28.

FINITE ELEMENT ANALYSIS AND COMPARISON OF HEAT POWER LOAD APPLIED ON THE TOP OF THE PISTON MADE OF CARBON GRAPHITE AND CAST ALLOY STEEL

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Abstract- *This paper describes the Thermal load analysis and comparison between Carbon Graphite and Cast Alloy Steel as piston materials.The model of the piston drawn in solidworks software and meshed using solidworks simulation software. Thermal load as heat power value of 200 Watt applied on the top of the piston head and find the result in the form of Temperature distribution and resultant temperature gradient where thermal conductivity effects shown as behavior of material while heat transfer or conduct. Analysis part was done in solidworks simulation software and compared both of the materials with each other and the main motive was to find the better materials need to be use in an IC engine according to the advanced era.*

Keywords: finite element analysis, meshing , cast alloy steel, thermal analysis, carbon piston analysis, comparison of carbon piston and steel piston.

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. 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. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder wall

II FEM:

The finite element method (FEM) is a numerical method for solving problems of engineering and mathematical physics. It is also referred to as finite elementanalysis (FEA). ... To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements.Finite Element Analysis (FEA) is a computer based method of simulating/analyzing the behavior of engineering structures and components under a variety of conditions. It is an advanced engineering tool that is used in design and to augment/replace experimental testing.

III. VOLUMETRIC PROPERTIES:

Table 1: Cats Alloy Steel

S NO	PROPERTIES	VALUE
1	MASS	0.198 kg
2	VOLUME	2.72e-005m^3
3	DENSITY	7300kg/m^3
4	WEIGHT	1.94 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:

Table 3: Cats Alloy Steel

S NO	PROPERTIES	VALUE
1	POISSONS RATIO	0.26
2	THERMAL EXPANSION COEFFICIENT	1.5e-005/K
3	DENSITY	7300 kg/m^3
4	THERMAL CONDUCTIVITY	38 W/(m-K)
5	SPECIFIC HEAT	440 J (kg-K)

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:

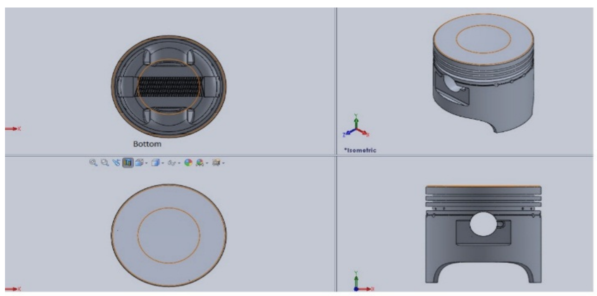

Figure 1. Model of Piston

VI. BOUNDARY CONDITIONS AND LOADS:

Applied Thermal Load as Heat power value of 200 Watt on the top of the 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

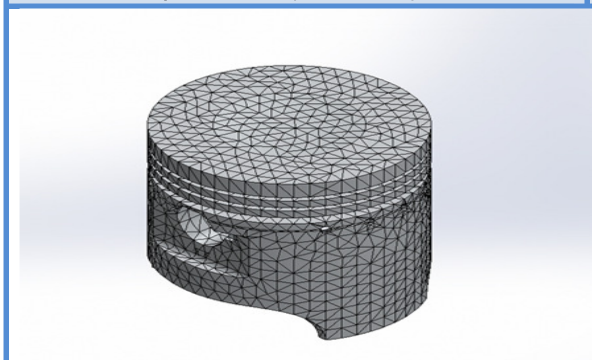

Figure 2: Meshed Model

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

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X. RESULTS AND DISCUSSION:

