Comparison of Carbon Graphite Piston with Grey Cast iron and Cast alloy steel by using Static Analysis method with pressure applied on piston.

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Abstract— The main objective of this research work is to investigate and analyze the stress distribution of piston at actual engine condition. In this paper static analysis with pressure applied on the top of piston head is done on different materials of piston as carbon graphite, grey cast iron and cast alloy steel. The parameter used for the analysis is operating gas pressure, temperature and material properties of piston. In I.C. Engine piston is most complex and important part therefore for smooth running of vehicle piston should be in proper working condition. Piston fail mainly due to mechanical stresses and thermal stresses. Analysis of piston is done with boundary conditions, which includes pressure on piston head during working condition .The 3D model is created using Solidworks software and FEA work is done in Solidworks simulation module.

Keywords— cast iron piston,IC engine piston, carbon graphite piston analysis, stress analysis on piston, strain, displacement, analysis on steel piston.

I. 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.

II. FEM (FINITE ELEMENT METHOD)

The finite element method (FEM) is a numerical method for solving problems of engineering and mathematical physics. It is also referred to as finite element analysis (FEA). Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain.To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses variational methods from the calculus of variations to approximate a

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solution by minimizing an associated error function.

III METHODOLOGY OF PROPOSED WORK

The methodology of this work is based upon information collected and processed the study and research phase. The technique to be applied for the design of piston are as follows:

- Data gathering of recent development in IC engine piston.
- Reverse engineering this piston, and calculated dimensions were measured and reproduced as a 3-D model in Solidworks software, and analyzed in Solidworks Simulation.
- Selection of Material from software's library
- Meshing of Piston.
- Applying Boundary conditions.
- Result calculation.
- Comparing Total deformation and Max. Von misses stress in Static analysis.

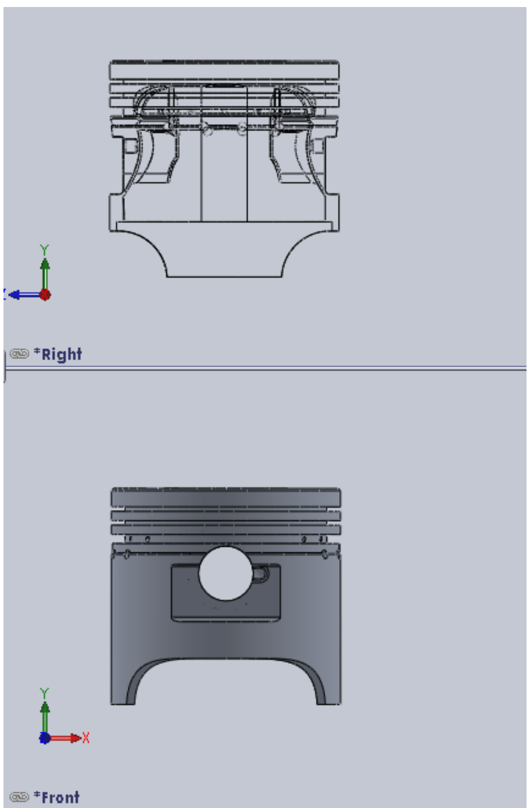
IV ENGINE SPECIFICATIONS

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:



VI. BOUNDARY CONDITIONS AND LOADS:

(i)Maximum gas pressure at top surface of the piston 5MPa

(ii)Piston pin holes are fixed.

Note: Model, mesh, Units, boundary conditions and loads will be same in all tests.

VII. ANALYSIS ON CAST IRON:

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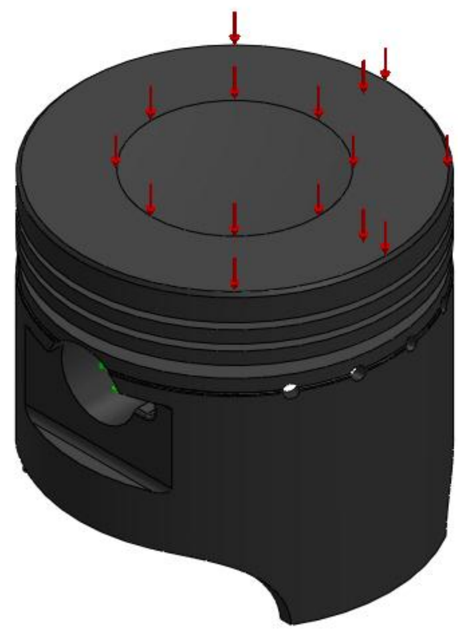
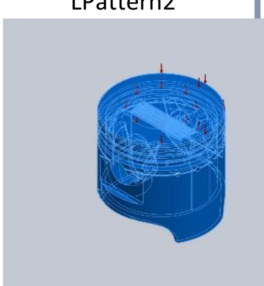
Volume 04 Issue 09
August 2017

