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Comparison between the piston of IC engine made with Cast Carbon Steel and Carbon Graphite using finite element analysis (FEA)

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Abstract— Cast carbon steel and carbon graphite pistons were subjected to thermal loads in this study, which was carried out via the use of finite element analysis (FEA). The working gas temperature and the material qualities of the pistons are employed in the simulation. These pistons were studied using a four-stroke 100cc hero bike engine's specs. A four-stroke 100cc hero bike engine's specs are used to demonstrate an analytical design process for cast carbon steel and carbon graphite pistons. With an applied temperature of 600 Kelvin (K), the FEA findings predict the GRADN: Temperature gradient and critical region on both pistons. It is crucial to identify the key region and the benefits and drawbacks of the two materials. As part of the design process, SolidWorks is used to create the 3D models of pistons (the Feature module), which are then meshes and

INTRODUCTION:

I. A piston is a cylinder-inside cylindrical component that exerts pressure on the combustion gases. Various materials are used to construct it. A piston rod and/or connecting rod are used in an engine to transmit the force generated by the expanding gas in the cylinder to the crankshaft. The piston rings seal the cylinder and enclose the moving component. The connecting rod's obliquity causes it to generate side thrust. Combustion gases also create a lot of heat, which is dissipated via the cylinder wall. The piston may also serve as a valve in certain engines, closing and opening apertures in the cylinder wall.

II. **FEM METHOD**:

The fundamentals of the FEM are straightforward. Assume that a field variable, such as displacement or stress, has to be distributed across a body or component of the engineering design in question. An example of this would be a component that is under stress, or a temperature that is being affected by a heat source. An 'element assembly' is used to represent a one-, two-, or three-dimensional solid's body as a collection of tiny bits known as 'finite elements.' As the number of degrees of freedom required to simulate each element is finite, the term "finite" is used. Only at the nodes, which are the connecting joints, are the components presumed to be connected. Because the components aren't independent things like bricks, they don't have any gaps or surfaces in between them. Discrete materials and structures may be modelled using systems that already exist.)

However, this course does not include aspects like as real-masonry bricks, particle mixtures, sand grains, or any of the like.)

III. METHODOLOGY OF PROPOSED WORK:

This project's approach is based on the data that was gathered and analysed throughout the investigation phase. Designing pistons requires the following methods:

IC engine piston development data collection.

Taking apart a system to find out what went wrong. This piston and its predicted dimensions were measured and replicated as a 3-D model in Solidworks software, and then examined in Solidworks Simulation..

Using the software's library to choose material.

Pistons mated together.

Boundary conditions may be applied.

Calculation of the outcome.

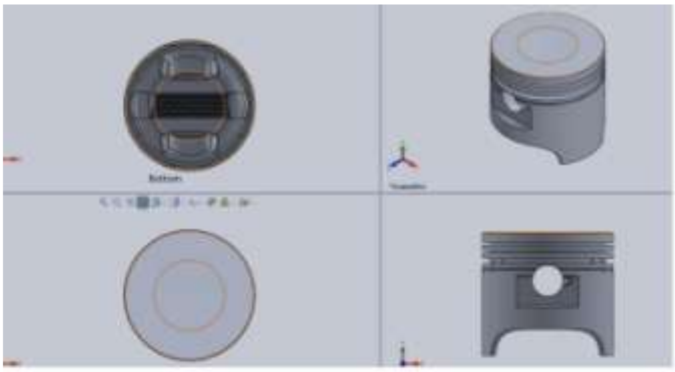
Thermal load analysis is performed by comparing the resulting temperature gradients.

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

I. REVERSE ENGINEERING THE PISTON:

The dimensions of the model piston were measured using vernier callipers and other measurement devices. In order to create a 3D model of this piston, SolidWorks 3D modelling software was used:



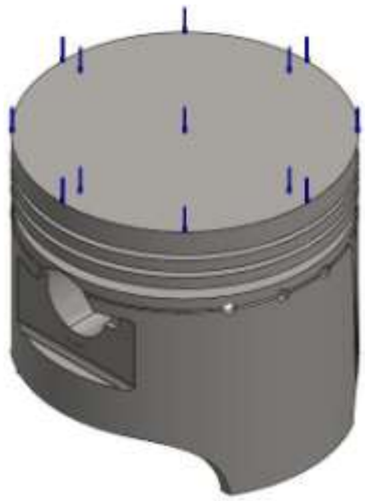
VI. BOUNDARY CONDITIONS AND LOADS:

Temperature was applied to the top of the piston at 600 Kelvin, and the piston pin holes were fixed.

Both tests will use the same units, boundary conditions, and loads

. VII. ANALYSIS ON CAST CARBON STEEL PISTON:

Model Information



Model name: Part1

Current Configuration: Default

Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified

<piston for study>-	Solid Body	Mass:0.199708 kg Volume:2.56036e-005 m^3 Density:7800 kg/m^3 Weight:1.95714 N	

Study Properties

Study name	Study 1
Analysis type	Thermal(Transient)
Mesh type	Solid Mesh
Solver type	FFEPlus
Solution type	Transient
Total time	1 Seconds
Time increment	0.1 Seconds
Contact resistance defined?	No
Result folder	SolidWorks document (c:\users\dell\appdata\local\temp)

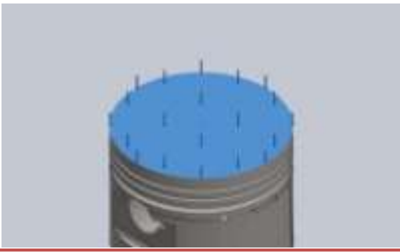
Units

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

Material Properties

Model Reference	Properties	Components
	Name: **Cast Carbon Steel** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress** Thermal conductivity: **30 W/(m.K)** Specific heat: **500 J/(kg.K)** Mass density: **7800 kg/m^3**	**Default**
Curve Data:N/A		

