Design of fins to maximize the heat transfer rate from the engine cylinder

Ankith Y.S[1], Jobin A George [2], prof. Vipin Raveendran[3]

[1,2]*Students of Musaliar College of engineering and technology pathanamthitta*

[3]*Assistant prof, Department of Mechanical Engineering, Musaliar College of engineering and technology pathanamthitta kerala*

Abstract- **An engine cylinder is one of the major automobile components . Which is subjected to high temperature variations and thermal stresses. We know that by increasing surface area, we can increase heat dissipation rate. The main aim of our project is to analyse the thermal properties, by varying geometry fin material and also the thickness of fins. In order to improve the efficiency and sustainability of the engine, heat dissipation has to be carried out quickly and in a very efficient way. Here analysis of the heat transfer characteristics of engine fins is done by using these following materials namely Aluminium 6061, Aluminium 356 and Aluminium 204. Modelling is done in SOLIDWORKS software, meshing is done in ANSYS workbench**

Index Terms- shape of the fin, Material of the fin, Geometry of the fin, heat transfer, ANSYS, fins.

I. INTRODUCTION

Heat is something which appears at the boundary when a system changes its state due to a difference in temperature between the system and its surrounding.

Heat transfer which is defined as the transmission of energy from one region to another as a result of temperature gradient takes place by the fallowing three modes conduction, convection and radiation. Heat transmission in majority of real situations, occurs as a result of combination of these modes of heat transfer.

Conduction: Conduction is the transfer of heat one part of the substance to another part of the same substance, or one substance to another in physical contact with it, without appreciable displacement of molecules forming the substance.

Convection: Convection is the transfer of heat within a fluid by mixing of one portion of the fluid with another. Convection is possible only in a fluid medium and is directly linked with the transport of medium itself. This mode is basically conduction in a very thin fluid layer at the surface and then mixing caused by the flow.

Radiation: Radiation is the transfer of heat through space or matter by means other than conduction and convection. Radiation heat is thought of as electromagnetic waves or quanta an emanation of the same nature as light and radio waves.

II. LITERATURE REVIEW

Various researches carried out in past decade shows that heat transfer through fin depends on number of fins, fin length, fin design, wind velocity, materials etc.

D. Merwin Rajesh K. Suresh Kumar [2014] The main aim of the project is to design and analyze cylinder with fins, by changing the thickness of the fins, and geometry of the fin. Analyzation is also done by varying the materials of fins. Present used material for cylinder fin body is Aluminum alloy 204 which has thermal conductivity of 110 – 150 w/mk. Our aim is to change the material for finbody by analyzing the fin body with other materials and also by changing the thickness.

Mr. N. Phani Raja Rao, Mr. T. Vishnu Vardhan [2013] carried out study To design cylinder with fins for a 150cc engine by varying the geometry such as rectangular, circular and curve shaped (parabolic) and Thickness of the fins. To determine transient thermal properties of the proposed fin models.

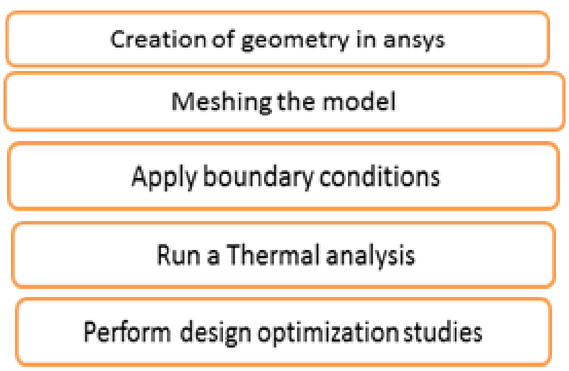
Pushkar Bhanudas Patil, Dr. M. K. Chopra [2017] conducted study to find out the effect of fin height on two-wheeler engine cylinder for temperature distribution.

Directional heat flux and Total Heat flux and thermal analysis is done on the generated results. Finally, to find out conclusions comparative study carried out between results.

