International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 09
August 2017

Analysis and Comparison of Carbon Graphite Piston over Aluminum Alloy 4032 Piston of Four Stroke 100cc bike (Hero Splendor) Engine.

Jatender Datta
Student, Phd (Mechanical Engg.) Desh Bhagat University, Punjab(India) Email: jatindatta4@gmail.com
under the guidance of
Dr. Sahib Sartaj Singh
(Workshop Suptt , Department of Mechanical Engineering)
Punjabi University, Patiala (INDIA).

***Abstract*—** This paper describes the stress distribution, displacement and thermal stresses of aluminum alloy 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 aluminum alloy piston and carbon graphite piston using specifications of four stroke 100cc hero bike engine. The results predict the maximum stress and critical region on aluminum alloy piston and carbon graphite piston using FEA. It is important to locate the critical area of concentrated stress for appropriate modifications. The CAD model of the pistons was drawn by using Solidworks (Feature module) and Simulation module was used to mesh the pistons, Static and couple field analysis.

Keywords—IC engine piston, carbon graphite piston analysis, stress analysis on piston, strain, displacement, analysis on aluminum alloy 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. FINITE ELEMENT METHOD

Finite element analysis is a computer based numerical technique for calculating the strength and behavior of engineering structures. It can be used to calculate deflection, stress, vibration, buckling behavior and many other phenomena. It can analyze elastic deformation or "permanently bent out of shape" deformation. The computer is required because of the astronomical number of calculations needed to analyze a large structure. The power and low cost of modern computers has made finite element analysis available to many disciplines and companies.
With the rapid advancement of technology, the complexity of the problem to be dealt by

a design engineer is also increasing. This scenario demand speedy, efficient and optimal design from an engineer. To keep pace with the development and ensure better output, the engineer today resorting to numerical methods. For problems involving complex shapes, material properties and complicated boundary conditions, it is difficult and in many cases interactive to obtain analytical solutions. Numerical methods provide approximate but acceptable solutions to such problems.

Finite element analysis is one of such numerical procedure for analyzing and solving wide range of complex engineering problems (may be structural, heat conduction, flow field...) which are complicated to be solved satisfactorily by any of the available classical analytical methods.

The computer intervention is the backbone of the procedure since it involves the solution of many simultaneous algebraic equations, which can be solved easily by the computer. Actually Finite Element Method was originated as a method of stress analysis. But today the applications are numerous. Now days, each and every design is developed through Finite Element Analysis. The numerous applications include the fields of Heat transfer, Fluid flow, Lubrication. Electric and Magnetic fields, Seepage and other flow problems. The various areas of applications include design of buildings and bridges, electric motors, heat engines, aircraft structures, space crafts etc. With the advances in Interactive CAD systems complex problems can be modeled with relative ease. Several alternative configurations can be tried out on a computer before the prototype is built.

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.

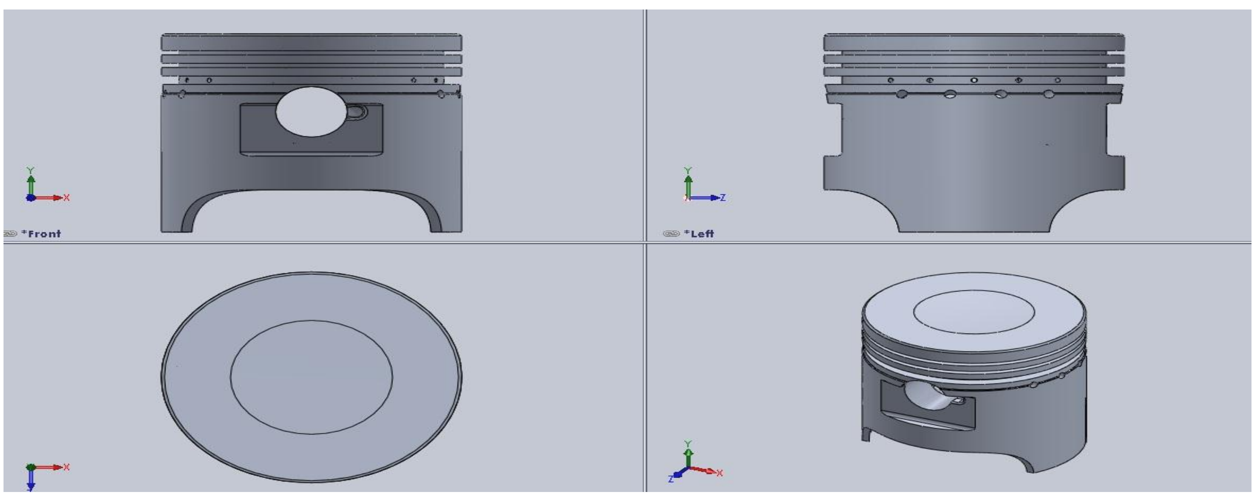
IV ENGINE SPECIFICATIONS

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 Aluminum Alloy 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