Model Information



Model name: Piston 100cc_Hero Splendor
Current Configuration: Default

Solid Bodies			
Document Name and Reference	**Treated As**	**Volumetric Properties**	**Document Path/Date Modified**
LPattern2 	Solid Body	**Mass:0.196012 kg** **Volume:2.7224e-005 m^3** **Density:7200 kg/m^3** **Weight:1.92092 N**	**DEFAULT**

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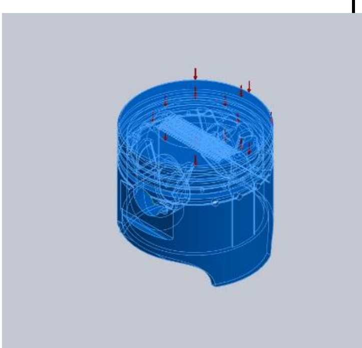
Volume 04 Issue 09
August 2017

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:** Gray Cast Iron **Model type:** Linear Elastic Isotropic **Default failure criterion:** Mohr-Coulomb Stress **Tensile strength:** 1.51658e+008 N/m^2 **Compressive strength:** 5.72165e+008 N/m^2 **Elastic modulus:** 6.61781e+010 N/m^2 **Poisson's ratio:** 0.27 **Mass density:** 7200 kg/m^3 **Shear modulus:** 5e+010 N/m^2 **Thermal expansion coefficient:** 1.2e-005 /Kelvin	Solid Body 1(LPattern2)(Piston 100cc_Hero Splendor)
Curve Data:N/A		

Mesh Information - Details

Total Nodes	139938
Total Elements	86193
Maximum Aspect Ratio	167.85
% of elements with Aspect Ratio < 3	90.8
% of elements with Aspect Ratio > 10	0.39
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:45
Computer name:	DEFAULT

