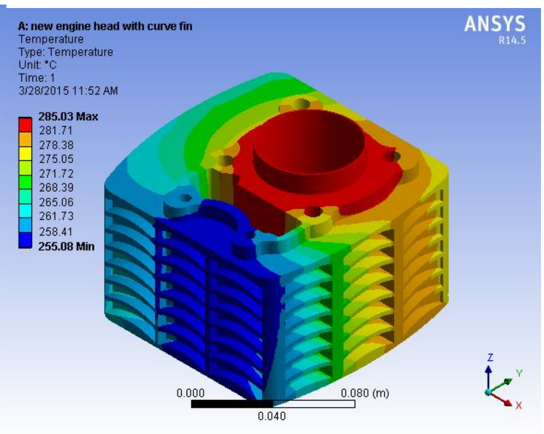
When the solver terminated, the results were examined. Temperature distribution and heat flux along the fin surface of engine cylinder as well as parameters and changes in other parameters can also be predicted by computational analysis. Fig.2 shows the temperature over the convective surface area of the engine fin having different

e-ISSN: 2321-1814, ISBN (Print): 978-1-62951-946-3

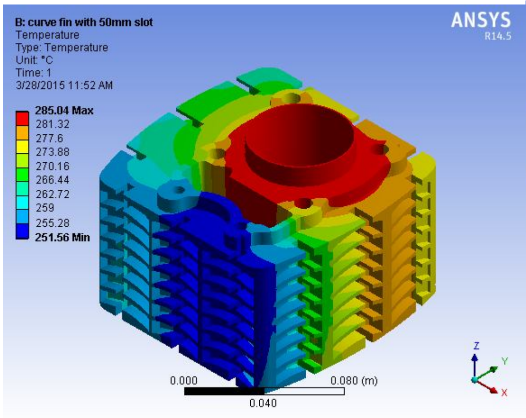
rectangular slot size. It can be seen that the larger perforated fin are pumping out the more heat from the base. The top ends of the fins are cooled faster.



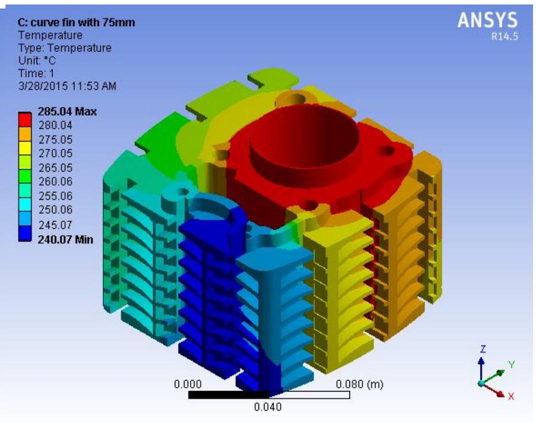
A)



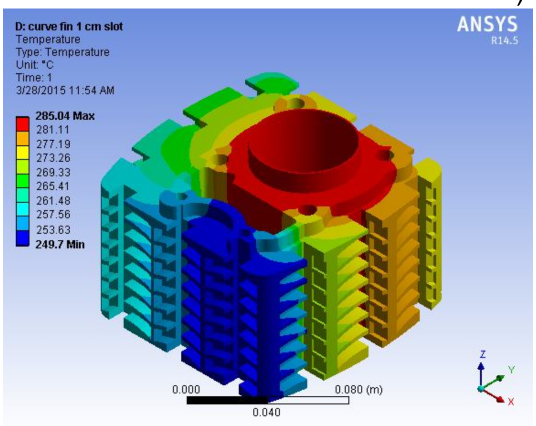
B)



C)