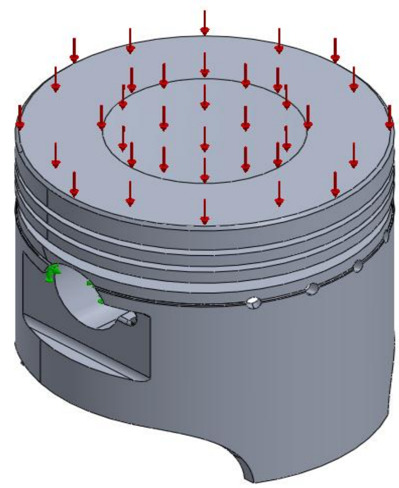
(i)Maximum gas pressure at top surface of the piston 5MPa

(ii) Temperature at Top surface of the piston 400°C

(iii)Piston pin holes are fixed .

VII. Report of static analysis on aluminum alloy 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

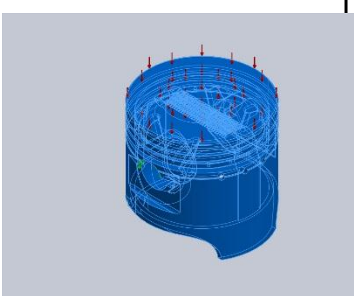
Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
LPattern2 	Solid Body	Mass:0.0729602 kg Volume:2.7224e-005 m^3 Density:2680 kg/m^3 Weight:0.71501 N	Default Aug 09 16:08:19 2017

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 09
August 2017

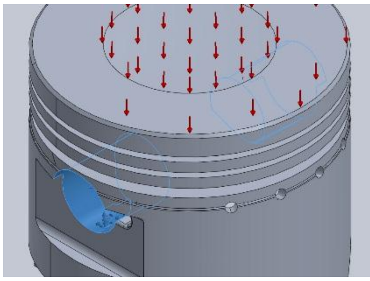
Units

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

Material Properties

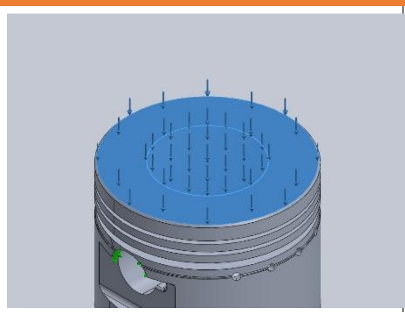
Model Reference	Properties	Components
	**Name:** 4032-T6 **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Yield strength:** 3.15e+008 N/m^2 **Tensile strength:** 3.8e+008 N/m^2 **Elastic modulus:** 7.9e+010 N/m^2 **Poisson's ratio:** 0.34 **Mass density:** 2680 kg/m^3 **Shear modulus:** 2.6e+010 N/m^2 **Thermal expansion coefficient:** 1.9e-005 /Kelvin	SolidBody 1(LPattern2)(Piston 100cc_Hero Splendor)
Curve Data:N/A		

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)	0.595554	9425.86	-0.991531	9425.86
Reaction Moment(NM)	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)

