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Heat Power Analysis on different materials of piston using finite element thermal analysis

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Abstract- The paper shows the behavior of piston made of Carbon Graphite and Aluminum Alloy 2618 applied heat power value of 200 Watt. The result of Temperature distribution and resultant temperature gradient was found and the main motive is to find the comparison between both of materials of piston. An example of 100 cc hero bike piston was taken and drawn a 3D model in the Solidworks software after taken the dimensions using different measuring instruments and the model was meshed and analyzed using solidworks simulation software.

Keywords: heat power analysis, aluminum 2618 piston, thermal load testing, temperature gradient, heat transfer.

I INTRODUCTION:

A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. Moreover, The first person to experiment with an internal-combustion engine was the Dutch physicist Christian Huygens, about 1680. But no effective gasoline-powered engine was developed until 1859, when the French engineer J. J. Étienne Lenoir built a double-acting, spark-ignition engine that could be operated continuously.

II THERMAL ANALYSIS:

Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. Several methods are commonly used – these are distinguished from one another by the property which is measured: Dielectric thermal analysis (DEA): dielectric permittivity and loss factor. Thermal analysis is also often used as a term for the study of heat transfer through structures. Many of the basic engineering data for modelling such systems comes from measurements of heat capacity and thermal conductivity.

III. 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

IV. MECHANICAL PROPERTIES:

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)

Table 3: Aluminum Alloy 2618

Table 4: 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)

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

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:

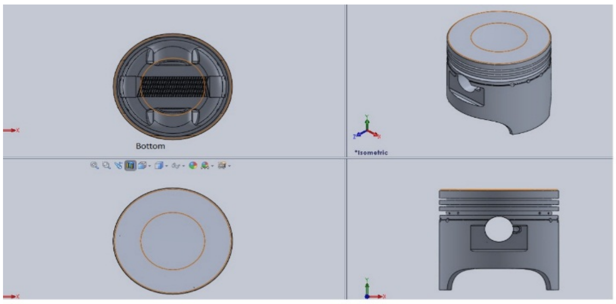

Figure 1. Model of Piston

VI. BOUNDARY CONDITIONS AND LOADS:

Applied Thermal load as heat power value of 200 Watt on the top of piston head.

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

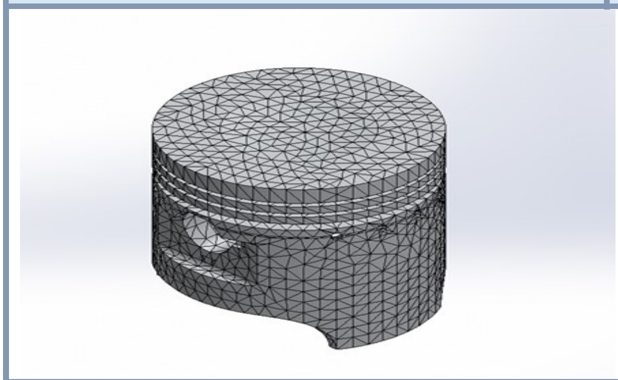

Figure 2: Meshed Model

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 DISCUSSION:

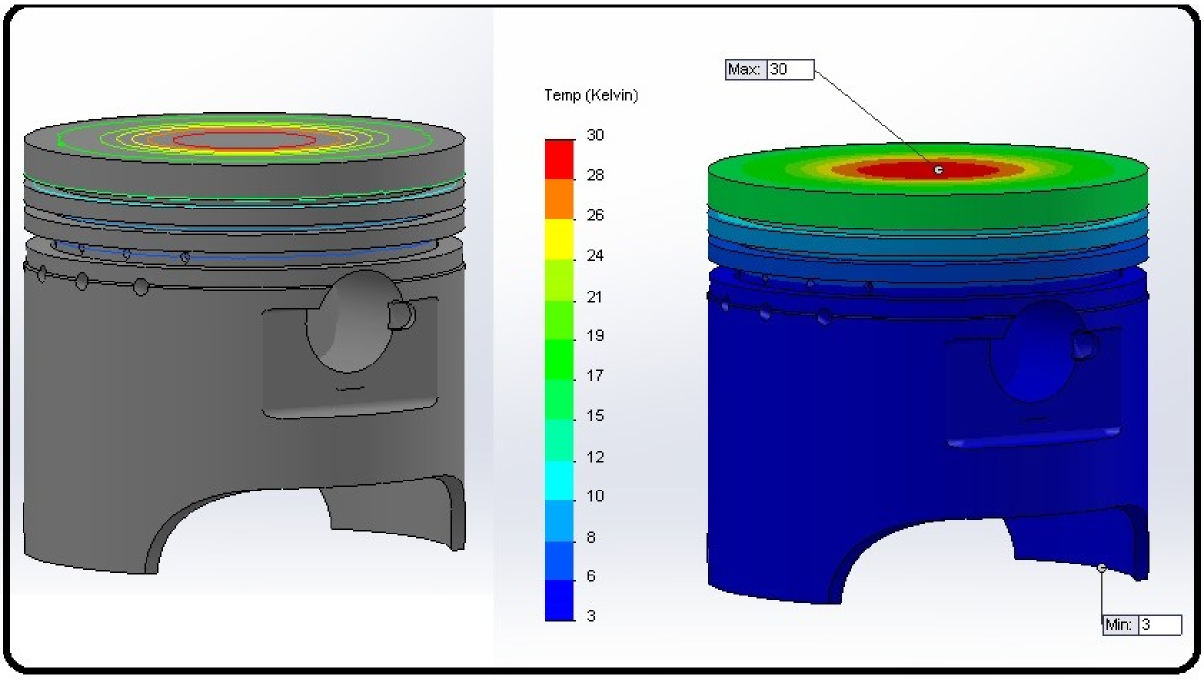

Figure 3.Result of Temperature distribution for Aluminum Alloy 2618

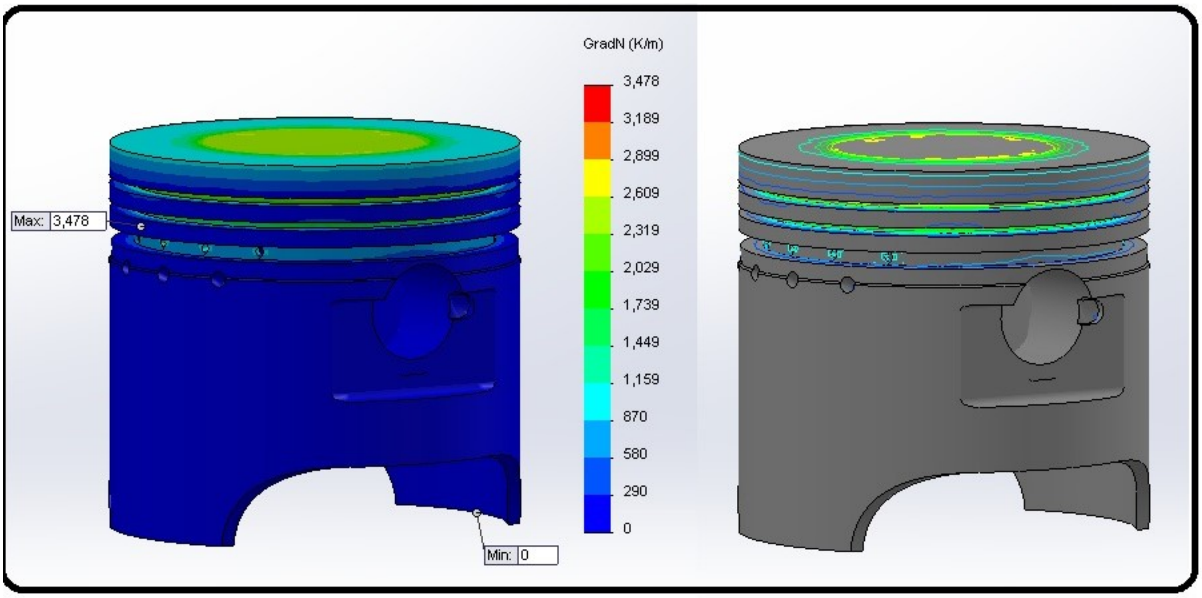

Figure 4. Resultant Temperature Gradient for Aluminum Alloy 2618

Figure 3: The maximum temperature shown on the top of the piston head and minimum 3 kelvin in the end portion of the piston due to heat produced by the gases in the combustion chamber.

Figure 4: In this study maximum temperature absorbed in just below the 2nd piston ring groove and heat transfer properly shows till the 3rd groove and slightly shown in the piston pin hole due to gases in the chamber.

