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Transient Thermal Analysis of Modified Piston Head for Improvement of Efficiency

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ABSTRACT

A piston is a major component of pumps, gas compressors and reciprocating engine. It is located in a cylinder and is made gas-tight by piston rings. The purpose of piston in an engine is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. The alloy from which a piston is made to determines its strength, wears characteristics and its thermal expansion characteristics. The normal temperature of gasoline engine exhaust is approximately 640ºC (913K). This is the melting point of most aluminum alloys and it is only the constant influx of ambient air that prevents the piston from deforming and failing.

For this purpose testing different types of materials such as aluminum alloys and alloy steel piston. And find out the von misses stresses, total deformation, heat distribution, and heat flux. The heat flux is more for Aluminum alloy than the cast iron material for the flat head and convex head piston. Therefore Aluminum material is the best suitable material for piston. The piston ring the heat flux is more for Alloy steel than the cast iron material. Therefore the material suitable for piston ring is Alloy steel. In this project we design the two models of pistons flat head & convex heads by using CATIA software, and analyzed statically and thermally by using ANSYS.

INTRODUCTION

1.1Heat Engines: Any kind of motor or machine which gets heat vitality from the ignition of fuel or some other source and coverts this vitality into mechanical work is named as a Heat Engines.

Heat Engine might be delegated:

• External Combustion Engines
• Internal Combustion Engines

1.1.1 External Combustion Engines (E.C. Motors): For this situation, burning of fuel happens outside of the chamber as if there should arise an occurrence of steam motors where the warmth of ignition is utilized to create steam which is utilized to move a cylinder in a chamber.

1.1.2 Internal Combustion Engines (I.C. Motors): For this situation, ignition of the fuel with oxygen of the air happens inside the chamber of the motor.

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The inner burning motors bunch incorporates motors utilizing blends of flammable gases and air, known as gas motors, those utilizing lighter fluid fuel or soul known as petroleum motors and those utilizing heavier fluid powers, known as oil pressure or diesel motors. Despite the fact that inside burning motors look very basic, they are exceptionally mind boggling machines. There are many parts which need to play out their capacities sufficiently to deliver yield power. There are two kinds of motors

- Spark start motor (S.I motor)
- Compression start motor (C.I motor)

1.3 Parts of an I.C. Motor:

- Cylinder
- Cylinder head
- Piston
- Gudgeon pin
- Connecting bar
- Crankshaft
- Crank
- Crank case
- Flywheel
- Governor
- Valves and valve working instrument

1.4 Effect Of Compression Ratio On Engine Performance

In an inward ignition motor, a cylinder packs a huge volume of a blend of fuel and air into a little space. The proportion of the most extreme cylinder volume to the base packed volume is known as the pressure proportion. Packing the fuel and air will cause them to consume quicker, which (however I don't know straightforwardly how) makes the motor run better. There are optional advantages to high pressure proportions, as well. High pressure proportion motors consume both significantly more neatly and substantially more effectively than lower-pressure motors. The expansion in productivity is because of the extra warmth and Brownian movement brought about by pressure completely disintegrating the fuel, taking into account how much work is placed into cooling the fuel-air blend in turbocharged vehicles. Another issue is motor effectiveness as an element of RPMs. A motor cutoff points power by lessening the admission of fuel and air to a motor; if just a large portion of the fuel and air is entering a cylinder, the pressure proportion is viably divided too.

2. LITERATURE REVIEW

2.1 Dynamics of Internal Combustion Engine with Variable Compression Ratio:

Internal combustion engines (ICE) with variable compression ratio (VCR) assures possibilities of exploitation characteristics and efficiency improvement, and reduces bad emissions and load of the elements of its crankshaft mechanism. The higher pressure and temperature of the operating substance at the end of the compression, as a result of higher compression ratio - ε, gives possibility for reduction of inductive period and increases the burning speed. We have a shorter time for combustion as a result of this, with lower and higher value of ε. It is also typical for ICE with VCR to have higher value of thermal efficiency. With the simulation model of the operating cycle of ICE with VCR were carried out numerical experiments at varying ε to its various minimal values from 15 to 21. The influence of change of ε at constant intake pressure, equal to atmospheric $P0 = 101300$ Pa, was researched, both on the processes of

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operating cycle of ICE with VCR, and on the load of its mechanism units.

