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Analysis and Comparison of Carbon Graphite Piston over Cast Iron Piston of Four Stroke 100cc bike (Hero Splendor) Engine.

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Abstract— *This paper describes the stress , strain, displacement and thermal stresses of cast iron piston and carbon graphite piston by using finite element Analysis (FEA) .The parameters used for the simulation are operating gas pressure, temperature and material properties of pistons. The specifications used for the study of these pistons belong to four stroke 100cc hero bike engine. This paper illustrates the procedure for analytical design of cast iron piston and carbon graphite piston using specifications of four stroke 100cc hero bike engine. The results predict the maximum stress and critical region on cast iron piston and carbon graphite piston using FEA. It is important to locate the critical area of concentrated stress for appropriate modifications. The 3D model of the pistons drawn by using Solidworks (Feature module) and Simulation module was used to mesh the pistons and Static analysis (FEA)*

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

I. INTRODUCTION

A piston is a component of reciprocating engines, reciprocating pumps, gas 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 (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 vibrational methods from the calculus of variations to approximate a 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:

- ❖ Collection 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.
- ❖ Material selection for analyse from solidworks's library.
- ❖ Meshing of 3D model of piston.
- ❖ Apply the Boundary conditions.
- ❖ Result calculation.
- ❖ Comparison of 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

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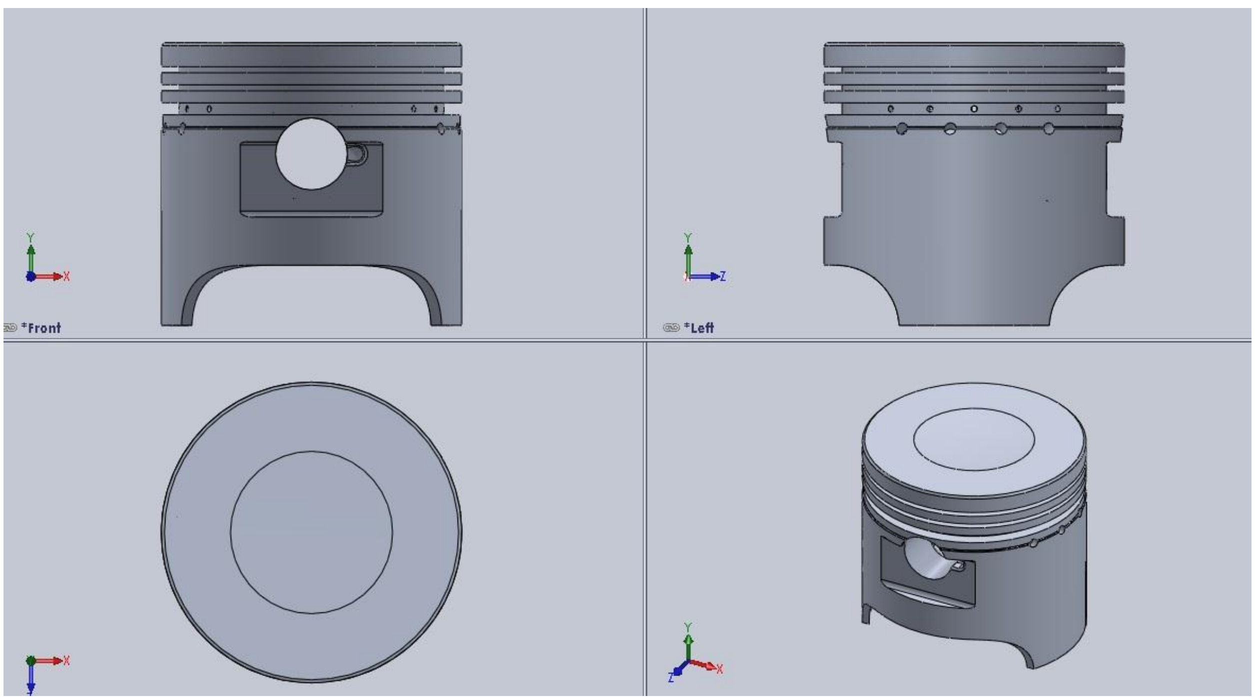
Air Filtration	Dry , Pleated Paper Filter
Fuel System	Carburetor
Fuel Metering	Carburetion

V Reverse Engineering the Piston:

With the help of vernier caliper the dimensions of the model piston were measured. By using this measurement 3D model of the piston were drawn using Solidworks modeling software.



