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Behavior of Piston with applied the Thermal load on Carbon Graphite and Aluminum Alloy 2618 as Piston materials and comparison with each other using Finite element analysis.

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Abstract- This paper shows the better material of piston using in IC engine. The motive of this paper to find the best piston material using finite element analysis. There are 2 different materials are taken, one is Carbon Graphite and other one is Aluminum Alloy 2618. Moreover, Piston of 100 cc hero bike engine was designed on Solidworks software using reverse engineering technique and meshed the model in solidworks simulation software for analysis. Thermal load as temperature of 473 degree kelvin applied on the top of the piston and found the Total Heat Flux & Temperature distribution and find the area where maximum heat is absorbed as well as compared the result for the selection of better material for piston of IC engine .

Keywords: FEA, Piston analysis, thermal load test , Total heat flux in piston , heat transfer analysis on piston, meshing, maximum temperature occur on piston.

I INTRODUCTION:

It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. The working of piston as in a spark ignition engine, the fuel is mixed with air and then inducted into the cylinder during the intake process. After the piston compresses the fuel-air mixture, the spark ignites it, causing combustion. The expansion of the combustion gases pushes the piston during the power stroke.

II FINITE ELEMENT ANALYSIS:

Finite element analysis (FEA) is a computerized method for predicting how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects. Finite element analysis shows whether a product will break, wear out, or work the way it was designed. It is called analysis, but in the product development process, it is used to predict what is going to happen when the product is used.

III. VOLUMETRIC PROPERTIES:

IV. MECHANICAL PROPERTIES:

Table 3: Carbon Graphite

Table 1: Aluminum Alloy 2618

S NO	PROPERTIES	VALUE
1	MASS	0.075 kg
2	VOLUME	2.72e-005m^3
3	DENSITY	2760 kg/m^3
4	WEIGHT	0.73 N

Table 2: Carbon Graphite

S NO	PROPERTIES	VALUE
1	MASS	0.060 kg
2	VOLUME	2.72e-005m^3
3	DENSITY	2240 kg/m^3
4	WEIGHT	0.59 N

S NO	PROPERTIES	VALUE
1	POISSONS RATIO	0.28
2	THERMAL EXPANSION COEFFICIENT	1.3e-005/K
3	DENSITY	2240 kg/m^3
4	THERMAL CONDUCTIVITY	168 W/(m-K)
5	SPECIFIC HEAT	44 J (kg-K)

Table 4: Aluminum Alloy 2618

S NO	PROPERTIES	VALUE
1	POISSONS RATIO	0.33
2	THERMAL EXPANSION COEFFICIENT	2.2e-005/K
3	DENSITY	2760 kg/m^3
4	THERMAL CONDUCTIVITY	146 W/(m-K)
5	SPECIFIC HEAT	875 J (kg-K)

IV. ENGINE SPECIFICATIONS:

Type	Air cooled, 4 - stroke single cylinder OHC
Displacement	97.2 cc
Max. Power	6.15kW (8.36 Ps) @8000 rpm
Max. Torque	0.82kg - m (8.05 N-m) @5000 rpm
Max. Speed	87 Kmph
Bore x Stroke	50.0 mm x 49.5 mm
Carburetor	Side Draft , Variable Venturi Type with TCIS
Compression Ratio	9.9 : 1
Starting	Kick / Self Start
Ignition	DC - Digital CDI
Oil Grade	SAE 10 W 30 SJ Grade , JASO MA Grade

V. REVERSE ENGINEERING THE PISTON:

With the help of measuring instruments like vernier caliper etc. the dimensions of the model piston were measured. By using this measurement 3D model of the piston were drawn using Solidworks 3D modeling software as below:

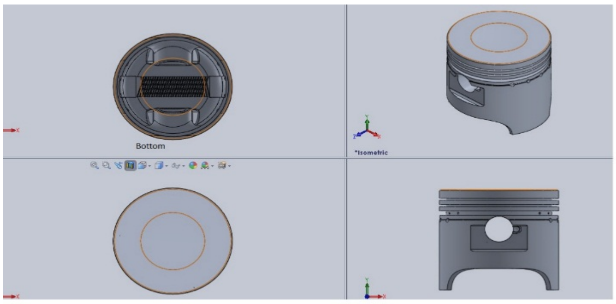

Figure 1. Model of Piston

VI. BOUNDARY CONDITIONS AND LOADS:

Applied Temperature value of 473 degree kelvin on the top of piston

Note: Units, boundary conditions and loads will be same in both tests.