2.2 Steady State and Transient Analysis: This chapter discusses the details of literature survey of the piston structural and thermal analysis work done for assessing the integrity of the structure for various loading conditions like temperatures and pressures. This chapter also discusses the literature survey of experimental work done for measuring the above said work. Piston in the engine will be operating under vary critical temperature loads. These temperature loads will be varying from time to time in a cycle. These temperatures will be higher during firing stroke and lower during the other strokes. It is always difficult to assess the piston temperature for various gas temperatures. So steady state thermal analysis will be carried out for predicting the piston temperatures for worst case loading conditions i.e. peak temperatures or for an average bulk gas temperature.

3. MODELLING

3.1 DESIGNING OF PISTON

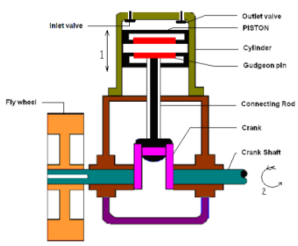

Fig.3.1.Parts of an I.C Engine

Table3.1Piston Dimensions

Piston Diameter(D)	100mm
Length Of The Piston (Lp)	105mm
Thickness Of Piston Head (T1)	5.25mm
Height Of Top Part(Lh)	52.5mm
Length Of Skrit (Ls)	70mm
Thickness Of Ring Land(X1)	9mm
Thickness Of First Ring (X2)	4mm
Axial Thickness (T4)	3mm
Thickness Of Barrel at Open End Of Piston(T6)	10.5mm
Pin Outer Diameter(dp)	25mm
Piston Inner Diameter(Di)	68.55mm
Thickness Of Crown Wall (T5)	7.5mm
Inlet Port	30mm
Outlet Port	25mm
Spark Plug	20mm
Gudgeon Pin	20mm
Cylinder Height	195mm
Clearance Volume	5mm
TDC TO BDC	60mm
Compression Ratio	12

MODELING OF PISTON

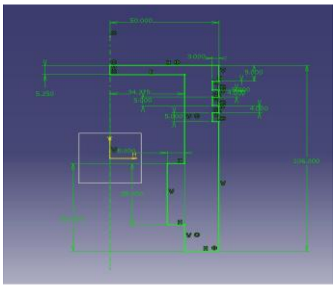

Fig.3.2 sketch view of piston

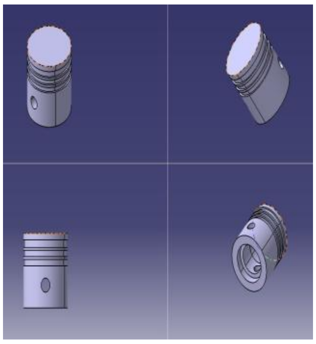

Fig.3.3 isometric view of piston

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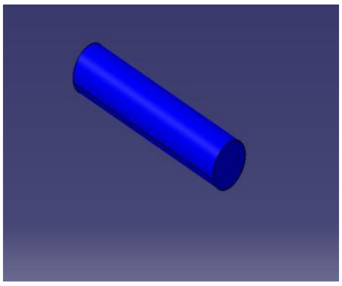