VI. BOUNDARY CONDITIONS AND LOADS

(i)Maximum gas pressure at top surface of the piston 5MPa
(ii) Temperature at Top surface of the piston 400°C
(iii)Piston pin holes are fixed .

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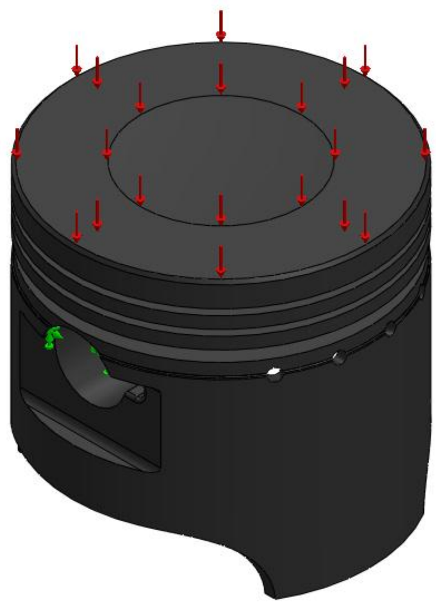
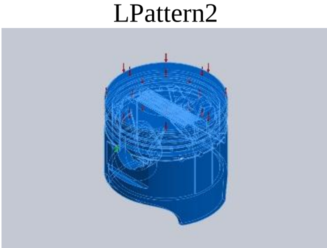
VII. Report of static analysis on cast iron piston where 5 MPa pressure applied on the top of the piston head as below:

Model Information



Model name: Piston 100cc_Hero Splendor
Current Configuration: Default

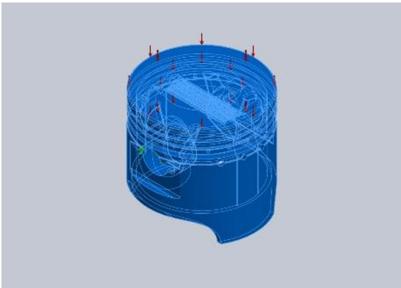
Solid Bodies

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** Aug 09 16:08:19 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:** Unknown **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	SolidBody 1(LPattern2)(Piston 100cc_Hero Splendor)

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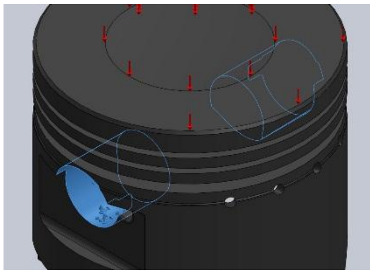
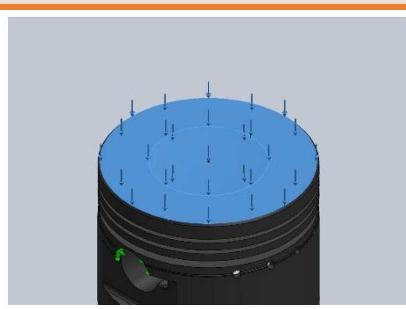
Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 2 face(s) **Type:** Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	-0.185829	9428.67	0.964079	9428.67
Reaction Moment(N·m)	0	0	0	0

Load name	Load Image	Load Details
Pressure-1		**Entities:** 2 face(s) **Type:** Normal to selected face **Value:** 5 **Units:** N/mm^2 (MPa)

Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	1.50467 mm
Tolerance	0.0752336 mm
Mesh Quality	High