A Sathishkumar, MD KathirKaman, S Ponsankar, C Balasuthagar [2015],their investigation is to examine the thermal properties by varying geometry, material and angle of cylinder fins using Ansys work bench and the models are created by changing the geometry like rectangular, circular, angular and curved shaped fins.

Pulkit Sagara, Puneet Teotiab, Akash Deep Sahlotc, H.C Thakurd, [2017] conducted study on Heat transfer analysis and optimization of engine fins of varying geometry. The main aim of the project is to analyse the heat transfer rate by varying the shape and surface roughness of fins. The main aim of this paper is to study following effects on the heat transfer through fins in motorcycle and other motor power vehicles by changing the geometry.

3. METHODOLOGY



The methodology followed was computational fluid dynamics (CFD). Then heat transfer analysis was carried out in software ANSYS. A four stroke cycle cylinder was selected. The dimensions of this block were measured and CAD model was generated using ansys 16.0.

4. MATERIAL PROPERTIES

material	Thermal conductivity(K)	Specific heat (Cp)	Density (p)
Aluminium Alloy 6061	180	962	2700
Aluminium Alloy A204	120	920	2750
Aluminium Alloy 356	167	963	2685

Table:1 Material properties

5. PARAMETERS

- Material of fins.
- Geometry of fins.
- Number of fins.
- Size of fins
- Air velocity

SI No	Parameter	Forms
1	Geometry of fins	1) Rectangle 2) Three Stepped
2	Number of fins	1) 5 fins 2) 7 fins
3	Length of fins from cylinder	1) 13mm 2) 16mm

Table:2 parameters

6. VALIDATION

Validation of ANSYS software is done by compairing heat transfer rate computed from ANSYS to analytical and published experimental measurments obtained from Sathishkumar, M D KathirKaman, S Ponsankar, C Balasuthagar Thesis. ANSYS 16.0 is used for these studies.

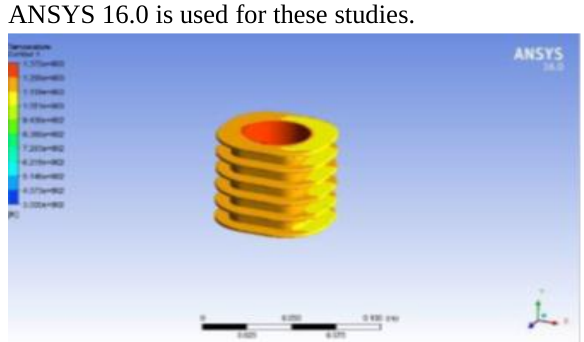


Figure 1 Temperature distributions of of engine fins with aluminium alloy AL204.

