Design & Thermal Analysis of Cylinder Fins with & without Extensions by using Different Materials

Ankit Karmakar[1] Ranu Rajoriya[2]
[1]PG Student [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]Astral Institute of Technology & Research, Indore, India

Abstract— An IC Engine releases heat to the surrounding through the mode of convection, to facilitate this. Fins are provides a means by which heat transfer rate can be improved. Heat transfer rate depends on Fin Geometry, Fin materials and Velocity of automobile vehicle. The main aim of the project is to study the cylinder fin and analyse the thermal performance by varying geometry and material. Models of cylinder with fin have been developed to predict the steady state thermal behavior. The analysis is done using Ansys 19.0 Present used material for internal core is grey cast iron and fin body with aluminum alloy. We are replacing with Grey cast iron, Aluminum alloy and copper alloy separately for entire body. The shape of the fin is rectangular; we have changed the shape with round shaped at the corner of fin. In this research paper, the heat transfer performance is analysed by design and modification of fin geometry. The heat transfer performance of fin without extension and with extension is compared using different materials.

Key words: Thermal Analysis, Fin Geometry, Extension, Material, Heat Transfer, Heat Flux

I. Introduction

A. Engine Cylinder

Cylinder is the one of the major components in Engine, which is subjected to high temperature and thermal stresses. The combustion of air and fuel takes place inside of the engine cylinder. The temperature of hot gases inside the I.C. engine varies from 40^0C or less to as high as 2700^0C. This is a very high temperature and may results the metal parts of the engine will lose their characteristics. This high temperature may also cause serve damage to various engine parts like valves, piston etc. To protect them from the damage the temperature should be reduced up to required working condition temperature of the engine.

B. Extended Surface (Fin)

Fins are the extended surfaces provided at a place from where heat is to be removed. The amount of convection, conduction, or radiation of an object determines the amount of heat it transfers. Increasing the surface area of object, increasing the temperature gradient between the environment and object, or increases the convection heat transfer coefficient increases the heat transfer. The Fins are used for cooling of an engine. The heat conducted through walls, boundaries, or solids has to be continuously dissipated to the atmosphere to maintain the system in a steady state condition. The fins increase the surface area thereby increasing the heat transfer by convection.

C. Objective of Current Research Paper

1) The shape of fin of the original model is rectangular, it has been changed the shape with round at the corner of fin.
2) Present used material for fin body is aluminum alloy and internal core with grey cast iron. We are replacing with grey cast iron, aluminum alloy and copper alloy separately for the fin geometry.
3) The heat transfer performance of fin geometry is analyzed by using rectangular extensions on fin body.

Steady state Thermal analysis is done on fin geometry by varying the materials to determine the Thermal behavior. The material for the original model is changed by taking the consideration of their thermal conductivity and density.

II. Literature Review

1) Mr. T. Vishnu Vardhan, Mr. N. Phani Raja Rao. ‘Thermal Analysis of engine cylinder fins by varying its geometry and material.’ The principle implemented in the project to increase the heat dissipation rate by using the invisible working fluid air. The main aim of the project is to varying material and geometry. In present study, magnesium alloy and aluminum alloy 6061 are used and compared with aluminum A204. The various parameters i.e. geometry and shape of fin are considered in the study, shape (Rectangular and Circular), thickness (3mm and 2.5mm). By changing the shape of the fin to circular shaped and by reducing the thickness, the weight of the fin body reduces thereby increasing the efficiency and heat transfer rate of the fin.
2) Harvinder lal, Pradeep singh, Baljit Singh Ubdi et al (2014). In this paper, effectiveness and the heat transfer performance of fin is analyzed by design of fin geometry with various extensions such as rectangular extensions, triangular extensions, circular extensions and trapezium extensions. The heat transfer performance of fin without extensions and with extensions is compared.
3) G. Babu and M. Lavankumar analyzed the thermal parameters by varying thickness, geometry and material of cylinder the fins geometry. The models were created by varying the geometry and also by varying thickness of the fins. Material used for manufacturing cylinder fin body was aluminum Alloy 204 which has thermal conductivity of 110-150 W/mk and also using Aluminum 6061 and Magnesium alloy which have higher thermal conductivities. They concluded that by changing the shape of the fin to curve shaped and by reducing the thickness, the weight of the fin body reduced thereby efficiency increases. The weight of the fin body is reduced when Magnesium alloy is used and using circular fin, material Aluminum Alloy 6061 and thickness of 2.5 mm is better since heat transfer ate is

more and using circular fins the heat lost is more, efficiency and effectiveness is also more.