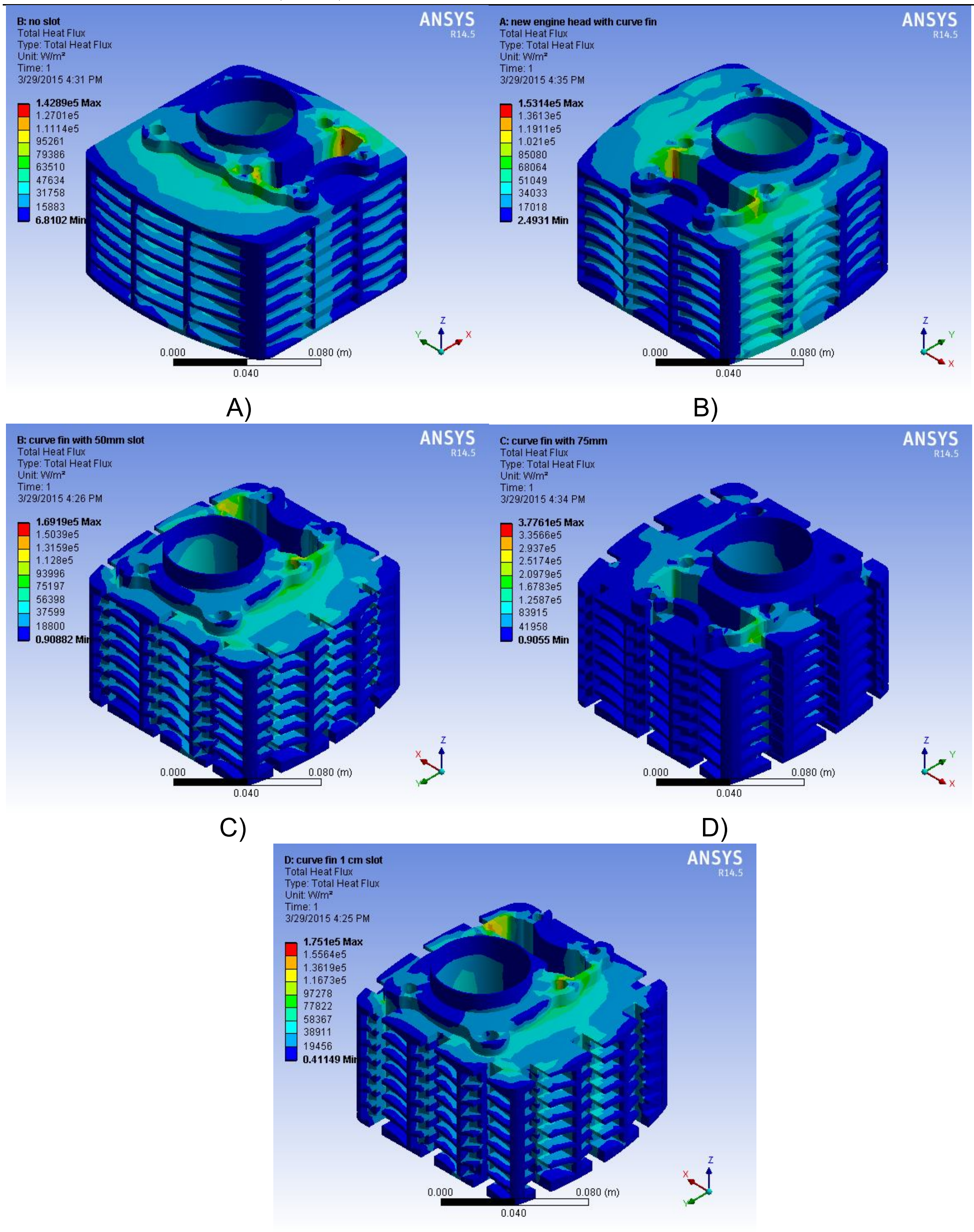


D)



E)

Figure 2: Temperature Contour of A) Bajaj Caliber plane fin B) Solid Curved fin C) 50mm slot fin D) 75mm slot fin E) 100mm slot fin Engine having Aluminium Alloy 2014 material



E)

Figure 3: Heat flux contour of A) Bajaj Caliber plane fin B) Solid Curved fin C) 50mm slot fin D) 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 is modified and changed it with the slotted one varying it size.

e-ISSN: 2321-1814, ISBN (Print): 978-1-62951-946-3

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 anddifferent materials as shown in fig 5.