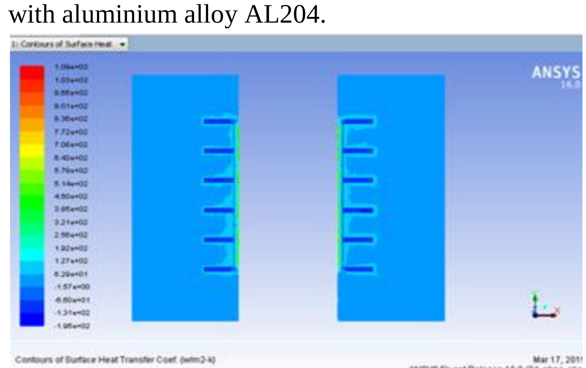


Figure 2 results of validation

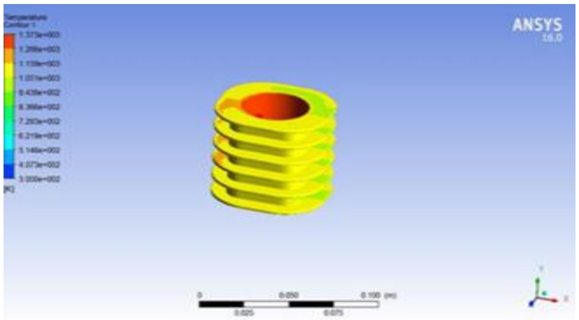


Figure 3 AL204 experimental results

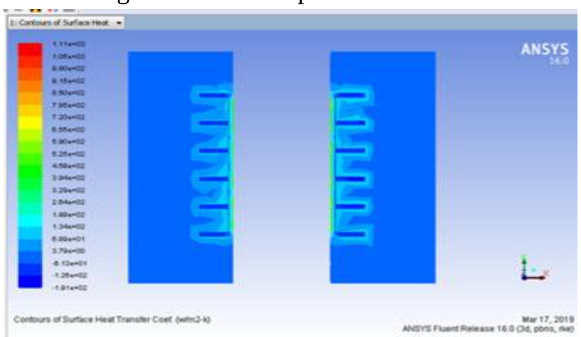


Figure 4 AL204 contours of surface heat transfer coefficient

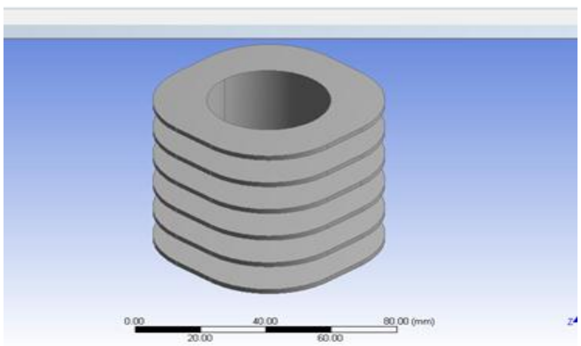


Figure 5: geometry of validated model

Engine cylinder with circular fins geometry is created using cross section mentioned in reference paper.

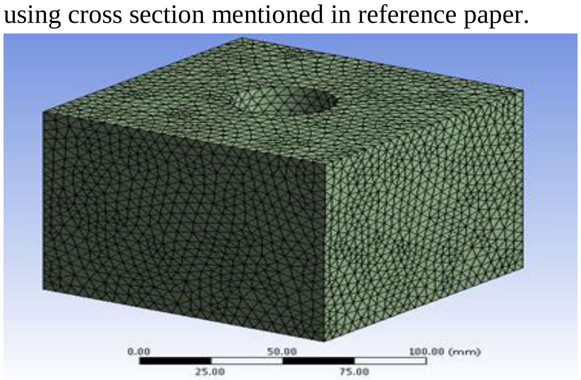


Figure 6: meshing of validated model

VALIDATION CONCULUSION

We can conclude after comparing the heat transfer rate contours obtained from ANSYS 16.0, Experimental and Analytical results that, obtained similar conclusion.

Contours illustrates the temperature distribution of circular fins with different alloys. It is seen from the contours the Aluminium Alloy 2014 showing higher temperature distribution compared to that of Aluminium Alloy 204.

7. MODELLING

In the section geometry, number of fins, size of the fin from the cylinder head, fin profile, stepped and rectangular profiles etc are done.