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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):	00:00:44
Computer name:	JATENDERDATTA

m

Meshed Model

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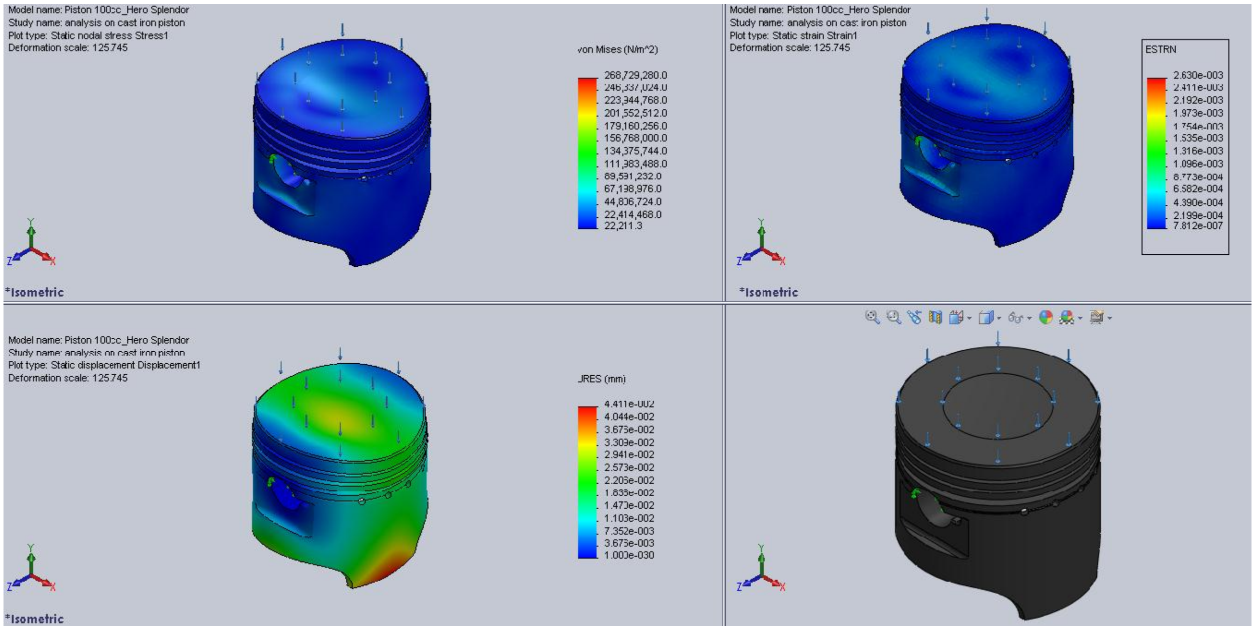
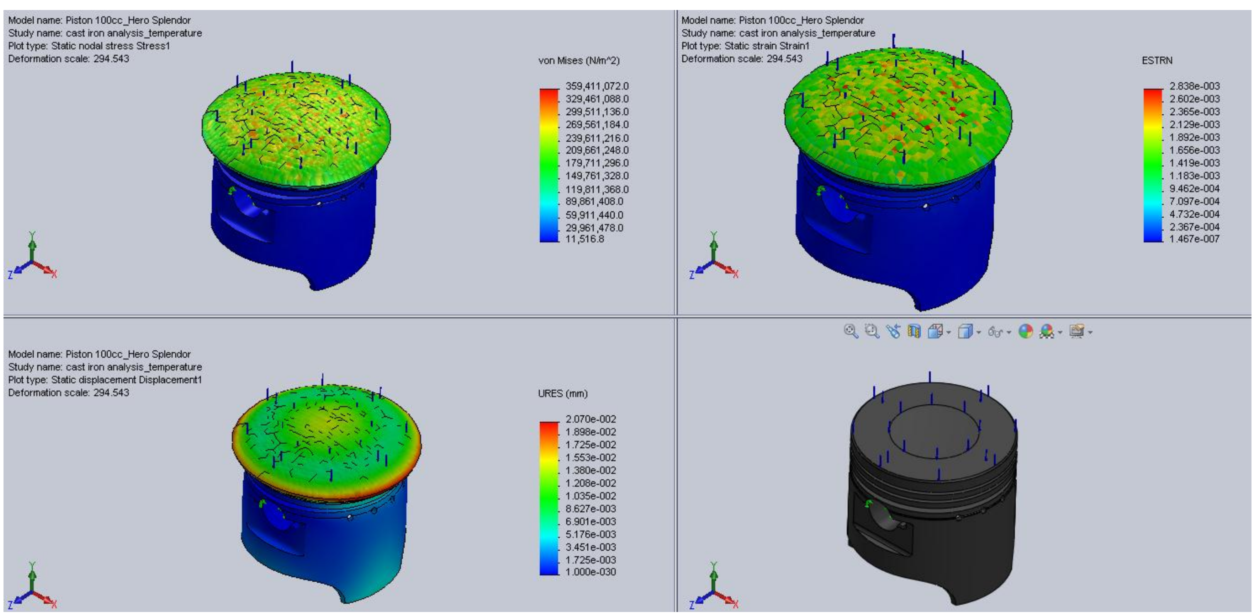


Study (I)

Here we found the result of static analysis where pressure of 5MPa has applied on the top of the piston head.