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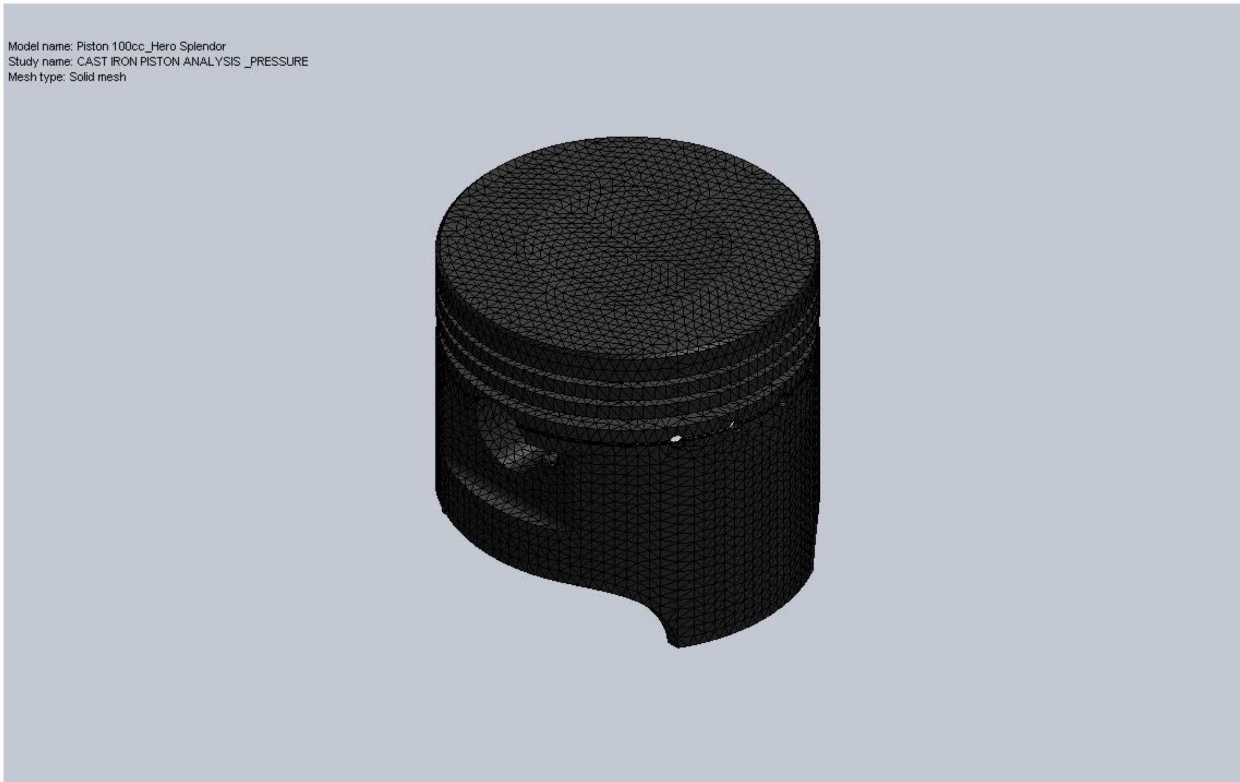
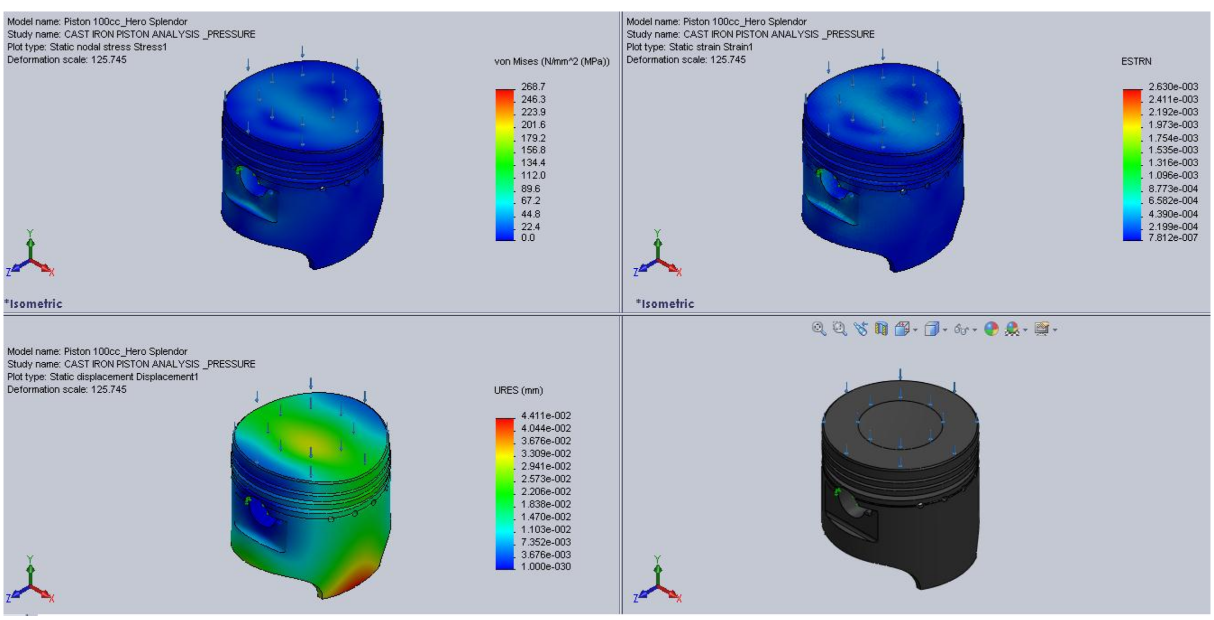