VII. MESHING OF PISTON:

Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	2.94563 mm
Tolerance	0.147281 mm
Mesh Quality	High

Mesh Information - Details

Total Nodes	26221
Total Elements	14224
Maximum Aspect Ratio	90.342
% of elements with Aspect Ratio < 3	84
% of elements with Aspect Ratio > 10	0.443
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:07

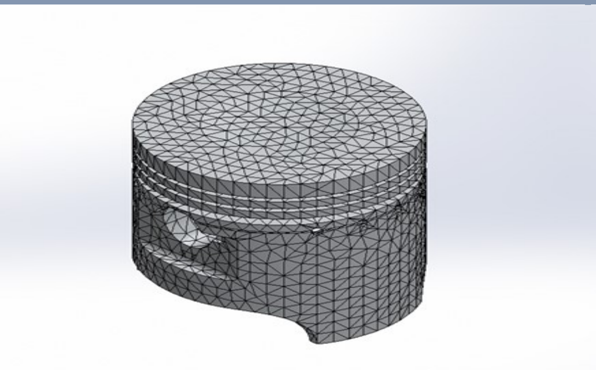

Figure 2: Meshed Model

VIII. Study Properties:

Study name	Study 1
Analysis type	Thermal(Transient)
Mesh type	Solid Mesh
Solver type	Direct sparse solver
Solution type	Transient
Total time	1 Seconds
Time increment	0.1 Seconds
Contact resistance defined?	No
Result folder	DEFAULT

IX .Units:

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

X. RESULTS AND DISCUSSIONS:

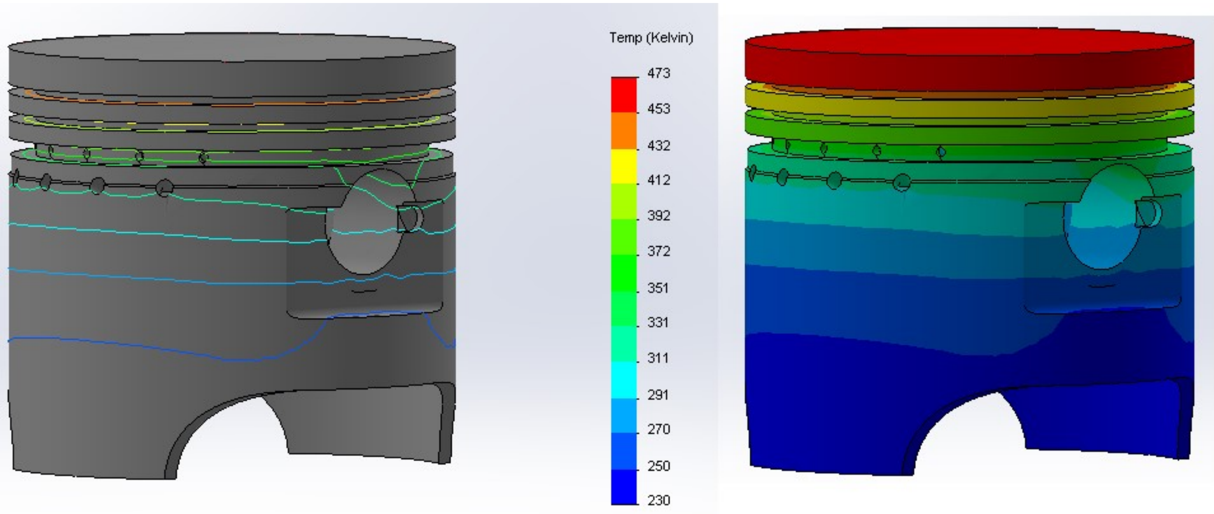

Figure 3. Temperature Distribution for Carbon Graphite

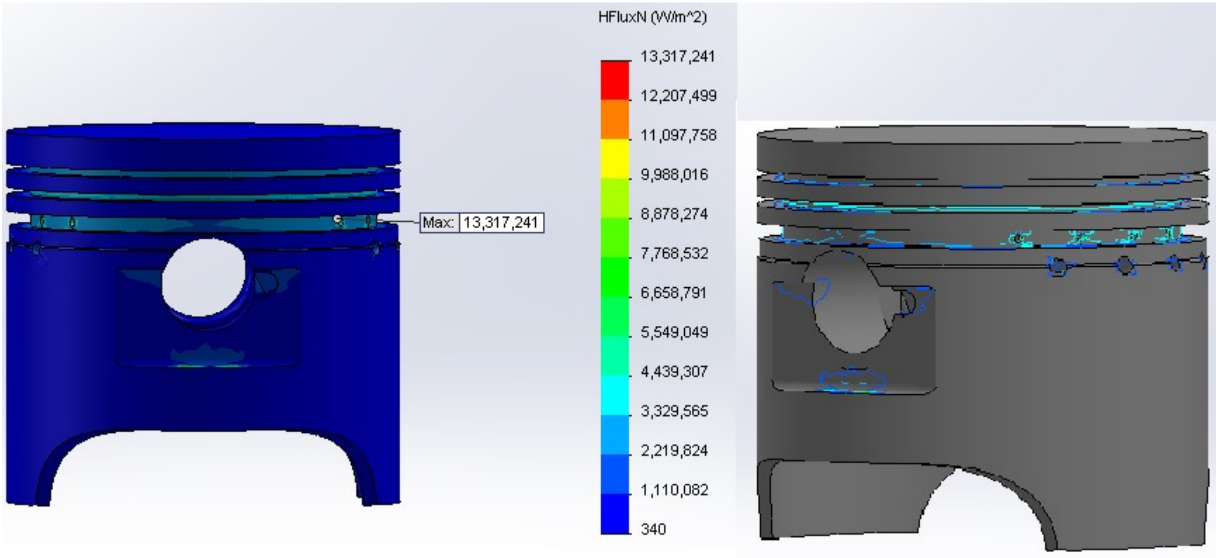

Figure 4. Total Heat Flux for Carbon Graphite

Figure 3. Result shows the maximum temperature occur on the top of the piston and excellent distribution of temperature till approximately end of the piston length found due to the heat generated by gases in the combustion chamber.

Figure 4. Here the result of Total heat flux shows the maximum value is found in the 3rd piston groove according to the result shown in upper image and found the heat transfer till just below the piston pin hole properly and slightly transfer till the area where the model shown in dark blue color.