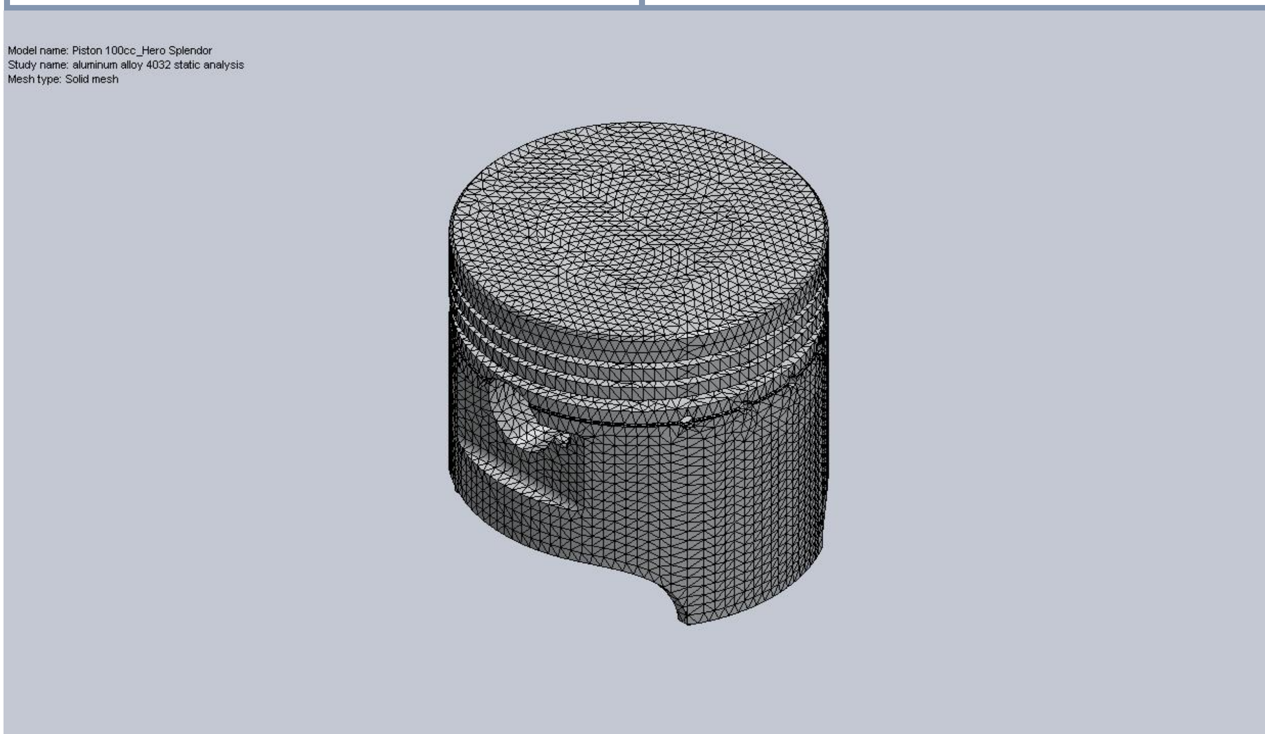
Mesh Information

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

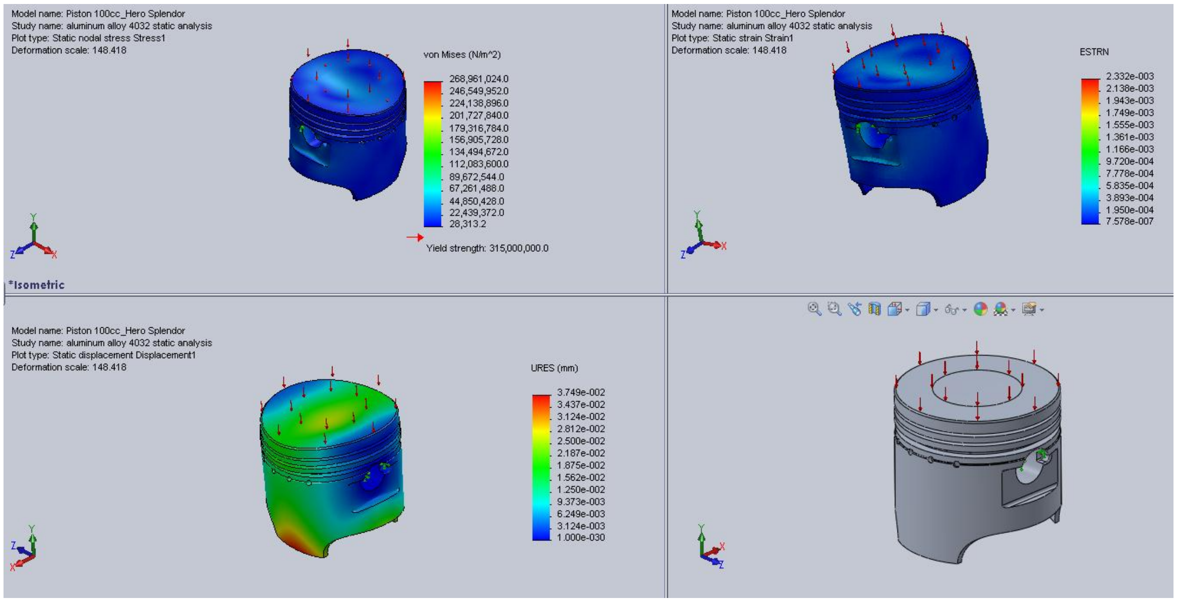
Mesh Quality	High

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



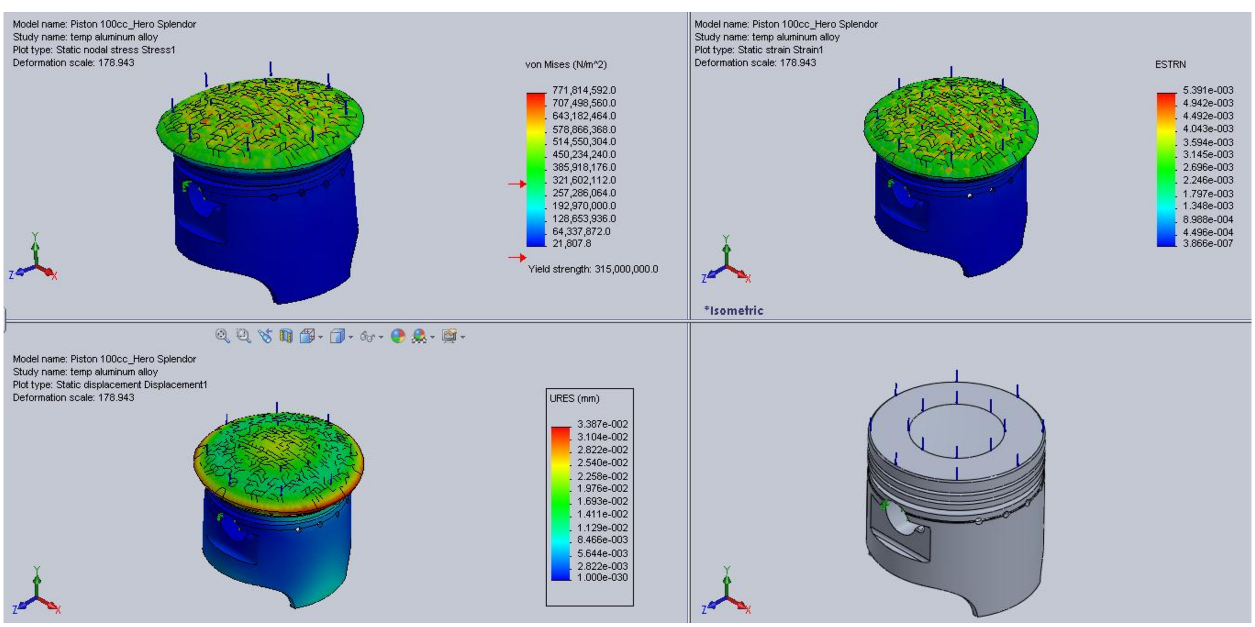
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 09
August 2017



Study (I)

Here we found the result of static analysis where pressure of 5MPa has applied on the top of the piston head in study (I)

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

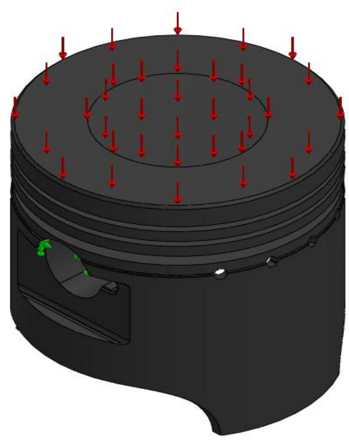


Study (II)

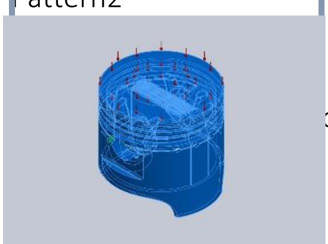