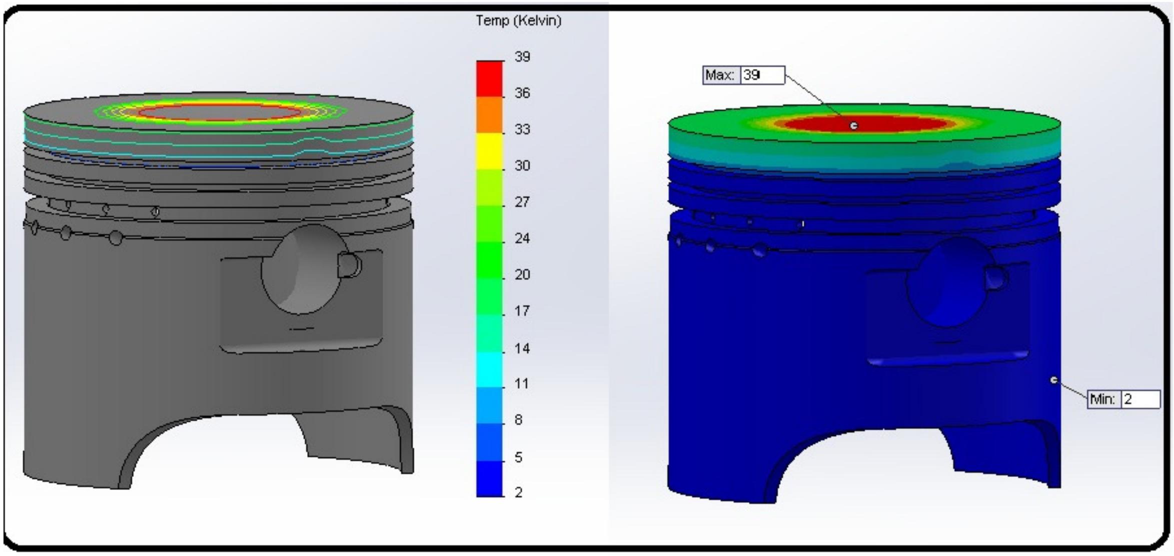

Figure 3.Result of Temperature distribution for cast alloy steel

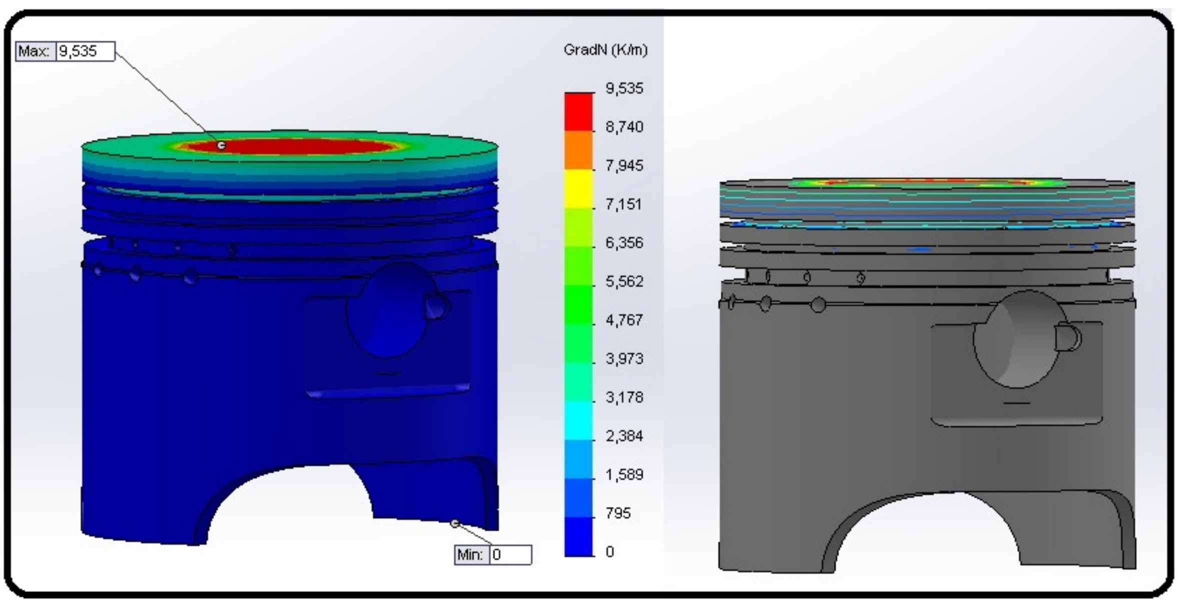

Figure 4. Resultant Temperature Gradient for Cast Alloy Steel

Figure 3: The maximum temperature shown on the top of the piston head and properly distributed till just below the piston pin hole due to heat produced by the gases in the combustion chamber.

Figure 4: In this study maximum temperature absorbed on the top of the piston head and heat transfer properly shows till the 1st groovedue to the gases in the chamber.

