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STRUCTURAL, THERMAL AND THERMO-MECHANICAL ANALYSIS OF FOUR STROKE PETROL ENGINE PISTON USING CAE TOOLS

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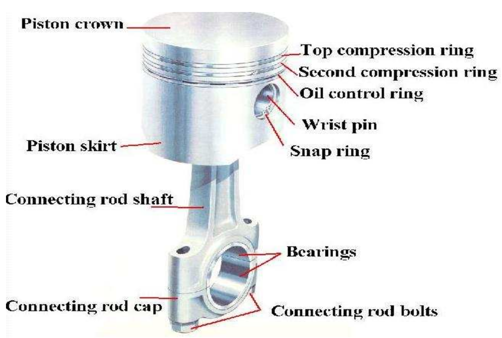
***Abstract* - In the internal combustion engine there are many reciprocating parts which are responsible for giving the motion to the engine. The working condition of the piston is so worst in comparison of other parts of the ic engine .The main objective of this research is to investigate and analyse the stress distribution of hero splendor pro bike piston at actual engine Condition. In this paper pressure, thermal and thermo-mechanical analysis is done. The parameter used for The analysis is operating gas pressure, temperature and material properties of piston. In this present research work a piston are designed for a single cylinder four stroke petrol engine using CATIA V5R20 software. Complete design is imported to ANSYS 14 software then analysis is performed. Two different materials i) Aluminium alloy ii) Cast Iron have been selected for structural, thermal and thermo mechanical analysis of piston. The finite element analysis is performed using ANSYS 14 software. Results are shown and a comparison is made to find the most suited design by various analyses**

Keywords: Icengine, Piston, structural, thermal, pressure, CATIAV5R20, ANSYS14**I**

I.INTRODUCTION

Computer Aided Engineering(CAE) analysis tools offer the tremendous advantage of enabling designers to consider virtually any molding option without incurring the expensive actual manufacturing of the machine component. The ability to try new concepts on the computer concedes the opportunity to omitted the problems before beginning production. Additionally, designers can easily and shortly determine the sensitivity of specific molding parameters on the quality and production of the final (last part) part. The complex parts of the component can be simulated easily by CAE(computer aided engineering) tool Among engine components exposed to thermal (heat) effects, the piston (heart of engine) is considered to be one of the most stressed, where a large amount of the heat transferred to a coolant fluid goes through it, this amount most depends on the thermal conductivity of the materials employed, the average speed and the geometry of the piston. A piston is a component of reciprocating Internal Combustion engines. 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 by the way of a piston rod Piston endures the cyclic gas pressure and the inertial forces at work and this working Condition may cause the fatigue(continues load) damage of piston, such as piston side wear, piston head cracks

Fig- 1- Piston Assembly



So there is a need to optimize the design of piston(engine component) by considering different parameters in this project the parameters selected are thermal(heat analysis) analysis of piston at different temperatures in different stroke. This analysis could be helpful for design engineer for modification(alternative design) of piston at the time of design. In this project we find the stress (structural) calculation, thermal analysis form that we can find out the various region where chances of demage (may be broken) of piston are possible. From analysis it is easy to optimize the design of piston. The main requirement (needs) of piston design is to measure the prediction of temperature distribution on the surface of piston which enables us to optimized the thermal aspects for design of piston at lower cost(cheaply). Most of the pistons

S/ No	Material	Aluminium alloy	Cast Iron
1	Young's modulus [GPa]	7.10E+10	1.80E+11
2	Poisson's ratio	0.33	0.26-0.3
3	Thermal conductivity [W/m °K]	209w/m-k	27-46 w/m-k
4	Thermal expansion	2.20E-05	1.00E-05
5	Specific heat [J/kg °C]	900J/kg^{0}C	840J/kg^0 C
6	Density [kg/m3]	2710kg/m 3	6800-7800kg/m 3

are made of an aluminum alloy which has thermal expansion coefficient, 80% higher than the cylinder bore material made of cast iron

This leads to some differences between running and the design clearances.clearence means gab between the components Therefore, analysis of the piston thermal behavior is extremely resolvable in designing more efficient compressor. Very Good sealing of the piston with the cylinder is the basic requirement to design of the piston. Also to improve or reform the mechanical efficiency and decreases the inertia force in high speed machines the weight of the piston also plays major role.

II PISTON MATERIAL'S

1-Aluminum Alloy,

2-Cast Iron

The most commonly used materials for pistons of Internal Combustion. Engines are cast iron, aluminum alloy. The cast iron pistons are used moderately rated engines with piston speeds below 6.5 meter / s and aluminum alloy Pistons are used for highly rated engines running at piston heavy speeds. It may be noted

1) The coefficient of thermal expansion for aluminum is about 2.5 times that of cast iron, therefore, a large clearance must be conceded between the piston and the cylinder wall in order to prevent seizing(seizing means one of the piston failure) of the piston when engine runs continuously under heavy loads.

