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Analyze the Behavior of Carbon Graphite & Aluminum Alloy 2618 As Piston Material Applied Heat Flux Load on the Both of Materials of Piston Using Finite Element Method

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Abstract – This paper describes the thermal load analysis and comparison of piston made of Carbon Graphite and Aluminum alloy 2618. An example of 100 cc hero bike piston has been taken and drawn a 3D model with the help of measuring instruments using Solidworks software. The main motive is to find the Resultant Temperature Gradient value and location where maximum and minimum temperature occur as well as find the temperature distribution with applied the heat flux value of 100 W/m^2.k. The meshing of model of piston was done in solidworks simulation software used for analysis to find the result and comparison between both of materials of piston.

Index Terms – Thermal analysis, meshing, simulation, temperature gradient, heat flux analysis, piston thermal load testing, temperature distribution.

1. INTRODUCTION

Piston is a cylindrical member which is placed inside cylinder and on the combustion gases exerts pressure. It is made up of cast iron or aluminum alloy. 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. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. It absorbs the side thrust resulting from obliquity of the connecting rod. It also dissipates the large amount of heat generated by the combustion gases form the combustion chamber to the cylinder wall. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder wall.

2. FEM METHOD

The basic principles underlying the FEM are relatively simple. Consider a body or engineering component through which the distribution of a field variable, e.g. displacement or stress, is required. Examples could be a component under load, temperatures subject to a heat input, etc. The body, i.e. a one-, two- or three-dimensional solid, is modelled as being hypothetically subdivided into an assembly of small parts called elements – ‘finite elements’. The word ‘finite’ is used to describe the limited, or finite, number of degrees of freedom used to model the behavior of each element. The elements are assumed to be connected to one another, but only at interconnected joints, known as nodes. It is important to note that the elements are notionally small regions, not separate entities like bricks, and there are no cracks or surfaces between them. (There are systems available that do model materials and structures comprising actual discrete elements such as real masonry bricks, particle mixes, grains of sand, etc., but these are outside the scope of this course.)

3. 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
Air Filtration	Dry , Pleated Paper Filter
Fuel System	Carburetor
Fuel Metering	Carburetion

4. REVERSE ENGINEERING THE PISTON

The model of piston was measured using various kinds of measuring tools and drawn using Solidworks software. The different views of model are shown as below:

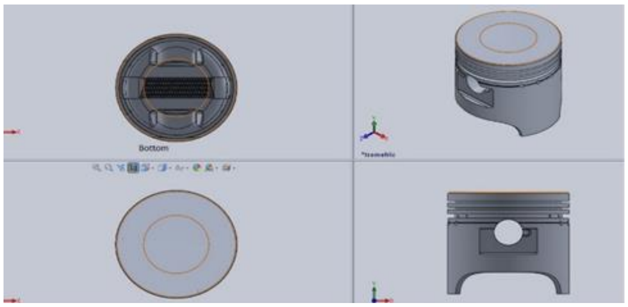

Figure 1. Model of Piston

5. VOLUMETRIC PROPERTIES

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

6. MECHANICAL PROPERTIES

Table 3: Carbon Graphite

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)