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 09
August 2017

IX . Now, we compared aluminum alloy 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-

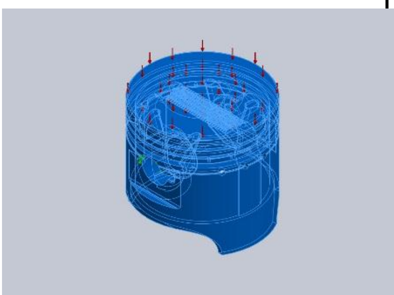
Model Information



/odel name: Piston 100cc_Hero Splendor
urrent Configuration: Default

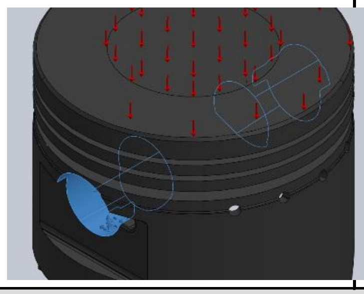
olid Bodies			
ocument Name and eference	**reated As**	**olumetric Properties**	**ocument Path/Date /lodified**
Pattern2 	olid Body	**/lass:0.0609817 kg** **olume:2.7224e-005 m^3** **ensity:2240 kg/m^3** **/eight:0.59762 N**	**efault** ug 09 16:08:19 2017