Thermal Loads

Load name	Load Image	Load Details
Temperature-1		**Entities: 1 face(s)** **Temperature: 600 Kelvin**

Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points

Element Size	2.94848 mm
Tolerance	0.147424 mm
Mesh Quality	High

Mesh Information - Details

Total Nodes	26259
Total Elements	14251
Maximum Aspect Ratio	90.34
% of elements with Aspect Ratio < 3	83.9
% of elements with Aspect Ratio > 10	0.428
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:08
Computer name:	DELL-PC

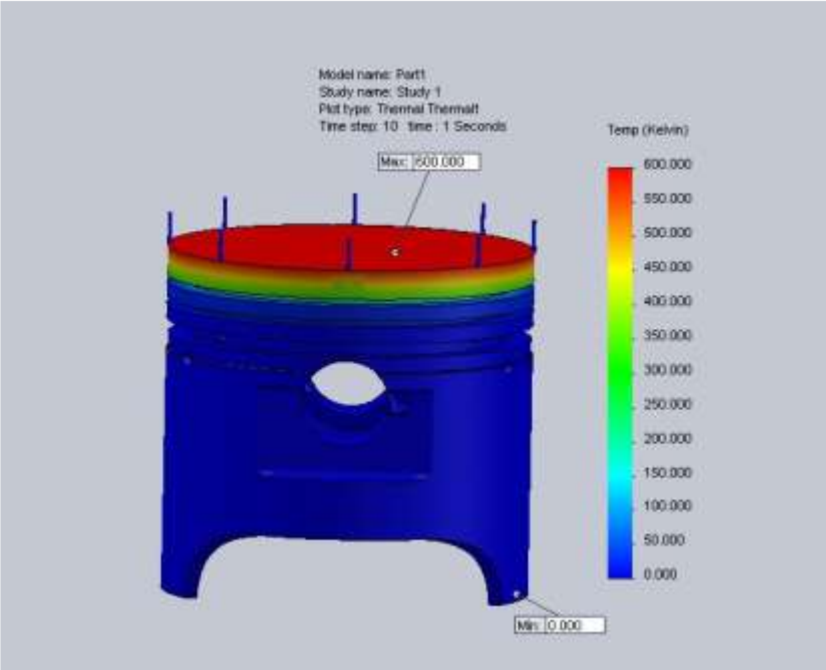


Figure- I

There is a 600 Kelvin maximum temperature on the piston head, while the lowest is 0 Kelvin at the piston bottom, which suggests that heat moves to the 1st groove of the piston ring.

VIII. ANALYSIS ON CARBON GRAPHITE PISTON:

Volumetric Properties:

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
LPattern2 	Solid Body	**Mass:0.0609817 kg Volume:2.7224e-005 m^3 Density:2240 kg/m^3 Weight:0.59762 N**	**DEFAULT**

Material Properties

Model Reference	Properties	Components
	**Name:** C (Graphite) **Model type:** Linear Elastic Isotropic **Default failure criterion:** Max von Mises Stress **Thermal conductivity:** 168 W/(m.K) **Specific heat:** 44 J/(kg.K) **Mass density:** 2240 kg/m^3	DEFAULT

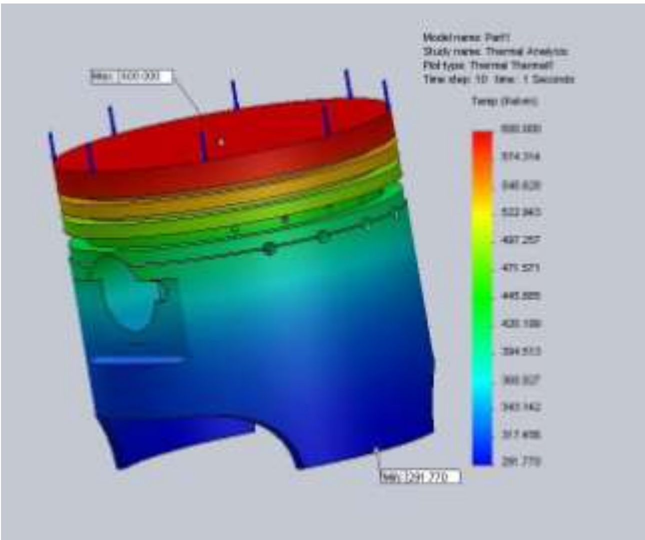


Figure – II

FIGURE II: According to the results shown in the figure, which show a maximum temperature of 600 Kelvin at the top of the piston head and a minimum temperature of 291.770 Kelvin at the bottom, the flow of heat is sufficient.

Conclusion-

Conclusion: Based on thermal (transient state) analysis results on Cast Carbon Steel piston (Result I) and c graphite (Result II), we found that the maximum heat flow occurred in c graphite instead of Cast Carbon Steel which is evidence that the thermal conductivity of Carbon Graphite Piston is much better than cast carbon steel piston which is best for the long life of the Piston.

It is also lighter than Cast Carbon Steel, which is better suited for an internal combustion engine. In contrast, carbon graphite has a lower thermal coefficient than Cast Carbon steel, which permits engine design to utilise smaller cold clearances without risking piston seize under heavy loads.

Carbon graphite pistons also have the benefit of having great thermal shock resistance and self-lubricant qualities, both of which contribute to the engine's operating durability and efficiency by reducing lubricant use.

When a result, C-Graphite is a corrosion resistant against acids and solvents, which helps to preserve

mechanical properties, and C-Graphite grows stronger as the temperature is increased.

Finally, based on the results of this research, Carbon Graphite pistons are superior than cast carbon steel pistons for IC engines.

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