Fig.3.4 Gudgeon Pin

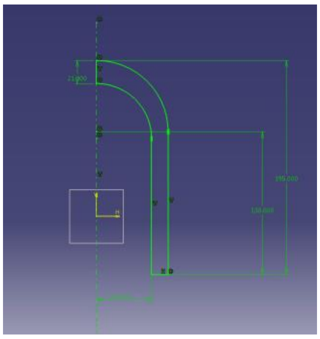

Fig 3.5. Sketch view of cylinder

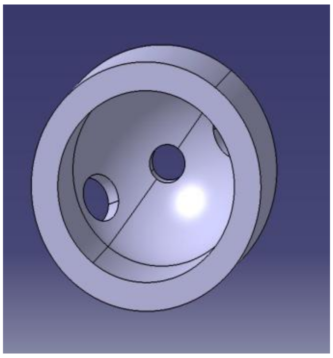

Fig 3.6 Bottom view of cylinder

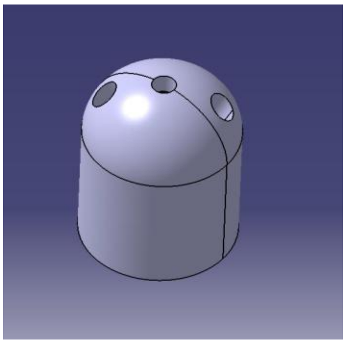

Fig 3.7 Final model of cylinder

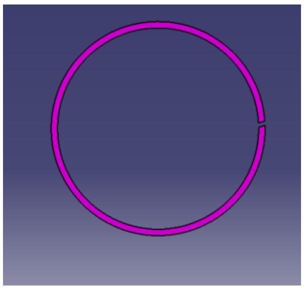

Fig 3.8 Piston ring

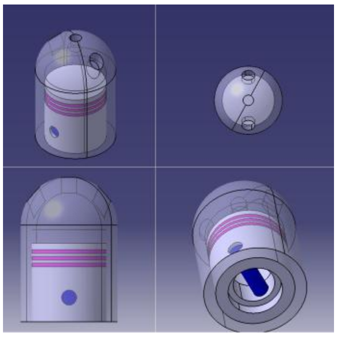

Fig 3.9 Assembly of flat head Piston, Cylinder, Piston ring and Gudgeon pin

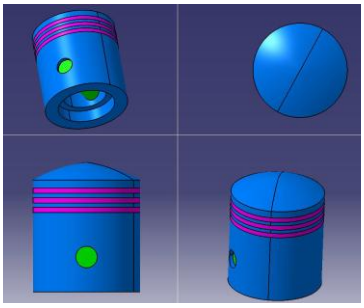

FIG 3.10. Convex head piston

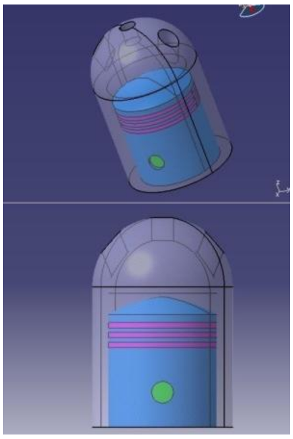

Fig 3.11 Assembly of convex head Piston, Cylinder, Piston ring and Gudgeon pin

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3.2 BASIC STEPS TO SOLVING ANY PROBLEM IN ANSYS

Like taking care of any issue deliberately, one needs to characterize the accompanying angles (1) arrangement domain, (2) physical model, (3) limit conditions and (4) physical properties. Later one have to tackle the issue and need to show the outcomes. The principle distinction in numerical strategies is an extra advance is known as work age. This is the progression that parts the troublesome model into little segments thus it very well may be basically comprehended or, in all likelihood it is abundance complex circumstance.

The accompanying characterizes the strategies in wording to some degree extra acclimate to the product.

• Build Geometry: Make 2D or 3D portrayal of the item to be demonstrated and tried by methods for the work plane arrange framework in ANSYS.

• Define Material Properties: Clarify an assortment of the basic materials that involve the article being demonstrated. This contains both warm &mechanical properties.

• Generate Mesh: ANSYS knows the cosmetics of part and characterizes how it ought to be down and out into pieces.