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

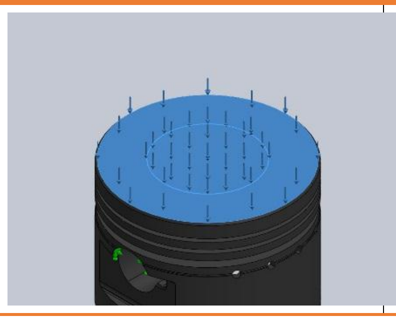
International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 09
August 2017

Loads and Fixtures

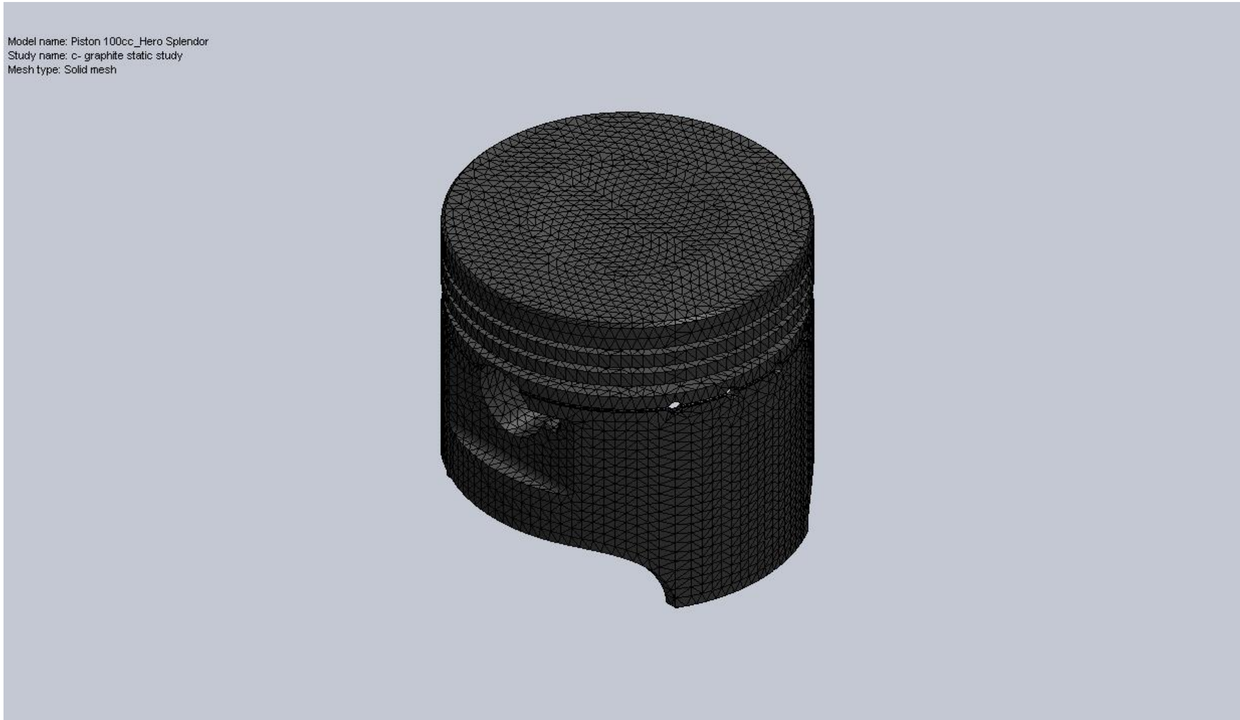
Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 2 face(s) **Type:** Fixed Geometry