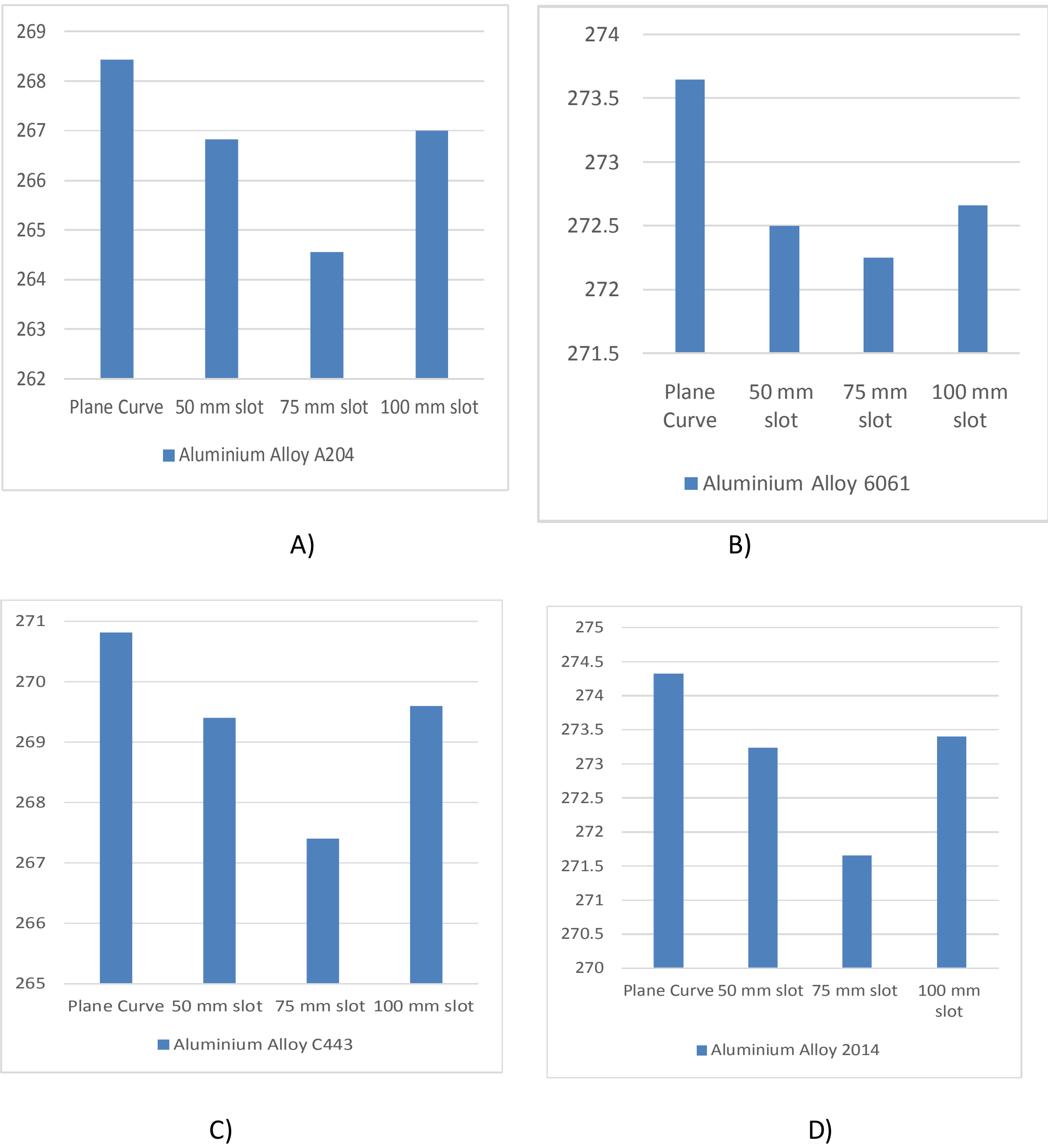


Figure 1: Average temperature of various fin surface having different material

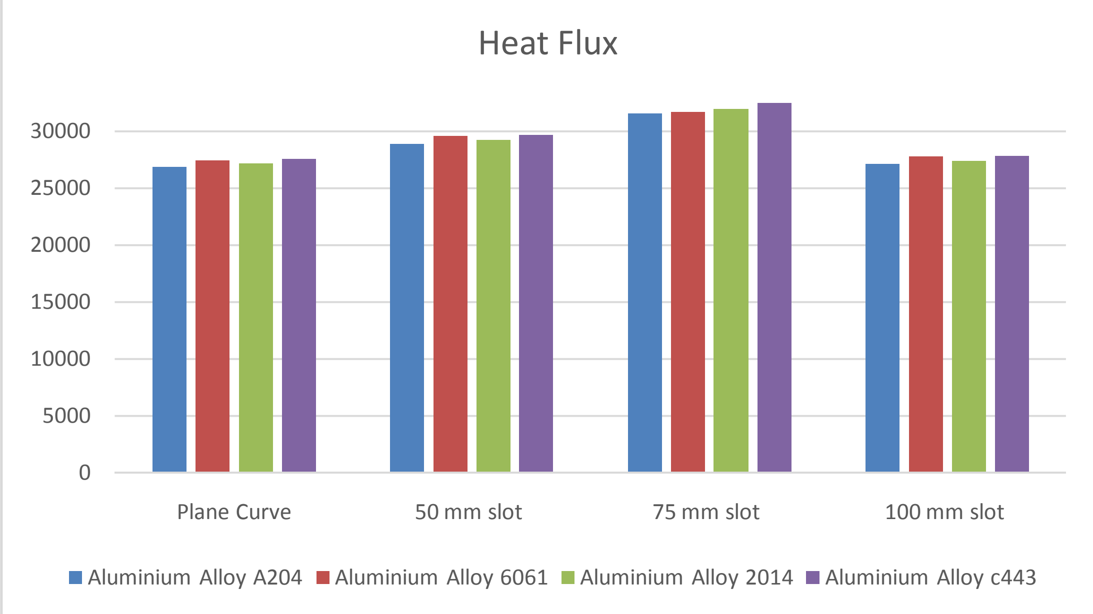


Figure 2: Comparison of Heat flux through the engine cylinder for different fins and material

Conclusion

From the investigation the following conclusion has been made:

1. The overall weight of the cylinder is reduced which leads to decrease in material cost.
2. Heat transfer is maximum for 75mm slotted fins within different slotted fin having same materials.
3. 75mm slotted fins having the minimum fin surface temperature
4. Heat transfer is maximum for 75mm slotted fin engine having Aluminium Alloy 2014 material.

Acknowledgment

We would like to be thankful to the Gautam Buddha University, Greater Noida. At the same time we could not forget the direct or indirect support of faculty and friends to make this paper successful.

References

[1] Thornhill D., Graham A., Cunningham G., TroxierP.and Meyer R., “Experimental Investigation into the Free Air-Cooling of Air-Cooled Cylinders”, SAE Paper 2003-32-0034, (2003)

[2] Thornhill D., Stewart A. and Cuningham G. “Experimental Investigation into the Temperature and Heat Transfer Distribution around Air-Cooled Cylinders” SAE paper 2006-32-0039/20066539 (2006)

[3] Thornhill D. and May A., “An Experimental Investigation into the Cooling of Finned Metal Cylinders in a free Air Stream”, SAE Paper 1999-01-3307 (1999)