• Apply Loads: When the framework is totally structured, the previous undertaking is to trouble the framework with limitations in particular physical loadings or limit conditions.

• Obtain Solution: This is in truth a stage, since ANSYS must comprehend inside what state (consistent state, transient… and so forth.) the difficult should be fathomed.

• Present the Results: As the last arrangement has been accomplished, there are a few way to introduce ANSYS arrangements, browse numerous alternatives, for example, tables, charts, and form plots.

4. THERMAL ANALYSIS OF FLAT HEAD PISTON BY APPLYING

Now the thermal analysis of flat head piston is performed by applying aluminium alloy and applying a temperature of 800k on the flat face of piston and convection coefficient of 22w/m2k and bulk ambient temperature of 300k.

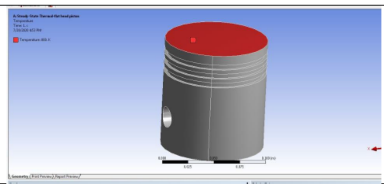
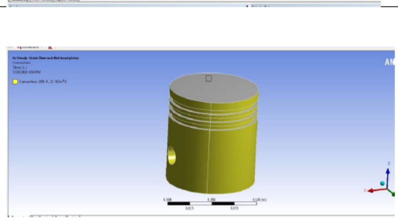
LOAD NAME	LOAD IMAGE	LOAD DETAILS
Temperature		Entities: 1 face(s) Temperature: 800kelvin
Convection		Entities: 22 face(s) Convention coefficient: 22W(m^2.k) Time variation:OFF Temperature variation:OFF Bulk Ambiant:300 Kelvin Temperature: Time Variation:OFF

Fig 4.1 Meshing of flat head piston

Name	Type	Min	Max
Thermal	TEMP: Temperature	712.31	800

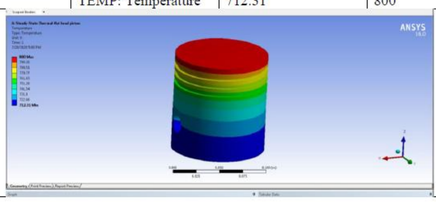


Fig.4.2.Temperature distribution on aluminium alloy.

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Name	Type	Min	Max
Thermal 2	HFLUXY:Y Heat Flux	1.4181	1.257e5

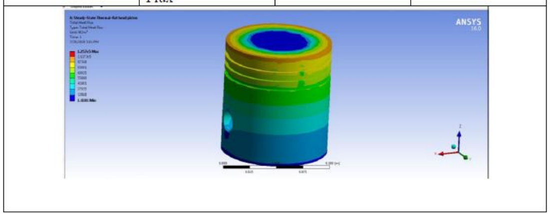


Fig.4.3. Heat flux on Aluminium alloy.

4.1 THERMAL ANALYSIS OF CONVEX HEAD PISTON BY APPLYING ALUMINIUM ALLOY MATERIAL

Now the thermal analysis of convex head piston is performed by applying 6061-T6 alloy and applying a temperature of 800k on the flat face of piston and convection coefficient of 22w/m2k and bulk ambient temperature of 300k.

THERMAL LOADS

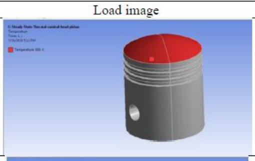
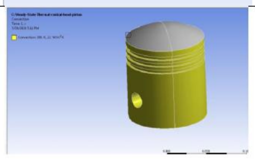
Load name	Load image	Load Details
Temperature		Entities: 1face(s) Temperature:800kelvin
Convection		Entities :22 face(s) Convention Coefficient: 22W(m^2.k) Time Variation: OFF Temperature Variation: OFF Bulk Ambient 300kelvin Temperature Time Variation: OFF