Resultant Forces

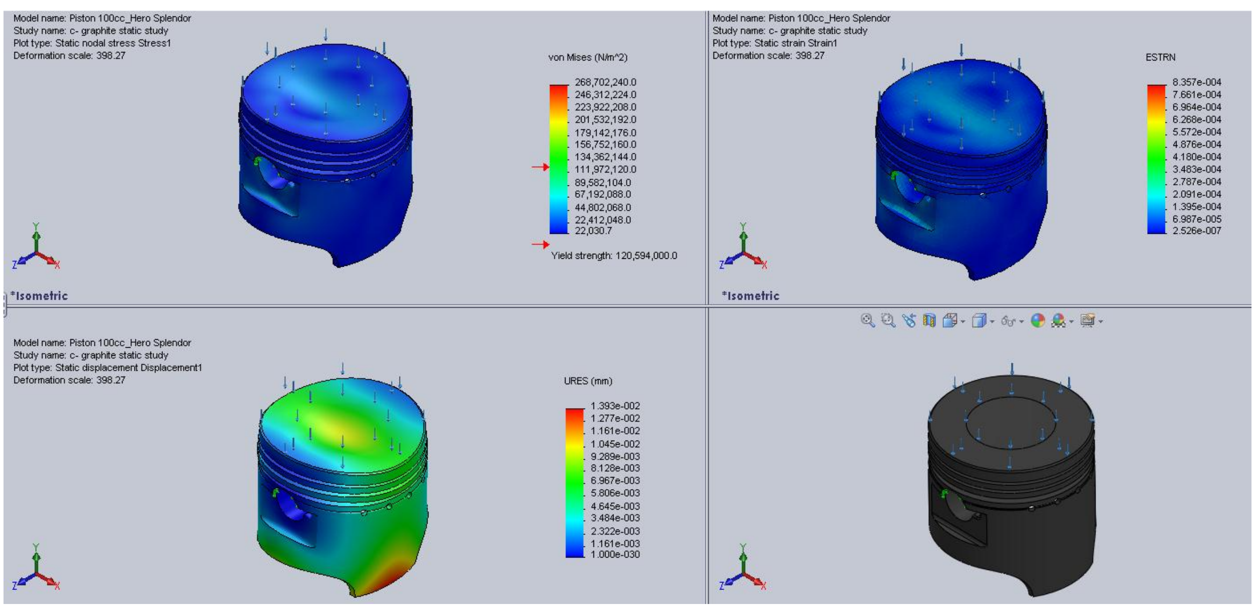
Components	X	Y	Z	Resultant
Reaction force(N)	-0.201809	9428.71	1.45164	9428.71
Reaction Moment(N·m)	0	0	0	0

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

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 09
August 2017



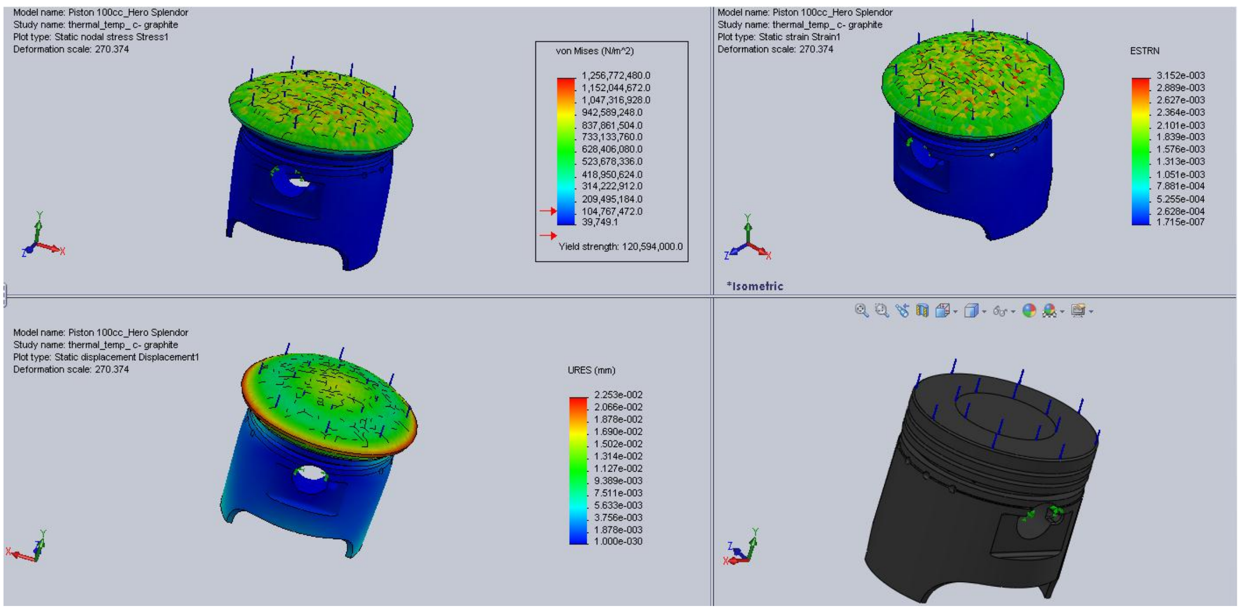
Meshed model



International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 09
August 2017

Study (III)