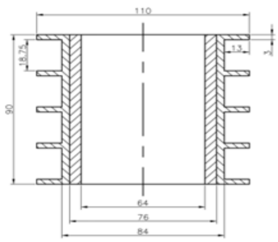


Figure 7: Rectangular model 13mm fin length, with 5 fins

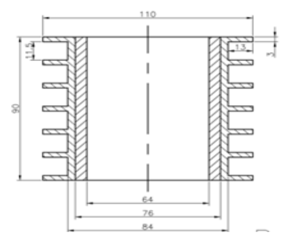


Figure 8 : Rectangular model 16mm fin length, with 5 fins

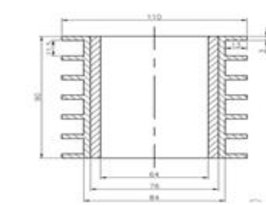


Figure 9 : Rectangular model 13mm fin length, with 7 fins

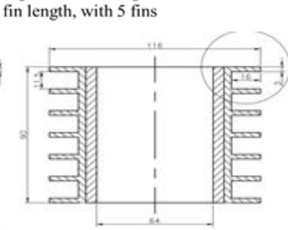


Figure 10 : Rectangular model 16mm fin length, with 7 fins

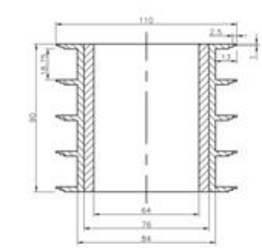


Figure 11: three stepped model 13mm fin length, with 5 fins

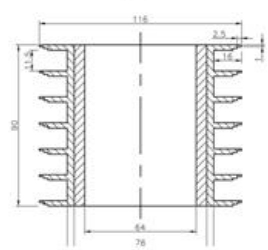


Figure 12: three stepped model 16mm fin length, with 5 fins

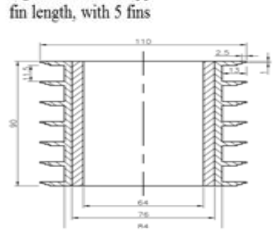


Figure 13 : three stepped model 13mm fin length, with 7 fins

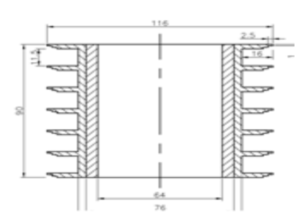


Figure 14 : three stepped model 16mm fin length, with 7 fins

8. MESHING

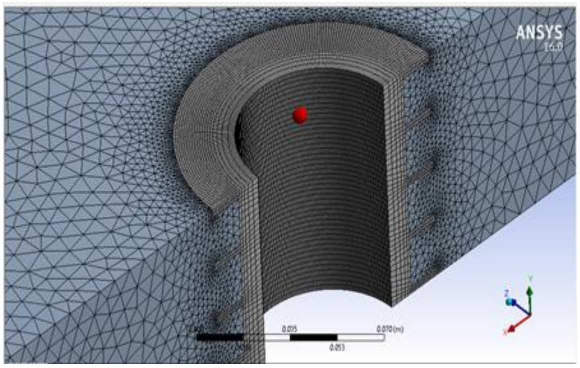


Figure 15: meshing of rectangular model in ANSYS