Fig 4.8 Temperature distribution

Name	Type	Min	Max
Thermal1	TEMP: Tem Perature	762.79	800

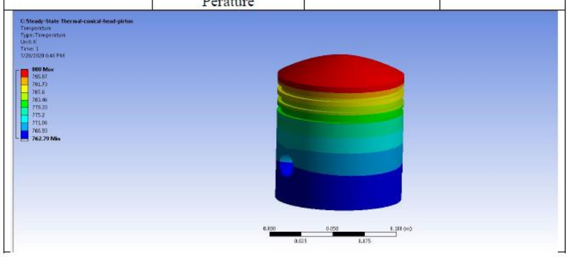


Fig 4.9 Temperature distribution on Aluminium alloy

Name	Type	Min	Max
Thermal 2	HFLUXY:Y Heat Flux	3.3795	2.3704e5

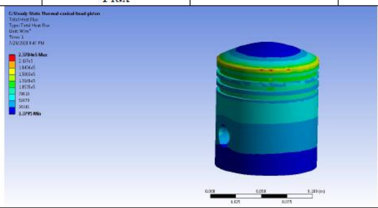


Fig 4.10 Heat flux on Aluminium alloy

4.2 THERMAL ANALYSIS OF PISTON RING BY USING ALUMINIUM ALLOY

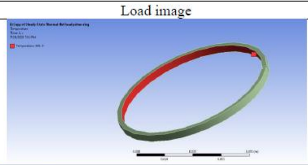
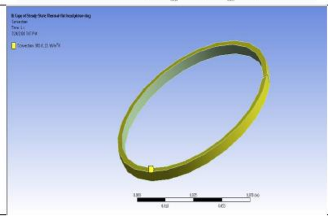
Load name	Load image	Load details
Temperature		Entites:1 face(s) Temperature:800 kelvin
Convention		Entities :5 face(s)- Convention coefficient:22 W(M^2.k) Time variation: off Temperature variation: off Bulk Ambient 300 kelvin Temperature Time Variation: off

Fig.4.15 Temperature distribution on piston ring

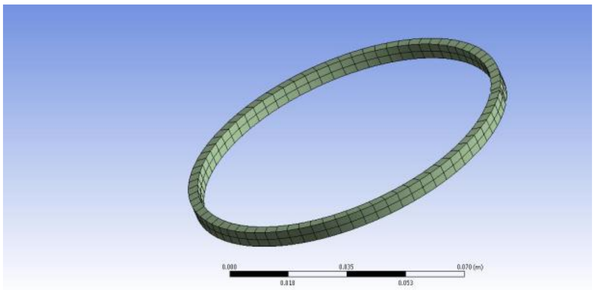


Fig.4.16 piston ring

4.3 Thermal Analysis of Piston Ring by Using Aluminium Alloy

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Name	Type	Min	Max
Thermal 1	TEMP: Temperature	799.53	800.82

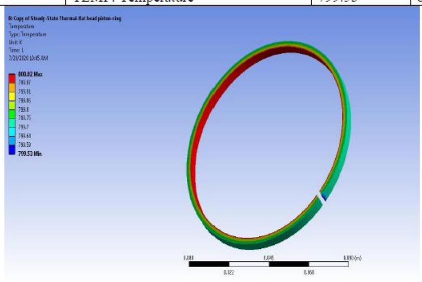

Fig 4.17 Temperature distribution on Aluminium Alloy

Name	Type	Min	Max
Thermal 2	HFLUXY:Y Heat Flux	0.00060798	39602

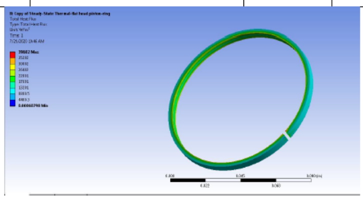

Fig 4.18 Heat Flux on Aluminium Alloy

5. RESULT

Comparison of Results

Table :5.1 Final Results of Piston for Aluminum Alloy

Shape of Crown	Flat head	Convex head
Temperature (Kelvin) Maximum Minimum	 800 712.31	 800 762.79
Total heat Flux(w/m^2) Maximum Minimum	 1.257e5 1.4181	 1.3704e5 3.3795