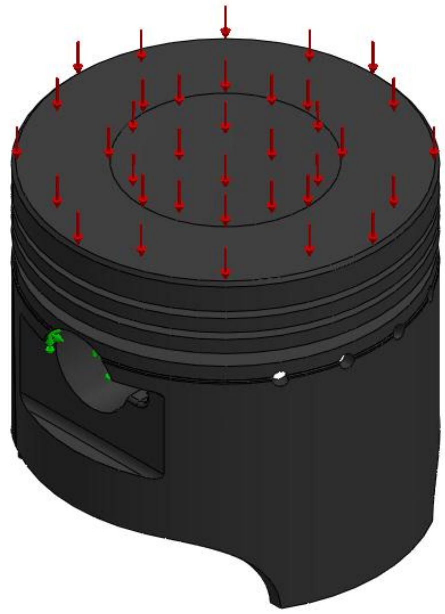
X. Result of static analysis on C- Graphite piston where temperature at top surface of the piston is 400°C



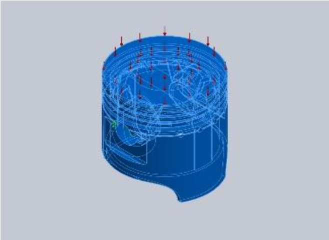
Study (IV)

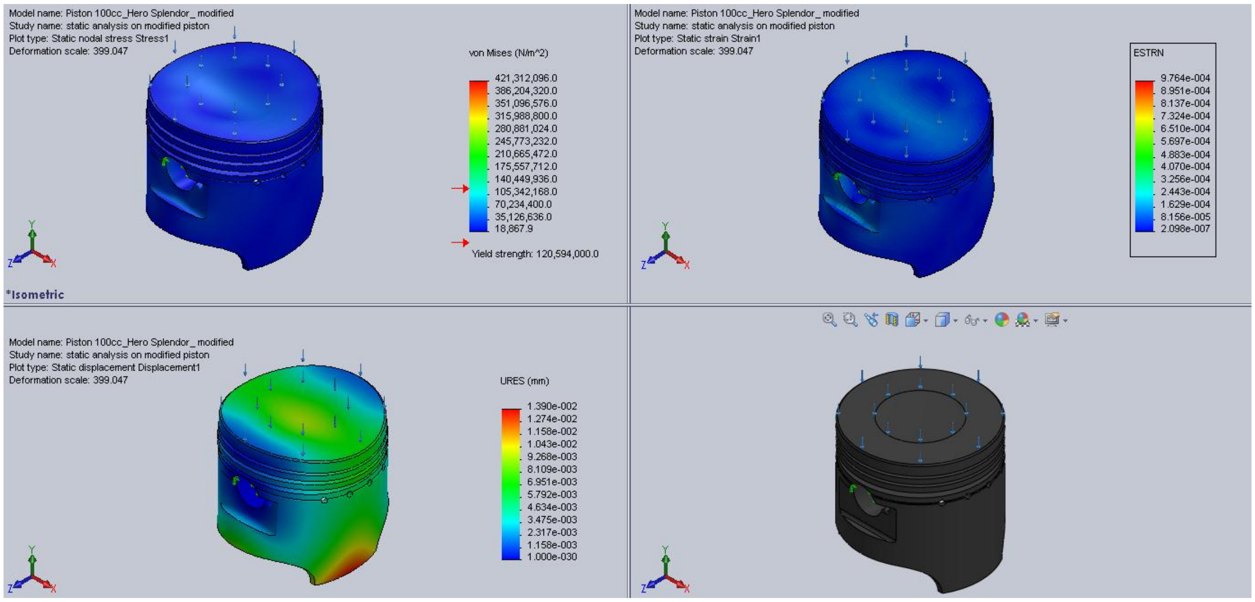
XI. Static analysis on c-graphite piston again with same boundary conditions , but, this time the thickness of 1mm has been added on the bottom side of the piston head, the result can be find as below-

Model Information



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



Study (V)

Conclusion-

In the conclusion, according to above static analysis results on aluminum alloy piston (Study I) and c-graphite piston Study III, we found according to result that aluminum alloy 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 aluminum alloy piston as shown in (study V).

On the other hand, when we analyzed both pistons (aluminum alloy & 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 aluminum alloy then we found that C-graphite material is lighter in weight than aluminum alloy according to volumetric properties, moreover, c- graphite piston has low coefficient of the thermal expansion as compare to aluminum alloy piston and another comparison result found is that thermal conductivity of c-graphite is much better than aluminum alloy. At last, according to above results c-graphite piston is better than aluminum alloy for IC engines.