III. METHODOLOGY

In this project work thermal analysis of fin has been perform in the engine cylinder by changing fin geometry, by using extensions on the fin surface and by changing fin material. A parameters for these analysis has been referred from the papers Ajay sonkar, Ishwar singh rajput, Jageshwar dhruw, Kishore kumar sahu (Vol.6 Issue 4 April 2017) and Pradeep singh, Harvinderlal, Balajit singh ubhi(Vol.3 Issue 5 may 2014)

A. *Introduction to ANSYS Software*

ANSYS software is a simulation software package that

1) Provides tools to conceptualize design and evaluate concepts on the desktop.
2) Allow designated products to be assumed to be evolving in the real world.
3) Create virtual prototypes with complex systems and products, including electronic, mechanical and integrated software that integrates all existing physical phenomena in the real world environment.

B. *Design & Modeling of Fin Geometry*

The engine was modeled as a cylinder with fins on its outer surface and a stroke volume.

1) Geometry of Engine with Fin

Size of fin: L x B x H = 158mmx158mmx3mm
Outer diameter of cylinder core = 78mm
Inner diameter of cylinder core =62mm
Space between two fins =24mm
Height of cylinder =120mm

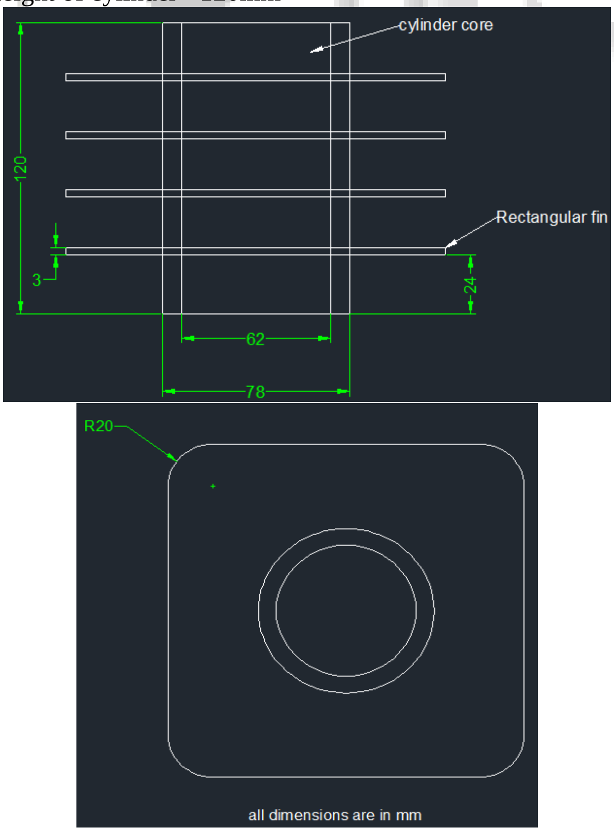

Fig. 1: Geometry of Engine Cylinder with Fin

2) Geometry of Rectangular Extension

Specifications of rectangular extension shown in the Fig. 2 and number of extensions used on main fin is 16 nos.