VIII. Result of static analysis on cast iron piston where temperature at top surface of the piston is 400°C as below-



Study (II)

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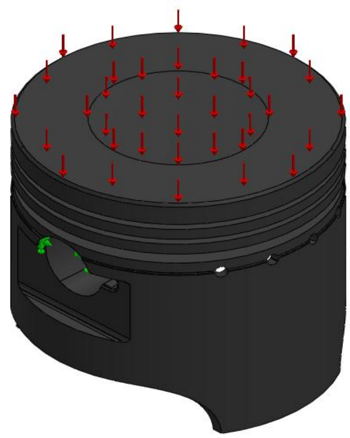
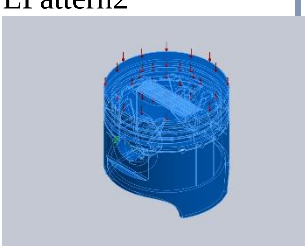
IX . Here, we compared cast iron material with C-Graphite, where the boundary conditions are same as previous studies as 5 MPa pressure applied on the top surface of the c-graphite pistion , the report of the static analysis on C-Graphite piston can be find as below-

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:0.0609817 kg** **Volume:2.7224e-005 m^3** **Density:2240 kg/m^3** **Weight:0.59762 N**	**Default** Aug 09 16:08:19 2017

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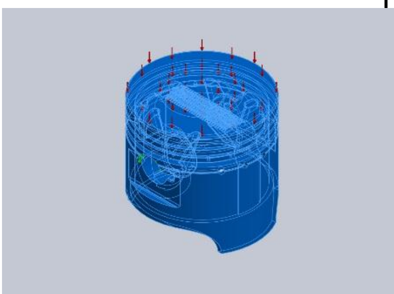
Material Properties

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	SolidBody 1(LPattern2)(Piston 100cc_Hero Splendor)
Curve Data:N/A		

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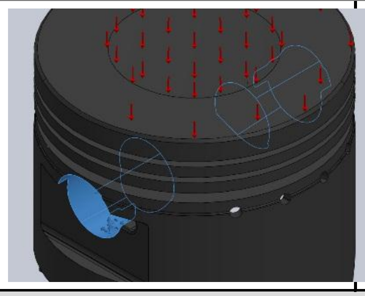
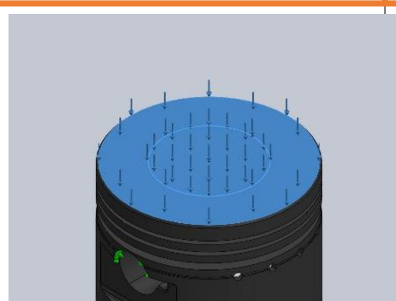
Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 2 face(s) **Type:** Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	-0.201809	9428.71	1.45164	9428.71
Reaction Moment(N·m)	0	0	0	0

Load name	Load Image	Load Details
Pressure-1		**Entities:** 2 face(s) **Type:** Normal to selected face **Value:** 5 **Units:** N/mm^2 (MPa)