REFERENCES

[1] B.R. Ramesh and KishanNaik," -Thermal StressAnalysis of Engine Piston", Journal, InternationalConference on Challenges and Opportunities in Mechanical Engineering, Industrial Engineering and ManagementStudies (ICCOMIM - 2012), 11-13 July, 2012

[2] Ajay Raj Singh, DrPushpendra Kumar Sharma,-Design, Analysis and Optimization of Three Aluminium Piston Alloys Using FEA, Ajay Raj Singh et al Int. Journal of Engineering Research and Applications ISSN : 2248-9622, Vol. 4, Issue 1(Version 3, January 2014, pp.94-102

[3] Dallwoo Kim, Akemi Ito, Yasuhiro Ishikawa, KatsuyukiOsawa, Yoshiyuki Iwasaki- Friction Characteristics of Steel Pistons for Diesel Engines

[4] A.R. Bhagat, Y. M. Jibhakate, KedarChimote- Thermal Analysis And Optimization Of I.C. Engine Piston Using Finite Element Method

[5] Bedajangam S. K., N. P. Jadhav- Friction Losses between Piston Ring-Liner Assembly of Internal Combustion Engine, International Journal of Scientific and Research Publications, Volume 3, Issue 6, June 2013 ISSN 2250-3153

[6]Ravi S Modi, MaulikModi, Dr. Tushar M Patel- "Investigation Of IC Engine Part With Coating A Review" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 04 Issue: 02| Jan - 2017.

[7]K.S.Mahajan and S.H.Deshmukh – "Structural and Thermal Analysis of Piston" International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161 ©2016 INPRESSCO.KANCHARLA RAJA SEKHAR,

[8]G. VIJAY PRAKASH- "THERMAL ANALYSIS OF A PISTON" Volume 5, Issue 4 OCT 2016.

[9]Yaohui Lu, Xing Zhang, Penglin Xiang, Dawei Dong – "Analysis of Thermal Temperature Fields and Thermal Stress under Steady Temperature field of Diesel Engine Piston" , Southwest Jiaotong University, Chengdu Sichuan 610031, China, 2016.

[10]V G Cioată, I Kiss, V Alexa and S ARațiu – "Mechanical and thermal analysis of the internal combustion engine piston using Ansys" International Conference on Applied Sciences (ICAS2016).

11.C. Kirner, J. Halbhuber, B. Uhlig, A. Oliva, S. Graf, G. Wachtmeister- "Experimental and simulative research advances in the piston assembly of an internal combustion engine" Preprint submitted to Tribology International March 17, 2016.

12. Dilip Kumar Sonar, MadhuraChattopadhyay – "Theoretical Analysis of Stress and Design of Piston Head using CATIA & ANSYS"

International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726: June 2015.

13. NunnaDurgaPrasanth ,Dr.BVenkataraman – “EXPERIMENTAL INVESTIGATION AND ANALYSIS OF PISTON BY USING HYBRID METAL MATRIX” [Nunna, 4(3): March, 2015] ISSN: 2277-9655 Scientific Journal Impact Factor: 3.449 (ISRA), Impact Factor: 2.114.

14. Kethavath Vishal, Dinesh Bajaj, A.Sai Kumar –“ Design and Structural Analysis of Composite Piston” Volume No: 2 (2015), Issue No: 10 (October) October 2015.

15. M.Srinadh , K. RajasekharaBabu – “Static and Thermal Analysis of Piston and Piston Rings” August 2015, Volume 3, Issue 8, ISSN 2349-4476.

16. Abino John, Jenson T Mathew- “Design and Analysis of Piston by SiC Composite Material” IJIRST –International Journal for Innovative Research in Science & Technology| Volume 1 | Issue 12 | May 2015.

17.Vaishali R. Nimbarte , Prof. S.D. Khamankar – “STRESS ANALYSIS OF PISTON USING PRESSURE LOAD AND THERMAL LOAD” Volume 3, Issue 8, August 2015.

18.G.Anusha , Ramlakshmi , K Mohan Krishna, P.Prem Kumar –“ Modeling and Analysis of Piston Design through Pro/E & ANSYS” © 2015, IRJET ISO 9001:2008 Certified Journal.

19.Claudia Lenauer n , Christian Tomastik, Thomas Wopelka, Martin Jech- “Piston ring wear and cylinder liner tribofilm in tribotests with lubricants artificially altered with ethanol combustion products” C. Lenauer et al. / Tribology International 2014.

20.Ajay Raj Singh, Dr. Pushpendra Kumar Sharma –“ Design, Analysis and Optimization of Three Aluminium Piston Alloys Using FEA” Int. Journal of Engineering Research and Applications ISSN : 2248-9622, Vol. 4, Issue 1(Version 3, January 2014).