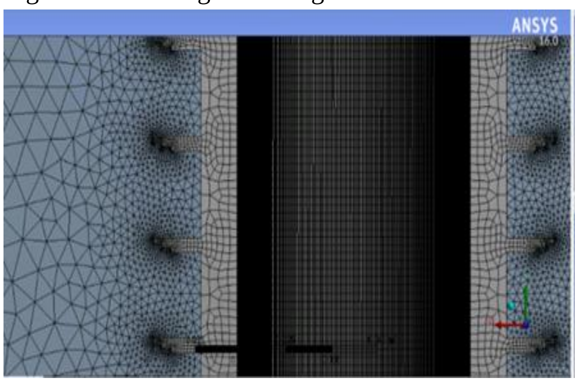


Figure 16: meshing of three stepped model in ANSYS

9. RESULTS

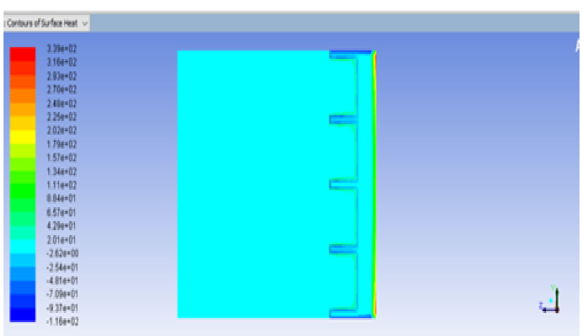


Figure 17 AL A204 rectangular fin HTC at35 km/hr

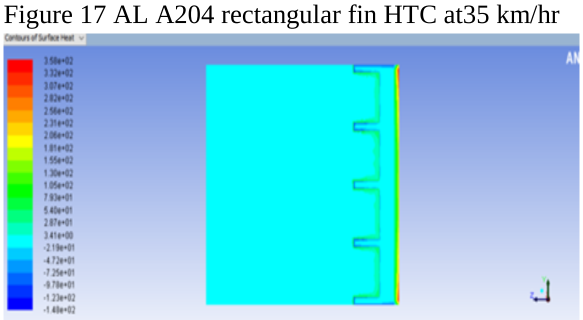


Figure 18: AL A204 rectangular fin HTC at85 km/hr

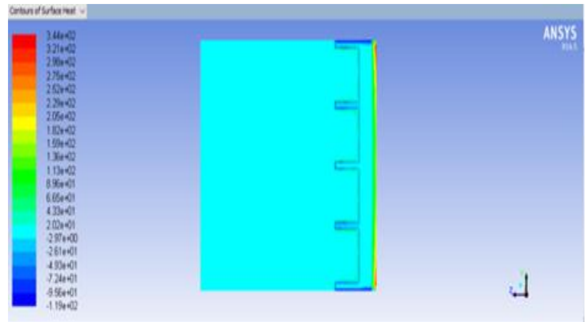


Figure 19: AL 6061 rectangular fin HTC at 35km/hr

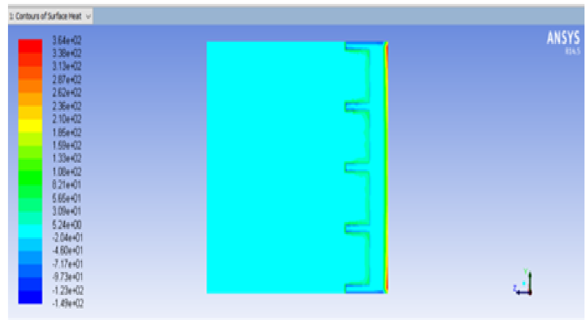


Figure 20: AL 6061 rectangular fin HTC at 85km/hr

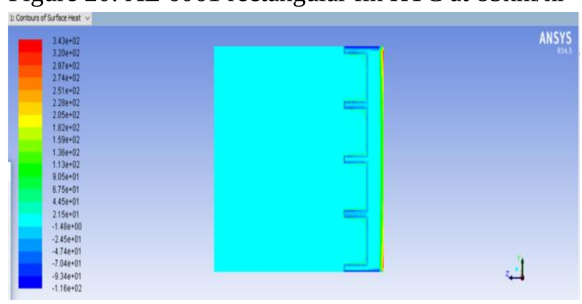


Figure 21: AL 356 material fin HTC at 35km/hr

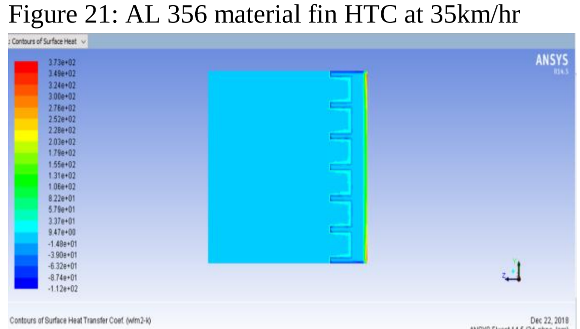


Figure 22:AL A204 material 7 fins at 35km/hr

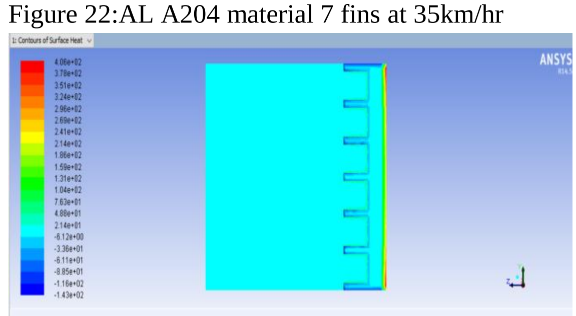


Figure 23: AL A204 material 7 fins at 85 km/hr

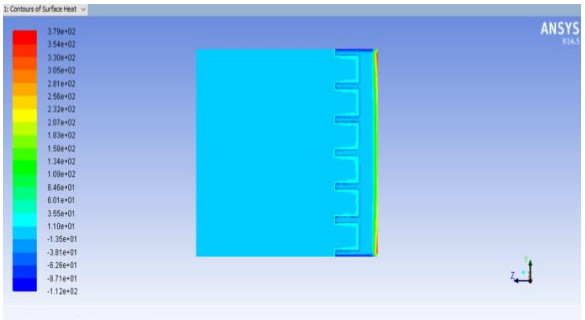


Figure 24: AL 6061 material 7 fins at 35 km/hr

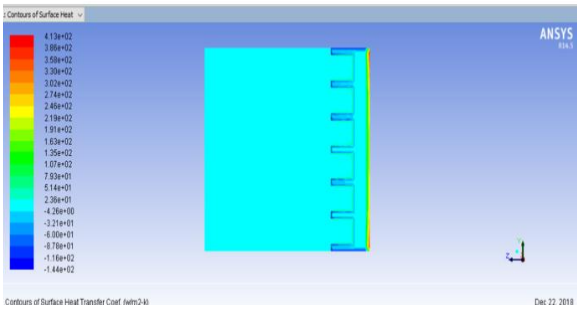


Figure 25: AL 6061 material 7 fins at 85 km/hr