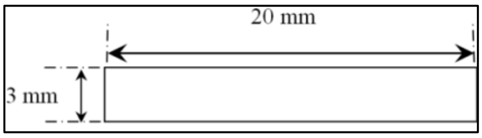

Fig. 2: Rectangular Extension

3) Modeling of Exiting Fin through creo 2.0

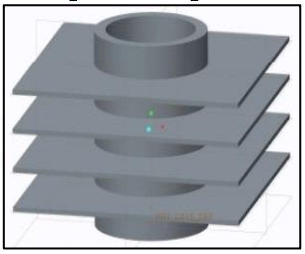

Fig. 3: Existing Model

4) Modeling of Modified Fin through creo 2.0

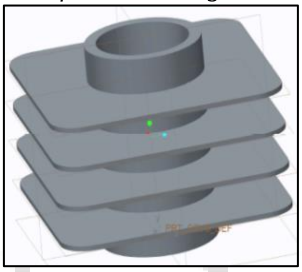

Fig. 4: Modified Model

5) Modeling of Modified Fin with Extension through creo 2.0

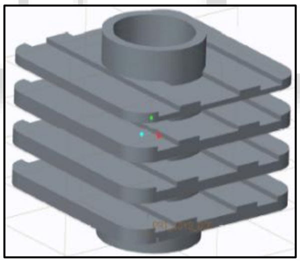

Fig. 5: Modified Model with Extension

C. *Boundary Conditions*

The following are the input parameters

Sr. No.	Loads	Value	Units
1.	Inlet temperature	1373	K
2.	Film coefficient	30	W/m^2K
3.	Ambient temperature	303	K
4.	Material		Grey cast iron, Aluminum alloy, Copper alloy

Table 1: Boundary Conditions

IV. ANALYSIS OF FIN FOR HEAT TRANSFER WITH ANSYS 19.0

A. *Import the Geometry*

The important factor is while saving the model in software creo it should be save in ".stp" file format. So it can access through the FEA software. Then, select the analysis type that is steady-state heat transfer process.

B. Generating the Mesh

The 3D mesh setting set mesh size towards fine the high in smooth and fast in transition. Select the model and generate the mesh for the design.

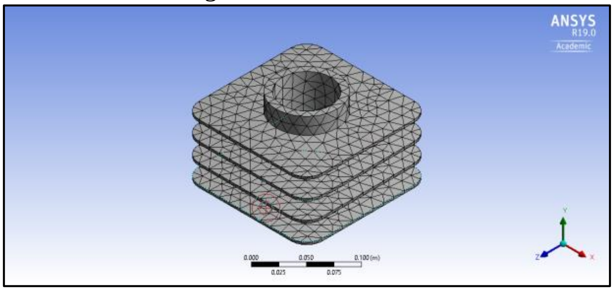

Fig. 6: Meshed fin

C. Assigning Material & Loads to the Meshed Model

1) Material & Properties

In this thesis we are taking three materials for the fin geometry. They are grey cast iron, aluminum alloy and copper alloy. Thermal analysis is done for all three materials.

Sr.no.	Materials	Density(in Kg/m3)	Thermal conductivity (in W/m-k)	Specific heat(J/Kg -^{0}K)
1.	Grey cast iron	7200	52	447
2.	Aluminum alloy	2770	120-160	875
3.	Copper alloy	8300	385	385

Table 2: Materials & Properties

2) Loading

In this step we define the boundary conditions for model, the temperature of inner surface of the cylinder core is taken as 1373K and atmospheric temperature is maintained at 303K and Film transfer coefficient as 30 W/m^{2}K.

D. Steady State Thermal Analysis

A steady state thermal analysis calculates the effect of thermal load on the fin geometry. Through steady state thermal analysis we can determine temperature distribution, Heat flux, Thermal gradient and heat flow rates in an object that do not vary with time.

The temperature at the inner wall of cylinder surface is taken at 1100 ^{0}C or 1373 K to account for heat generated due to combustion inside the engine.

The following are the input parameters

Inlet temperature =1373 K, Film coefficient = 30 W/m^{2}K Ambient temperature =303 K.

V. RESULT & DISCUSSION

The heat transfer and flow characteristic of fin can be visualizes by contour diagram of temperature distribution and Heat flux, values of temperature and graph of Heat transfer. The results produced by the software ansys 19.0 in the form of color contours of the required parameters.