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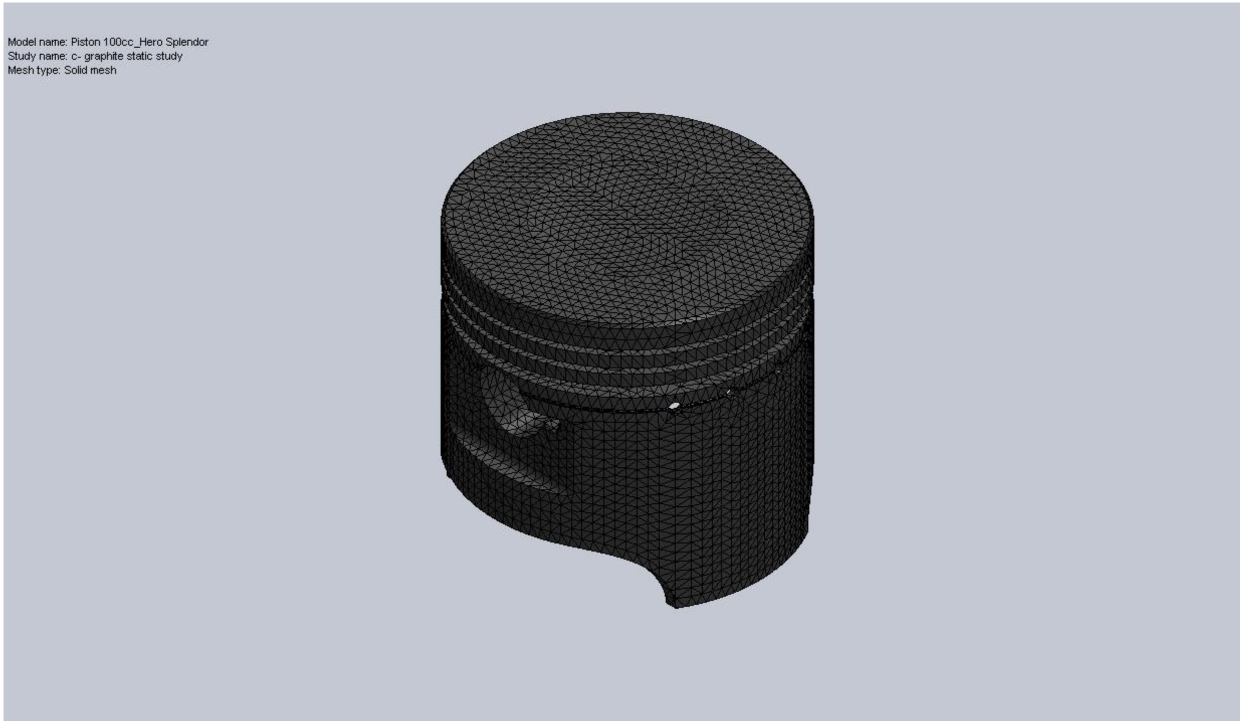
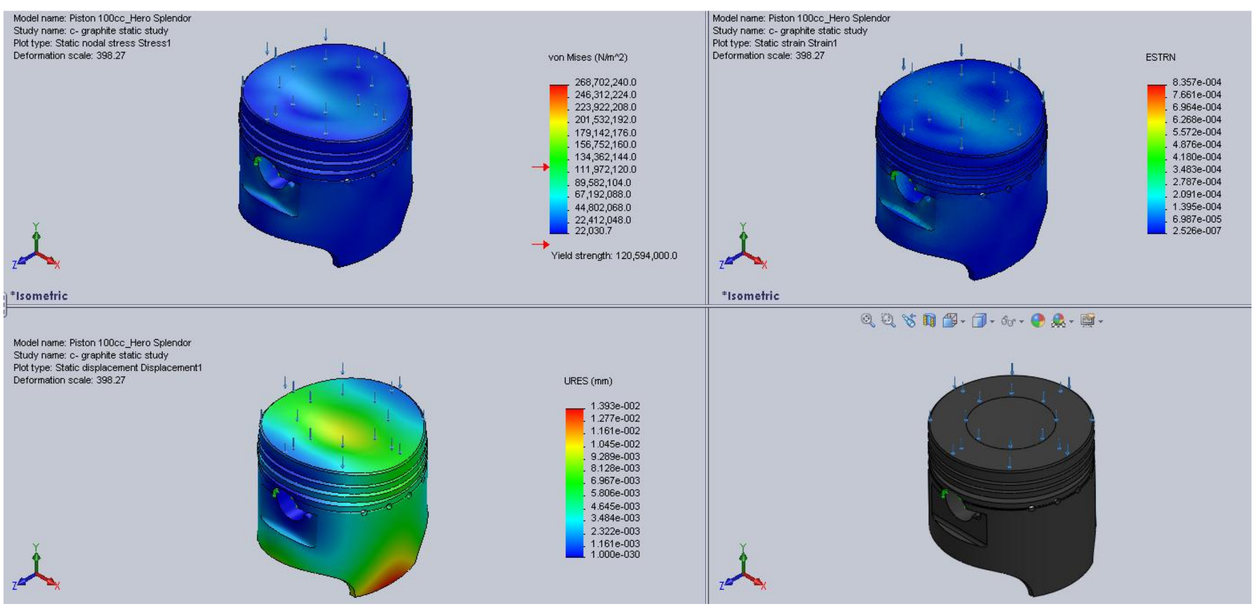