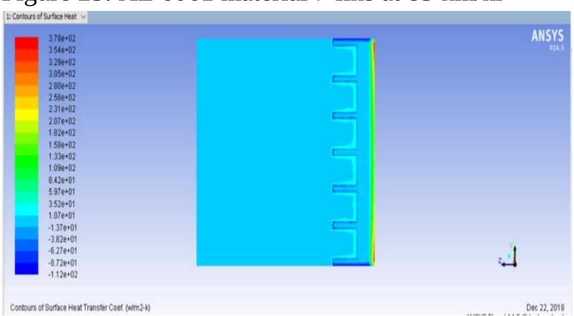


Figure 26: AL 356 material 7 fins at 35 km/hr

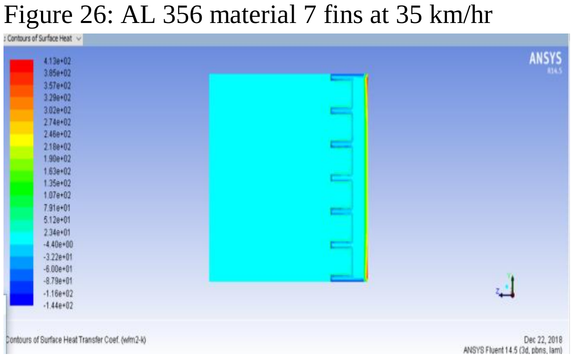


Figure 27: AL 356 material 7 fins at 85 km/hr

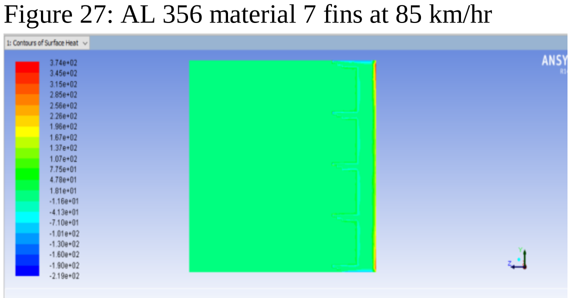


Figure 28: AL 6061material 7 fins at 35 km/hr

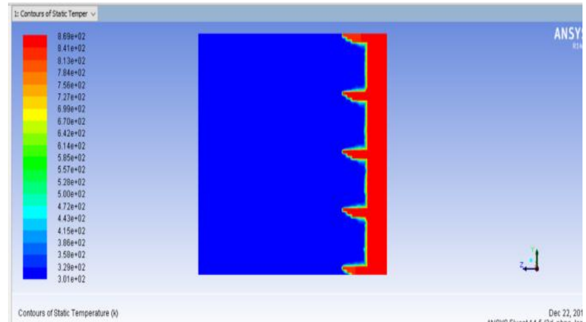


Figure 29: AL 6061material 7 fins at 85 km/hr

Materi-al	Fins	Speed km/hr	Fin lengt-h	No: of fins	Max Temp.	Min Temp	Htc
Al 6061	rectangular	35	13	5	875	847	344
				7	868	840	379
			16	5	876	845	378
				7	867	839	426
		85	13	5	874	845	364
				7	866	835	413
	3 steppe-d	35	13	5	869	841	374

Al 356	rectangular	35	13	5	875	846	343
				7	867	839	378
		85	13	5	874	844	363
				7	866	837	413
	rectangular	35	13	5	873	845	339
				7	867	838	373
		85	13	5	871	841	358
				7	864	832	406

Table:3 Results

GRAPHS

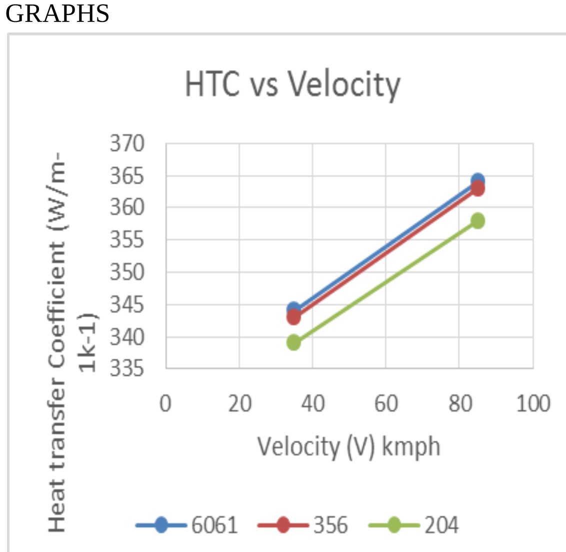


Figure 30: Graph of htc vs velocity