A. Temperature Distribution of Existing Models

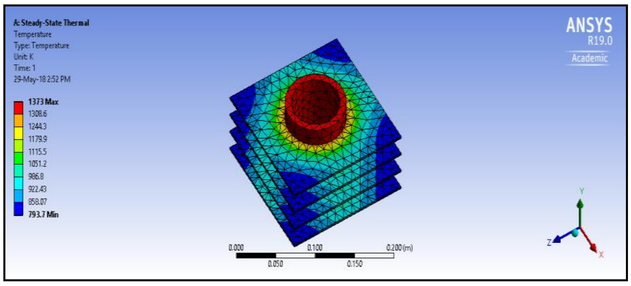

Fig. 7: Gray Cast Iron Material

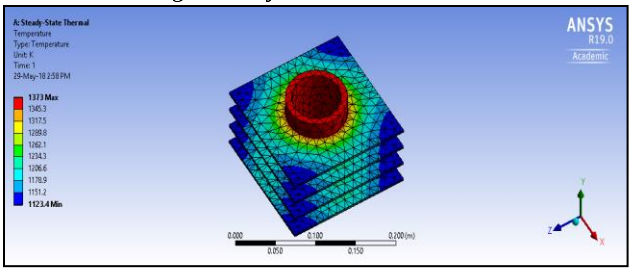

Fig. 8: Aluminum Alloy Material

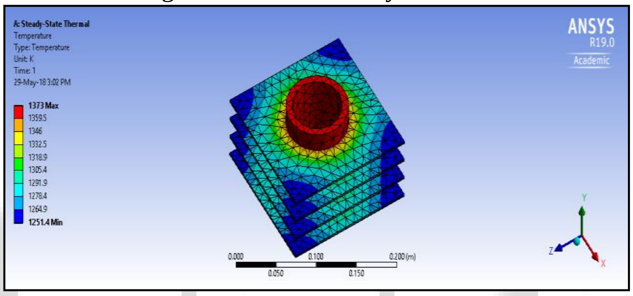

Fig. 9: Copper Alloy Material

B. Temperature Distribution of Modified Model Without extension

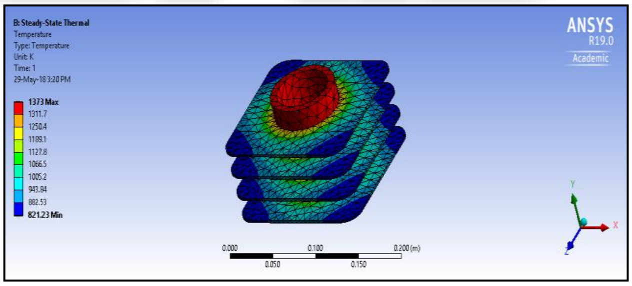

Fig. 10: Gray Cast Iron Material

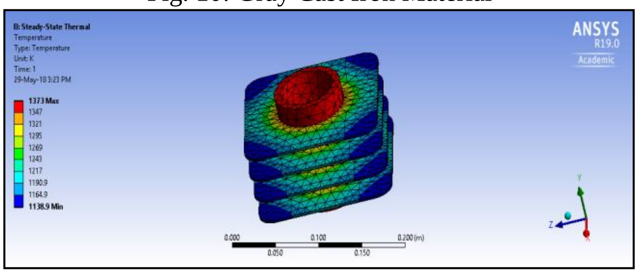

Fig. 11: Aluminum Alloy Material

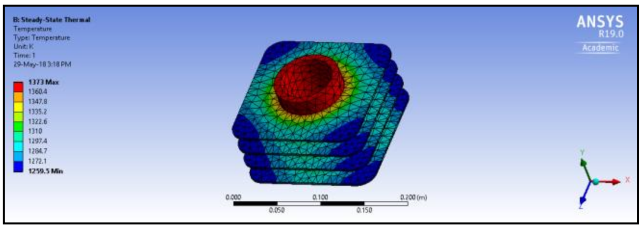

Fig. 12: Copper Alloy Material

C. Temperature Distribution of Modified Models With extension:

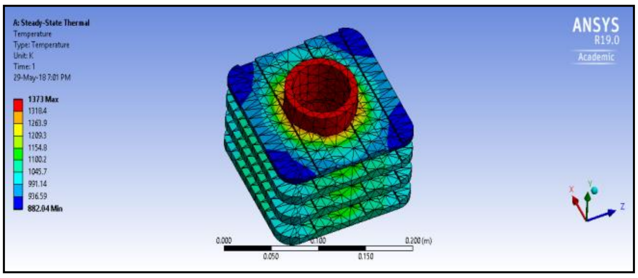

Fig. 13: Gray Cast Iron Material

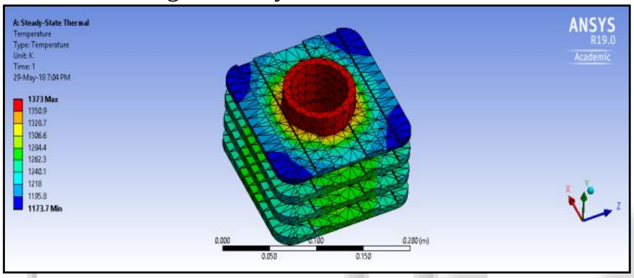

Fig. 14: Aluminum Alloy Material

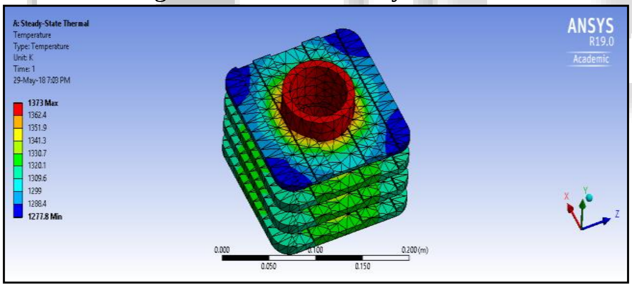

Fig. 15: Copper Alloy Material

D. Result comparison between Existing Fin & Modified Fin

Sr.no.	Material	Temperature Distribution (K)					
		Existing Fin		Modified Fin without Extension		Modified Fin with Extension	
		MAX	MIN	MAX	MIN	MAX	MIN
1.	Grey cast iron	1373	793.7	1373	821.23	1373	882.04
2.	Aluminum alloy	1373	1123.4	1373	1138.9	1373	1173.7
3.	Copper alloy	1373	1251.4	1373	1259.5	1373	1277.8

Table 3: Temperature Distribution Cylinder Fins

Sr.no.	Material	Heat Flux(W/m^2)					
		Existing Fin		Modified Fin without Extension		Modified Fin with Extension	
		MAX	MIN	MAX	MIN	MAX	MIN
1.	Grey cast iron	9.1239e5	6171.8	1.073e6	4990.8	8.33773e5	9161.1
2.	Aluminum alloy	1.2343e6	1111.8	1.4536e6	2545.4	1.1122e6	5500.7
3.	Copper alloy	1.3623e6	2308.5	1.5929e6	3788.6	1.2124e6	6692.7

Table 4: Heat Flux Cylinder Fins

E. Graphical Representation

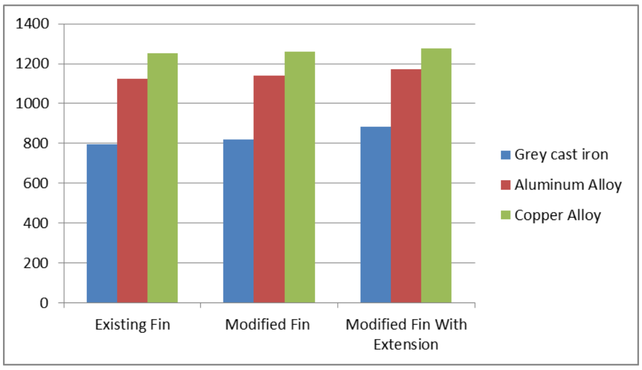