Meshed model



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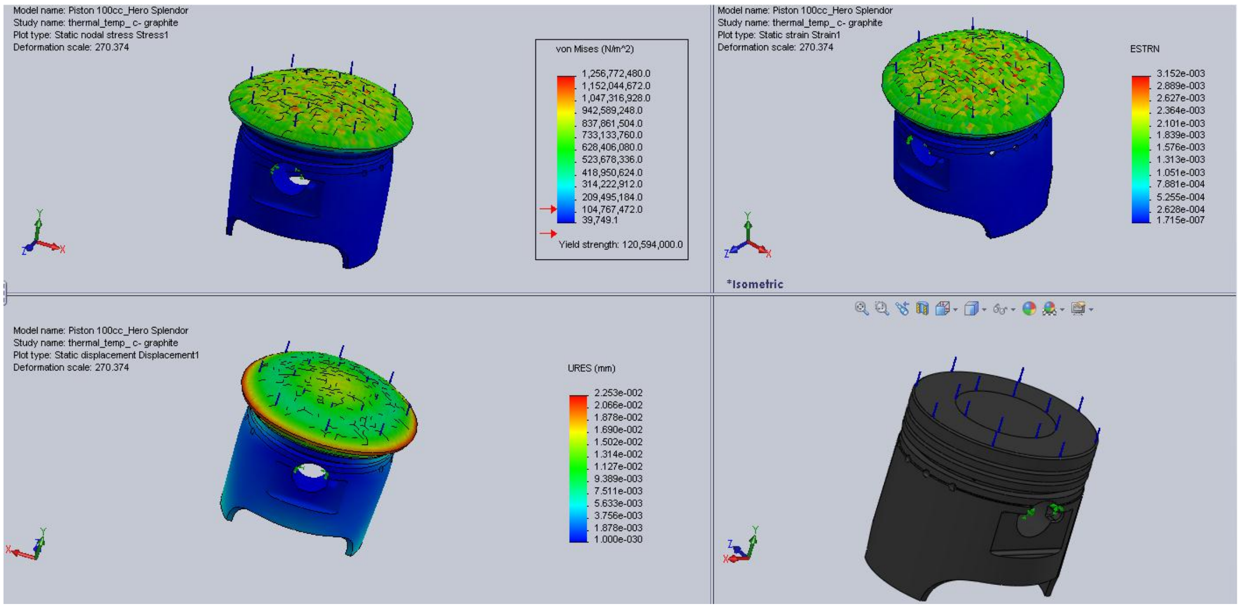
Study (III)

X. Result of static analysis on C- Graphite piston where temperature at top surface of the piston is 400°C



Study (IV)

XI. Static analysis on c-graphite piston again with same boundary conditions , but, this time the thickness of 1mm has been added on the bottom side of the piston head, the result can be find as below-

Model Information

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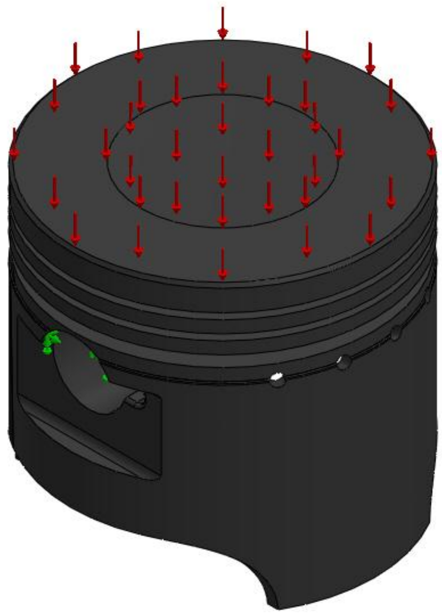
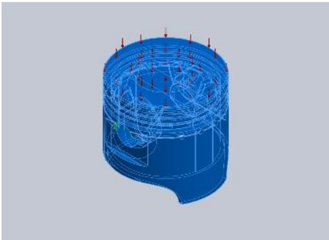