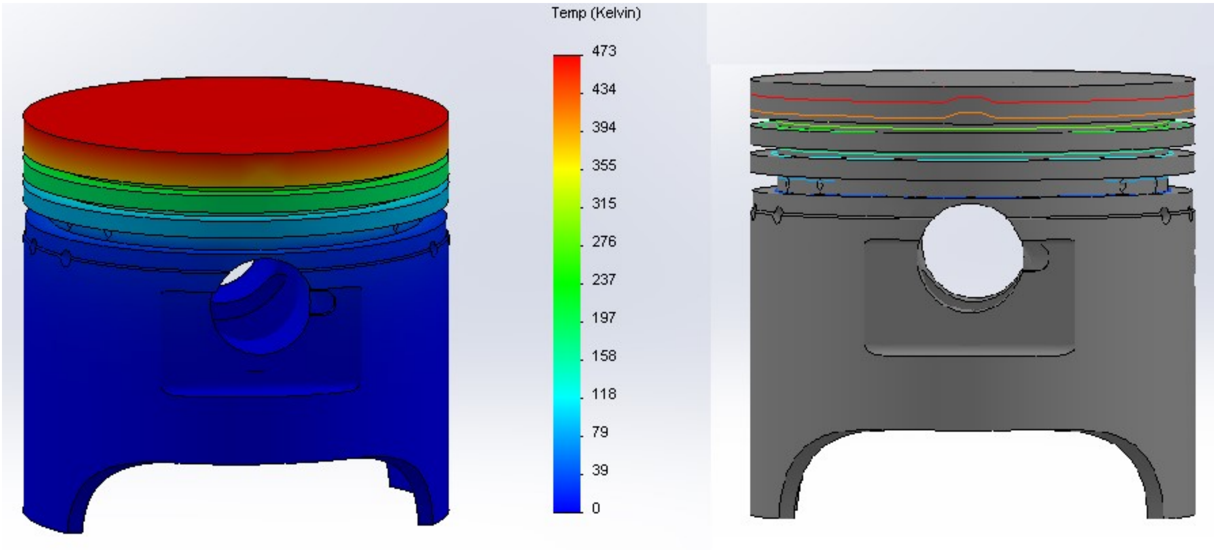

Figure 5. Temperature Distribution for Aluminum Alloy 2618

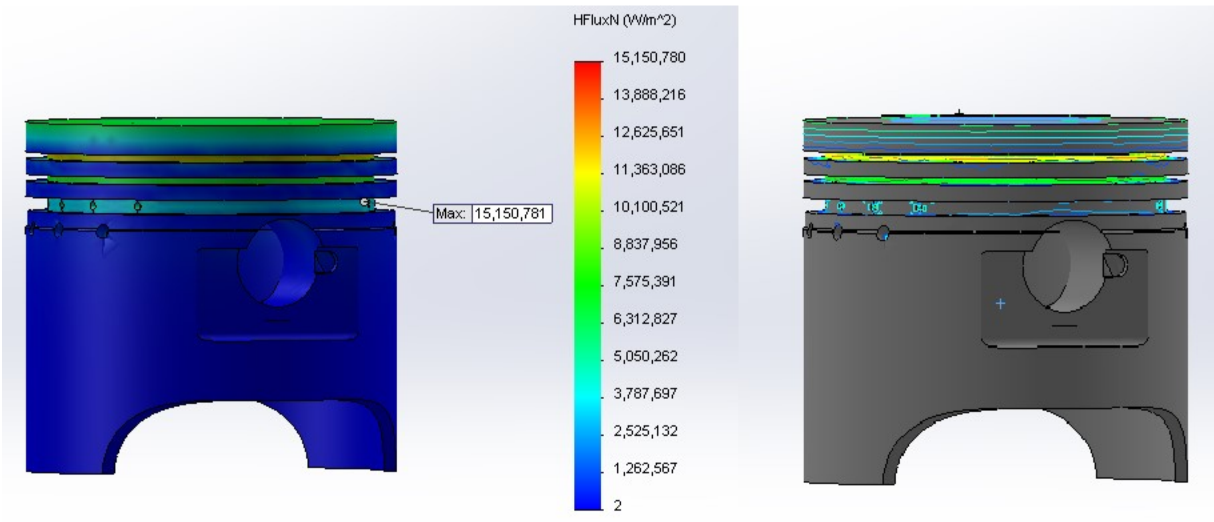

Figure 6. Total Heat Flux for Aluminum Alloy 2618

Figure 5. Result tells the maximum temperature occur on the top of the piston and distributed till 3rd groove of piston head properly due to the gases in the chamber.

Figure 6 . In this study , the maximum value of heat flux shown in the upper portion of 3rd groove of the piston ring and transferred properly till holes placed just down the 3rd groove and after that area the heat transfer found very low .

XI. CONCLUSION:

According to the result , there is none to say, the result clearly says the maximum heat transfer in the piston made of Carbon Graphite due to its higher thermal conductive and lower specific heat capacity as compared to another material as Aluminum Alloy 2618.

Other advantage of Carbon Graphite piston is that it has low thermal expansion coefficient as compared to aluminum alloy 2618 and according to the volumetric property of both of materials , it tells the Carbon Graphite has much lighter than Aluminum 2618.

On the other hand , Carbon Graphite are resistance against chemical attack and oxidation. Carbon shows an excellent resistance to thermal shock.

At last, Carbon Graphite found the best material for piston of IC engine and need to be developed.

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