Fig. 16: Temperature Distribution of Existing fin, Modified Fin (without Extension) and Modified Fin (with Extension)

F. Mass Calculation between Existing Model and Modified Model using Materials Grey Cast Iron, Aluminum Alloy & Copper Alloy

Sr. No.	Material	Mass	
		Existing fin	Modified fin
1.	Grey cast Iron	3.2641 kg	3.2344 kg
2.	Aluminum alloy	1.2558 kg	1.2443 kg
3.	Copper alloy	3.7627 kg	3.7285 kg

Table 5: Mass Calculation

VI. CONCLUSION

In this thesis the original model is changed by changing the geometry of the fins and material. The shape of fin of the original model is rectangular, it has been changed the shape with round at the corner of fin. By changing the shape of fin geometry, the overall weight is reduced and heat transfer rate increases. Present used material for fin body is aluminum alloy and internal core with grey cast iron. We are replacing with grey cast iron, aluminum alloy and copper alloy separately for the fin geometry. Thermal analysis is done for all three materials. The material for the original model is changed by taking the consideration of their thermal conductivity and density. By observing the thermal analysis results, copper alloy having better heat transfer rate compare to other two materials. But if we consider weight and cost, using aluminum alloy is better. So we can conclude that using material aluminum alloy is better, changing shape with round at the corner of fin is better compare to existing model. By observing the results, heat transfer through fin with extension is higher than that of fin without extension, so using fin with extension is better than fin without extension.

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