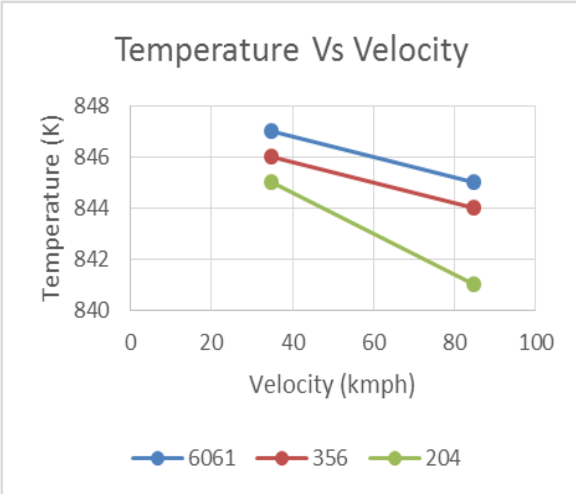


Figure 31: Temperature vs Velocity

10. CONCLUSIONS

Upon simulating the various engine cylinder models considering various parameters like material, geometry, height of fins and the number of fins at certain velocities and concluded that-:

Heat transfer through the stepped fins is more than their Heat corresponding rectangular fin models. Fins with the length of 16mm showed better performance than their 13mm counterparts regardless of the other parameters.

Aluminum Alloy 6061 is better since heat transfer rate, efficiency and effectiveness of the fin is more. Number of fins also played an important role .Models with 7fins proved to be more efficient than the models with 5 fins regardless of the other parameters.

Increase in the velocity from 35kmph to 85kmph resulted in more heat transfer regardless of the other parameters

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