7. BOUNDARY CONDITIONS AND LOADS

Applied Heat Flux value of 100 W/m^2.k on the top of piston

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

8. 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

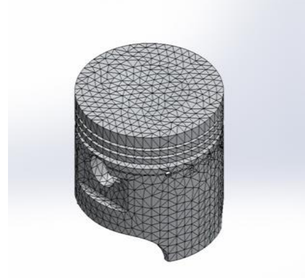

Figure 2: Meshed Model

9. 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

10. UNITS

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

11. RESULTS AND DISCUSSIONS

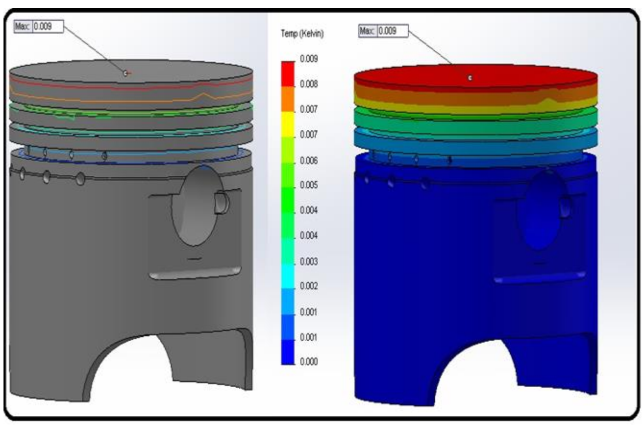

Figure 3. Temperature Distribution result for piston made of Aluminum Alloy 2618

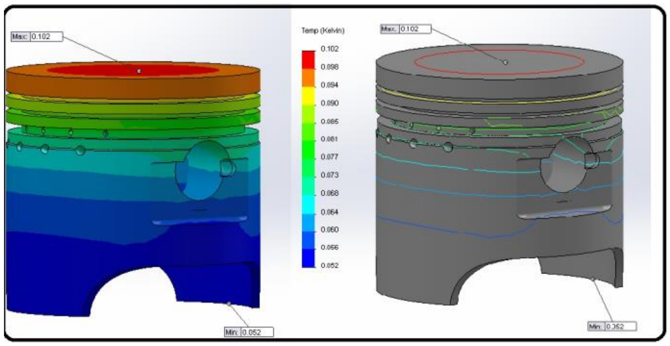

Figure 4. Temperature Distribution result for piston made of Carbon Graphite

Figure 3: Maximum Temperature shown on the top portion and edge of the piston and heat transfer by 3rd piston ring groove due to heat of gases in chamber.

Figure 4: Maximum Temperature shown on the top of the piston but does not shown on the edges and transferred by the last point of the piston length due to gases.

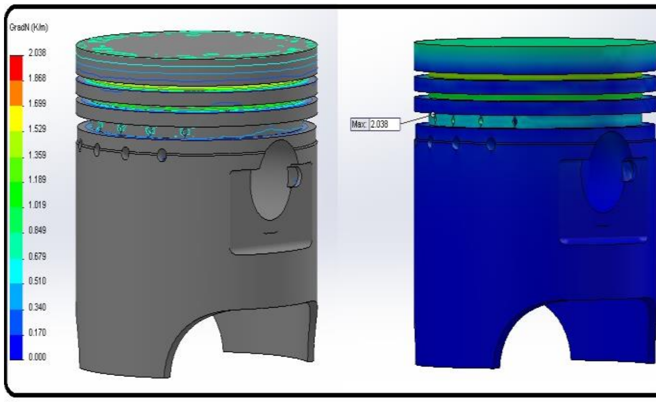

Figure 5. Resultant Temperature Gradient result for piston made of Aluminum Alloy 2618

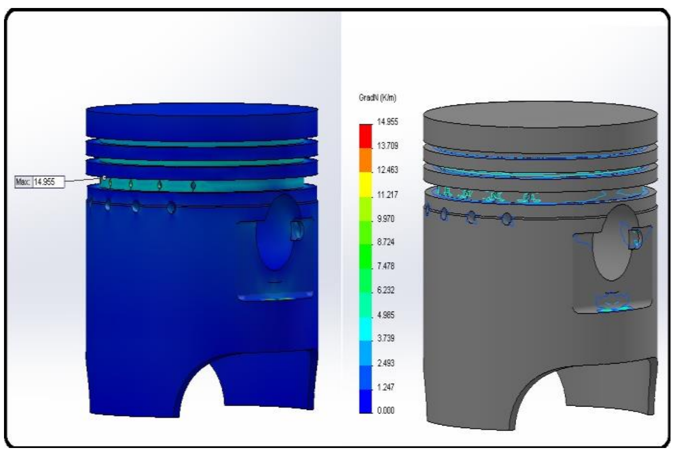

Figure 6. Resultant Temperature Gradient result for piston made of Carbon Graphite

Figure 5: Maximum Temperature shown on the 3rd groove of piston and transferred properly by holes placed just down the 3rd ring groove due to heat generated in combustion chamber of IC engine.

Figure 6. Maximum Temperature shown on the 3rd groove of piston and transferred properly till the hole of the piston pin. even it is also shows just down portion of the piston pin hole due to heat generated in combustion chamber of IC engine.

12. CONCLUSION

According to the above results, Maximum heat Transferred occur in the piston made of Carbon Graphite as compared to Aluminum Alloy 2618 due to the higher thermal conductivity and low specific heat capacity of the Carbon Graphite material where life of the piston will be increased. Moreover, Carbon Graphite is much lighter in weight than Aluminum Alloy 2618 as well as low thermal expansion coefficient, Furthermore, Carbon graphite is only material in which mechanical strength increase while temperature rise as compared to other metals. Furthermore, Carbon Graphite has self- lubricant properties which increase the operational reliability of the engine and reduced the consumption of lubricant. According to the above conclusion Carbon Graphite may be replaced as piston material in IC engine for better performance.

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