Table:5.2 Final Results of piston for cast Iron

Shape of crown	Flat head	Convex head
Temperature (Kelvin) Maximum Minimum	 800 701.2	 800 697.1
Total heat Flux(w/m^2) Maximum Minimum	 1.332e5 1.422	 2.2496e5 6.4686

Table:5.3 Final Results of piston for Structural Steel

Shape of crown	Flat head	Convex head
Temperature (Kelvin) Maximum Minimum	 800 712.31	 800 708.58
Total heat Flux(w/m^2) Maximum Minimum	 1.257e5 1.4181	 2.2765e5 6.1799

Table :5.4 Final Results of Piston for Aluminum Alloy

Shape Of Crown	Alloy Steel	Cast Iron	Structural Steel
Temperature (Kelvin) Maximum Minimum	 800.82 799.53	 800.05 798.688	 800.05 798.84
Total heat Flux(w/m^2) Maximum Minimum	 39602 0.00060798	 28791 0.0013539	 29782 0.00073561

The alloy from which a piston is made not only determines its strength and wears characteristics, but also its thermal expansion characteristics. Hotter engines require more stable alloys to maintain close tolerances without scuffing. The main factors influencing on piston are:

- Strength and rigidity of head thickness
- Heat distribution of poison material

If the calculated stresses are too great, it is necessary to change piston design. Such changes may be:

- Increasing the piston head thickness
- Changing the piston crown shape
- Changing the material
- Length of piston
- Piston Rings

By comparing the above results of flat head and convex head piston the heat flux is more than for aluminium alloy than the cast iron material. Therefore aluminium alloy material is the best suitable material for piston. By comparing the above results of piston ring the heat flux is more for Alloy than the cast iron material. Therefore aluminium alloy material is the best suitable material for piston ring.

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GRAPHS:

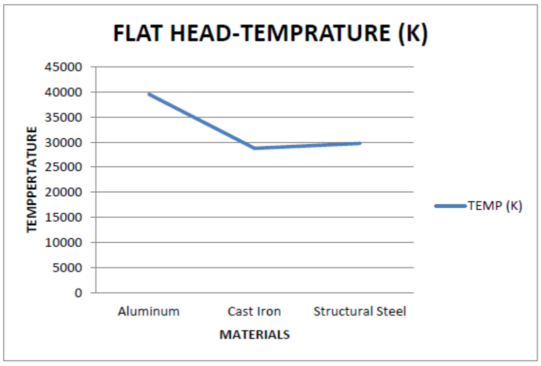

Fig 5.1 Plot Material Vs Temperature Piston with Flat Head

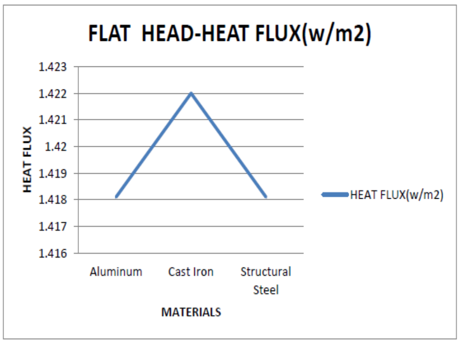

Fig 5.2 Plot Material Vs Heat Flux Piston with Flat Head

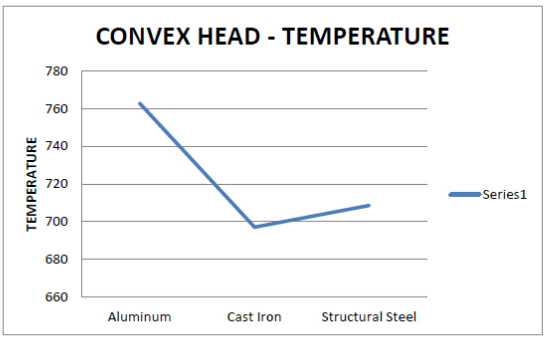

Fig 5.3 Plot MATERIAL VS TEMPERATURE Piston with Convex Head

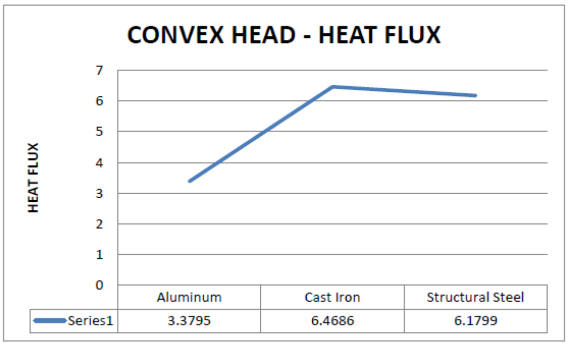

Fig 5.4 Plot Material vs Heat Flux Piston Convex Heat

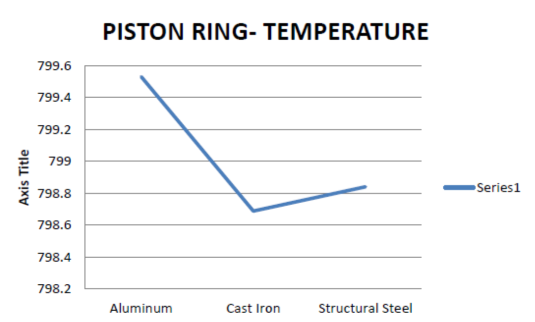

Fig 5.5 Material vs Temperature for model of Piston Rings

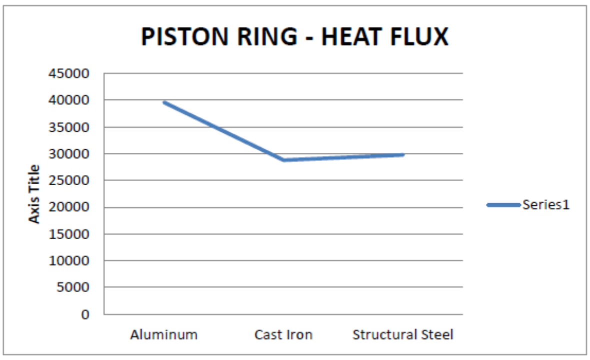

Fig 5.6 Material vs Heat Flux for model of Piston Rings

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CONCLUSIONS

In our undertaking we have structured a cylinder utilized in bike and displayed in 3D demonstrating programming CATIA and afterward we dissect the cylinder with various materials like Aluminum combination and Alloy steel with assistance of fem bundle ANSYS .In this Project we depicts the pressure appropriation of the seizure on cylinder Two stroke motor by utilizing FEA.

➢ By contrasting consequences of both the materials Aluminum combination and Alloy steel , the acquired outcomes, for example, warm warmth move are inside the protected zone of standard for level head and raised head cylinder.

➢ So, far the taken bore estimates the got outcomes are inside the norm and configuration is protected. At last the raised shape crown cylinder is having better plan as a result of the burdens are low contrasted with aluminum composite and warmth transition produced is additionally low.

➢ By changing cylinder materials with various pieces we can structure the cylinder as per their quality and warmth transitions are should likewise be possible by utilizing FEM.

➢ We Conclude and dissect the warm pressure dissemination of cylinder at the genuine
motor condition during ignition process

➢ By contrasting the above consequences of level head and arched head cylinder the warmth transition is more for aluminum amalgam than the cast iron material. In this manner Aluminum material is the best appropriate material for cylinder.

➢ By contrasting the above consequences of cylinder ring the warmth transition is more for Alloy steel than the cast iron material. Hence Aluminum amalgam material is the best appropriate material for cylinder

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