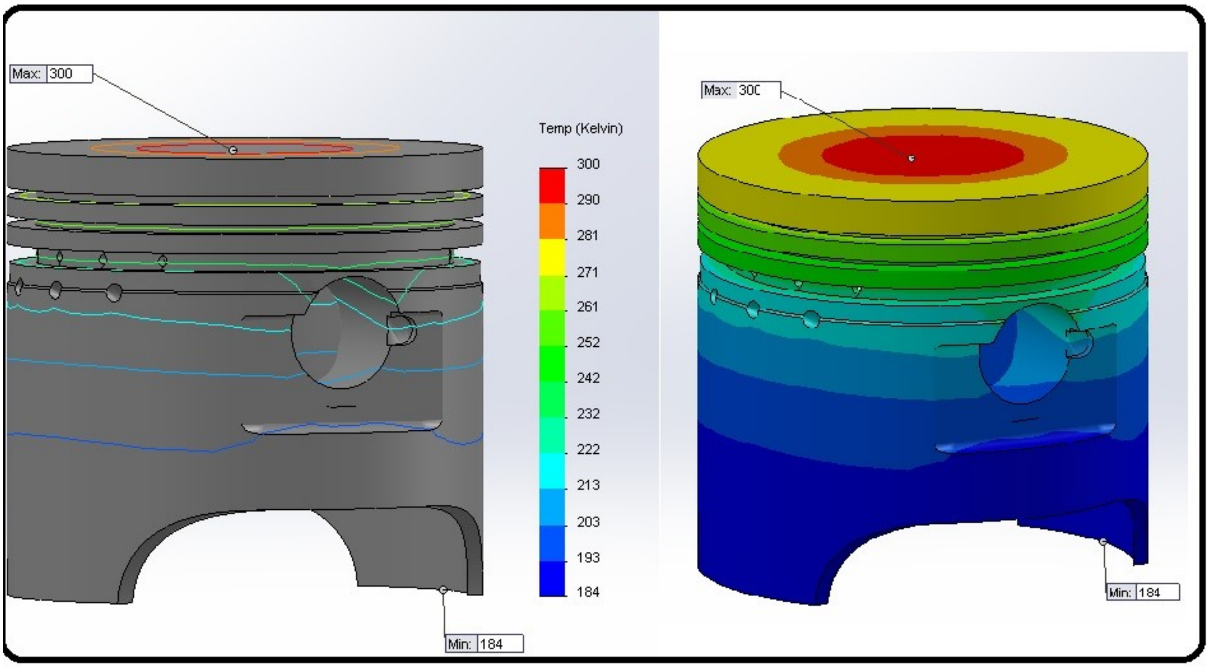

Figure 5. Temperature distribution result for Carbon Graphite material

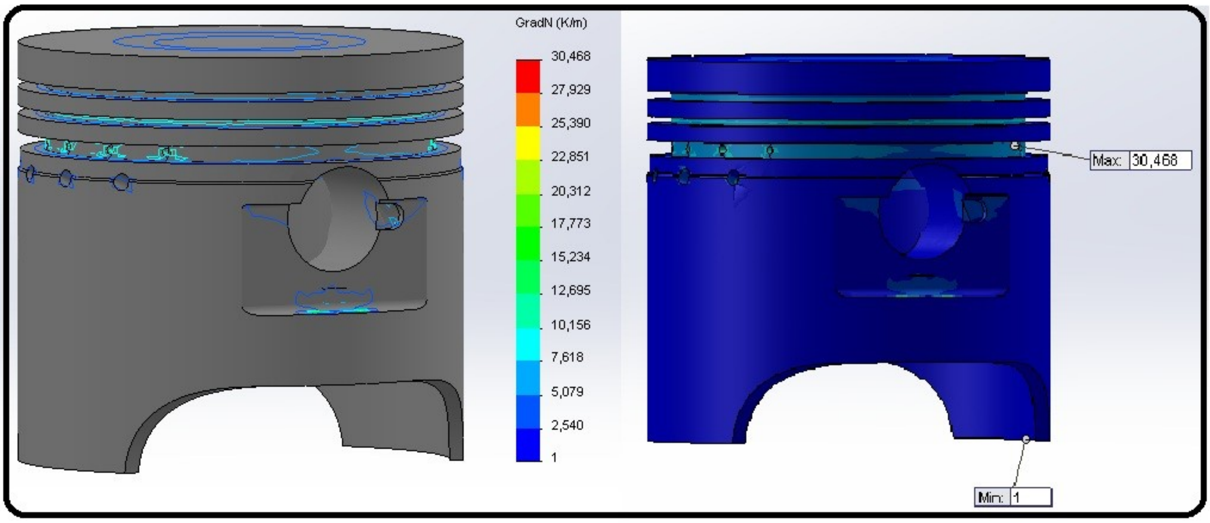

Figure 6 . Resultant Temperature Gradient for Carbon Graphite

Figure 5: The maximum Temperature occur on the top of the piston and excellent distributed till end of piston length due to heat in the combustion chamber.

Figure 6: Here the result shows the maximum value of resultant temperature gradient occur till last end portion of the piston and heat transfer shows till just below the piston pin hole properly as shown in image due to heat generated by the gases at the time of combustion in the chamber.

XI. CONCLUSION:

On the basis of above results, Maximum temperature distribution and heat transfer shown in the piston made of Carbon Graphite in the comparison of Aluminum Alloy 2618 . The Thermal conductivity of Carbon Graphite is higher than aluminum alloy 2618 as well as lighter in weight

Furthermore, Carbon Graphite is a self-lubricant material and its mechanical strength increase while temperature rise even other metals reduces.

Carbon Graphite found the more suitable material for piston of IC engine.

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