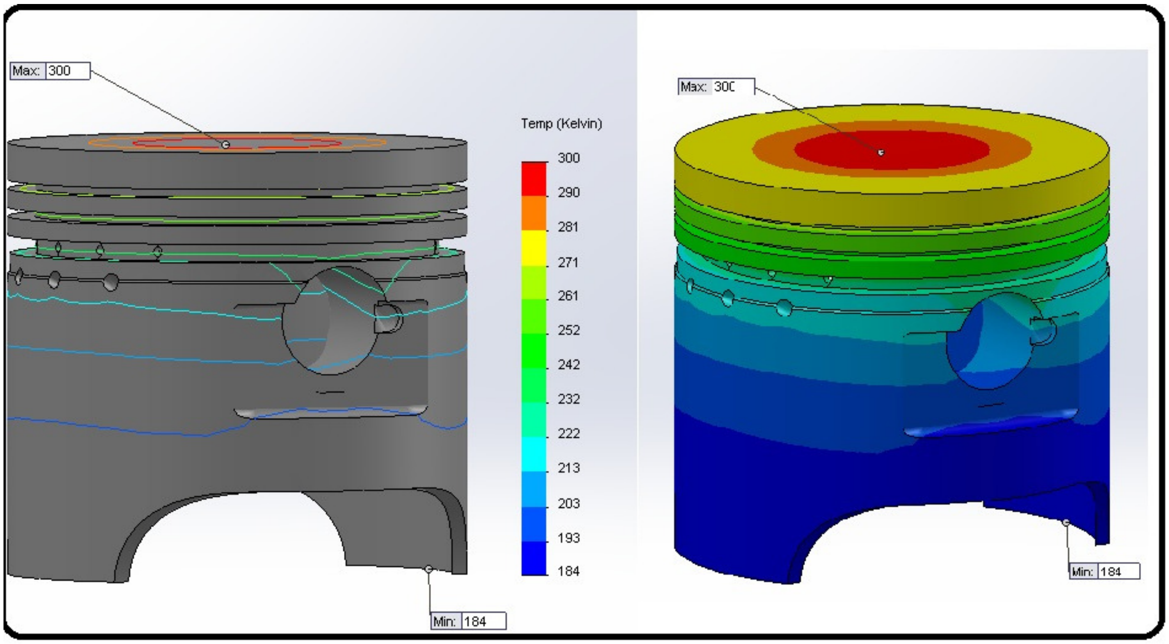

Figure 5. Temperature distribution result for Carbon Graphite material

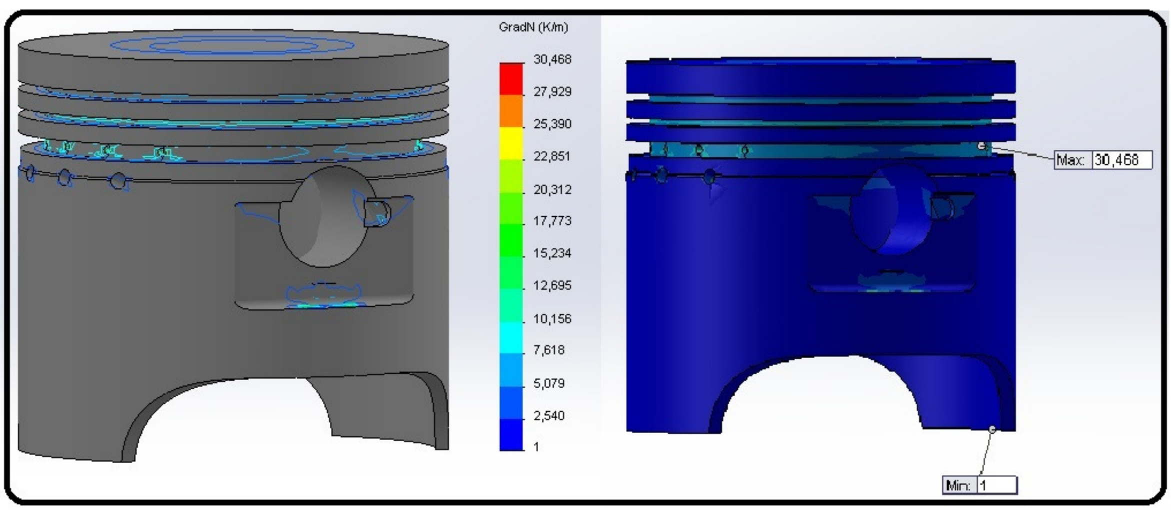

Figure 6 . Resultant Temperature Gradient for Carbon Graphite

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.

Figure6: 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 properlyas shown in image due to heat generated by the gases at the time of combustion in the chamber.

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XI. CONCLUSION:

As per above results and discussions , the result goes in the favor of piston made of Carbon Graphite material as compared to cast alloy steel. Carbon graphite has property of excellent thermal conductivity and lower specific heat capacity as compared to cast alloy steel.

Carbon Graphite has a self-lubricant property where oil consumption can be reduced and according to the volumetric property carbon graphite is a lighter in weight according to the cast alloy steel and it has low thermal coefficient expansion as compared to Cast alloy steel.

At last, In this advanced era Carbon Graphite piston is a need to replace with other materials for better engine efficiency.

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