[4] Gibson H., “The Air Cooling of Petrol Engines, Proceedings of the Institute of Automobile Engineers”, Vol.XIV, 243-275 (1920).

[5] Biermann E. and Pinkel B., “Heat Transfer from Finned Metal Cylinders in an Air Stream”, NACA Report No. 488 (1935).

[6] Masao Yoshida, Soichi Ishihara, Yoshio Murakami, Kohei Nakashima and Masago Yamamoto, “Air-Cooling Effects of Fins on Motorcycle Engine”, JSME International Journal, Series B, 49(3), (2006).

[7] Zakhirhusen, Memon K., Sundararajan T., Lakshminarasimhan V., Babu Y.R. and Harne Vinay, Parametric study of finned heat transfer for Air Cooled Motorcycle Engine, SAE Paper, 2005-26-361, (2005).

[8] Zakirhusen, Memon K. and Sundararajan T., Indian Institute of Technology Madras, V. Lakshminarasimhan, Y.R. Babu and Vinay Harne, TVS Motor Company Limited, “Simulation and Experimental Evaluation of Air Cooling for Motorcycle Engine”, 2006-32-0099 / 20066599 (2006).

[9] Pathak Sunil, Turbo charging and oil techniques inlight motor vehicles, Res.J. Recent Sci, 1(1), 60-65 (2012).

[10] Dev Nikhil, Attri Rajesh, Mittal Vijay, Kumar Sandeep, Mohit, Satyapal, Kumar pardeep, Thermodynamic analysis of a combined heat and power system, Res.J. Recent Sci, 1(3), 76-79 (2012).

[11] Sachin Kumar Gupta; Harishchandra Thakur; Divyank Dubey, Analyzing Thermal Properties of an Engine Cylinder Fins by Varying Slot Sizes and Material, HCTL Open International Journal of Technology Innovations and Research (IJTIR), Volume 14, April 2015, eISSN: 2321-1814, ISBN (Print): 978-1-62951-946-3.