Model name: Piston 100cc_Hero Splendor_ modified
Current Configuration: Default

Solid Bodies			
Document Name and Reference	**Treated As**	**Volumetric Properties**	**Document Path/Date Modified**
Boss-Extrude8 	Solid Body	**Mass:0.0617103 kg** **Volume:2.75492e-005 m^3** **Density:2240 kg/m^3** **Weight:0.604761 N**	**Default** Aug 14 16:55:00 2017

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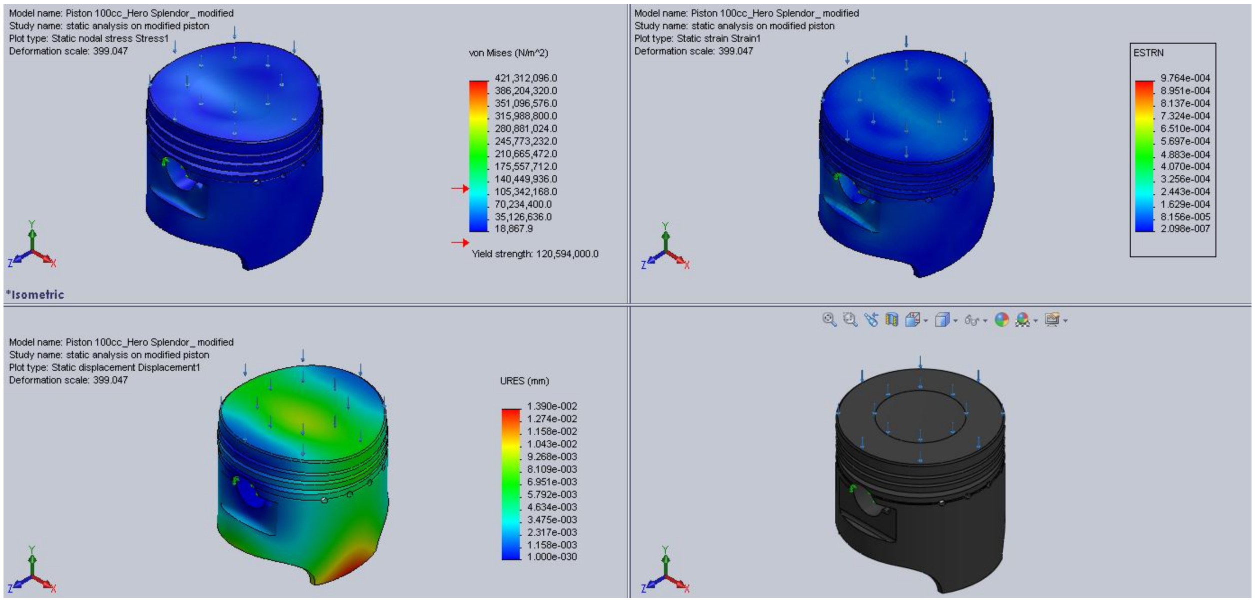

Study (V)

Conclusion-

In the conclusion, according to above static analysis results on cast iron piston (Study I) and c-graphite piston Study III, we found according to result that cast iron piston is slightly strong than c-graphite, but the result we got after slightly changing the design of c-graphite piston by 1mm (addition in thickness) on the bottom side of piston head then the results found differ than previous results, here the results are better than cast iron piston as shown in (study V).

On the other hand, when we analyzed both pistons (cast iron & c-graphite) as study II & study IV, after applied the temperature of 400°C on the top of the piston head then the results came out in the favor of c-graphite piston.

Furthermore, we compared c- graphite with cast iron then we found that C-graphite material is lighter in weight than cast iron according to volumetric properties, moreover, the thermal conductivity of c-graphite is much better than cast iron. At last, according to above results c-graphite piston is better than cast iron for IC engines.

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