VIII. STRESS, STRAIN AND DISPLACEMENT PLOTS:



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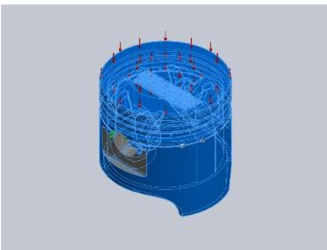
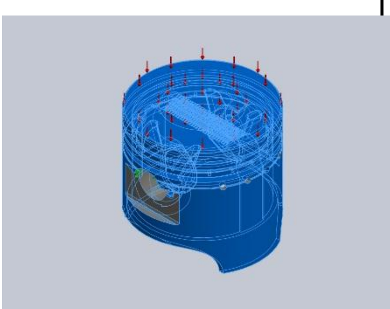
August 2017

IX. ANALYSIS ON CAST ALLOY STEEL:

Volumetric Properties:

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
LPattern2 	Solid Body	**Mass:0.198735 kg** **Volume:2.7224e-005 m^3** **Density:7300 kg/m^3** **Weight:1.9476 N**	**DEFAULT**

Material Properties

Model Reference	Properties	Components
	**Name:** Cast Alloy Steel **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Yield strength:** 2.41275e+008 N/m^2 **Tensile strength:** 4.48082e+008 N/m^2 **Elastic modulus:** 1.9e+011 N/m^2 **Poisson's ratio:** 0.26 **Mass density:** 7300 kg/m^3 **Shear modulus:** 7.8e+010 N/m^2 **Thermal expansion coefficient:** 1.5e-005 /Kelvin	SolidBody 1(LPattern2)(Piston 100cc_Hero Splendor)
Curve Data:N/A		

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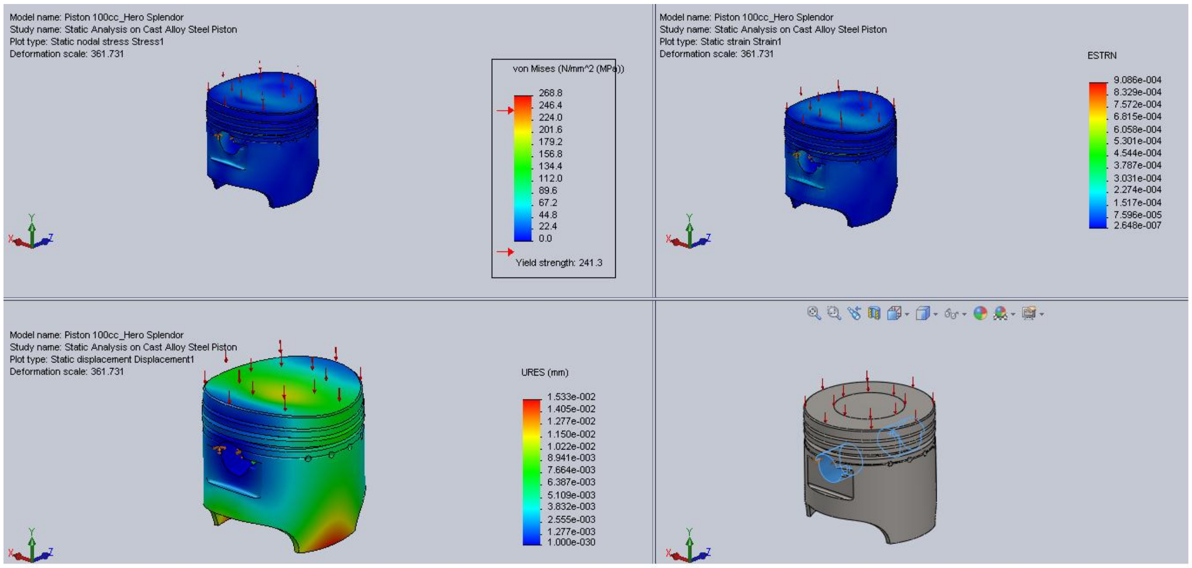
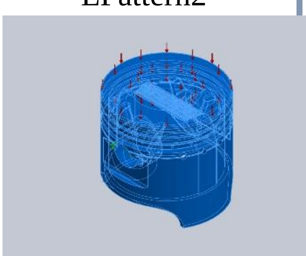
X. STRESS, STRAIN AND DISPLACEMENT PLOTS:



XI. 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**

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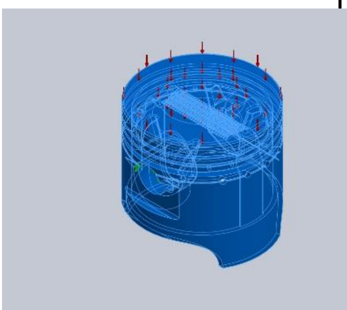
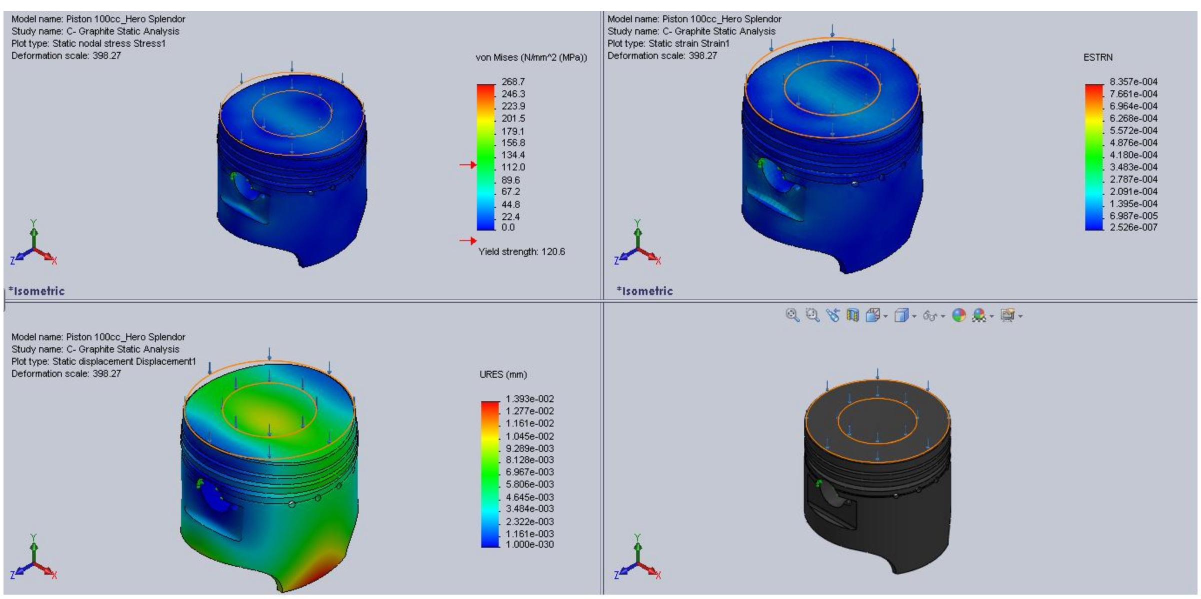
August 2017

Material Properties

Model Reference	Properties	Components
	**Name:** C (Graphite) **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Yield strength:** 1.20594e+008 N/m^2 **Tensile strength:** 1.00826e+008 N/m^2 **Elastic modulus:** 2.1e+011 N/m^2 **Poisson's ratio:** 0.28 **Mass density:** 2240 kg/m^3 **Thermal expansion coefficient:** 1.3e-005 /Kelvin	Solid Body 1(LPattern2)(Piston 100cc_Hero Splendor)
Curve Data:N/A		

X. STRESS, STRAIN & DISPLACEMENT PLOTS:



Conclusion-

In the conclusion, according to above static analysis results on cast iron, cast alloy steel and c-graphite pistons, we found according to result that the maximum stress value of carbon graphite and cast iron is same but slightly less than cast alloy steel.

Moreover, cast iron is lighter in weight in the comparison of cast alloy steel. But according to volumetric properties, Carbon Graphite material is much lighter than cast iron and cast alloy steel.

Furthermore, according to material properties cast iron has low Thermal expansion coefficient as compared to carbon graphite and cast alloy steel but according to properties, there is slightly difference between c-graphite and cast iron.

On the other hand, cast iron has good thermal conductivity as compared to cast alloy steel. But the carbon graphite has excellent thermal conductivity as compared to cast iron and cast alloy steel. There is so much difference.

At last, according to the above study, Carbon Graphite piston is much better as compared to cast iron and cast alloy steel for IC engine especially due to light weight and excellent thermal conductivity, in fact carbon shows an excellent resistance to thermal shocks.

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