2) The aluminum alloys used for pistons have high(large) heat conductivity (nearly four times that of cast iron),therefore, these pistons ensure high rate of heat transfer and thus keeps down the maximum temperature difference between the center and edges of the piston top

3). The aluminum alloys are about three times lighter than cast iron, therefore, its mechanical strength is good at low temperatures, but they lose their strength (about 50%) at temperatures above 325°C. Sometimes, the pistons of aluminum alloys are coated with aluminum oxide(Al_2O_3) by anelectrical method

III DESIGN CONSIDERATION FOR APISTON:

In designing a piston, the following Points should be taken into consideration:

1. It should have enormous or high strength to Withstand the high gas pressure and inertia Forces.
2. It should have minimum mass to minimize the inertia forces.
3. It should form an most effective gas and oil Sealing of the cylinder.
4. It should concede sufficient bearing area To deter undue wear.
5. It should disperse the heat of combustion shortly to the cylinder walls.
6. It should have high (heavy) speed reciprocation Without un wanted noise.
7. It should be of important rigid Construction to withstand thermal(heat) and Mechanical(structural load) distortion.
8. It should have sufficient support for the Piston pin

IV THEORETICAL CALCULATION

1) Piston Diameter D= 78.5 mm

2) Piston inside diameter Di=D-2(s+t+Δt)

S= 5 (piston crown wall thickness)

t= 3.5 (ring radial thickness)

Δt= 0.8 (ring radial clearance in the piston groove)

Di =78-2(5+3.5+0.8)

Di= 59.9mm

3) Skirt radial thickness

$$ST=\frac{D-Di}{2}$$

D= piston diameter

Di = piston inside diameter

$$ST=\frac{78-59.9}{2}$$

ST=9.05

4) Piston outer diameter (dδ)

$h1 + hc = \frac{d\delta)}{2}$

h1 = height of piston top part

dδ = piston pin outer diameter

h1 = 0.60 × 78

h1 = 46.8mm

hc=h- hS
hc= Piston Crown Height
h - Piston Height
hS – Piston Skirt Height
h=88.5
hS=58.5
hc= 88-58
hc=30.5
$h1 + hc = \frac{d\delta)}{2}$
dδ = 34.1

5) Piston Pin inside Diameter

dP= 0.27 × 78
dP= 21.19

6) Web Thickness

$= \frac{di+b}{2}$
b = distance between boss end faces
b = 0.4 × 78
b= 31.2
Web thickness = $\frac{(59.9-31.2)}{2}$ = 14.1
Web thickness =14.35

V THE BOUNDARY CONDITIONS

One of the most important aspects to be Considered during the analysis in order to achieve maximum accuracy is the selection of the boundary conditions. The top surface of the piston is subjected to hot gases which take different values of temperature of gases Tg and convective heat transfer coefficient Hg for the different crank angles. The boundary condition for the present problem have been under taken to be as given below

1) Temperature Level of piston head =573K (273+300)
2) Temperature Level of piston ring =493K (273+220)
3) Temperature Level of piston skirt=463K (190+273)
4) Temperature Level of piston bottom portion =243K (273+70)

(Thermal load)

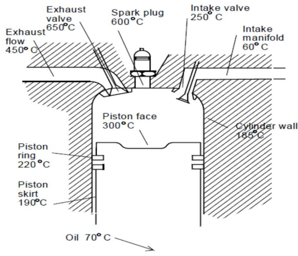
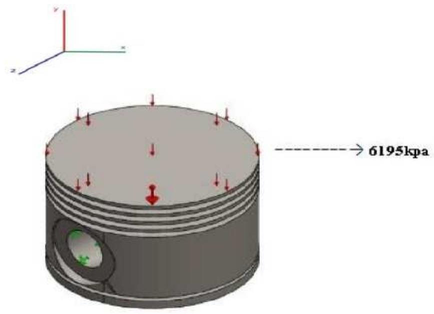


Fig 4: boundary conditions



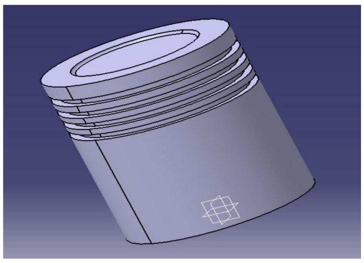
(Pressure load)

S/NO	DIMENSIONS	SIZE RANGES	PREFERABLE SIZE
1	Piston Diameter	-	78.5
2	Piston Height	(0.8-1.3)D	88.5
3	Skirt Height	(0.6-0.8)D	58.5
4	Radial Thickness	(0.040-0.045)D	3.5
5	Ring Radial Clearance	(0.70-0.95)D	0.8
6	Crown Wall Thickness	(0.05-0.10)D	5
7	Piston Crown Thickness	(0.05-0.10)D	7.5
8	Crown Depth	-	1.5
9	Top Ring Land Height	(0.03-0.05)D	3.5
10	Piston Inner Diameter	-	59.9
11	Crown Diameter	-	53.36
12	Radial Skirt Thickness	-	9.3
13	1st Piston Groove Thickness	(0.06-0.12)D	7.8
14	Oil Ring Height & Thickness	-	3
15	Piston pin Outer Diameter	(0.22-0.28)D	34.1
16	Piston Hub Inside Diameter	(0.65-0.75)D	21.19
17	Web Thickness	-	14.35
18	Top Head Thickness	-	6
19	Piston Inner Fillet	-	1.5
20	Skirt Undercut Height	-	5.8
21	Skirt Undercut Thickness	-	5
22	Skirt radial thickness	-	9.05

Pressure load is act the on the top portion of the piston, it is called piston head, pressure load will be vary according to engine specification now I have take single cylinder four stroke engine piston

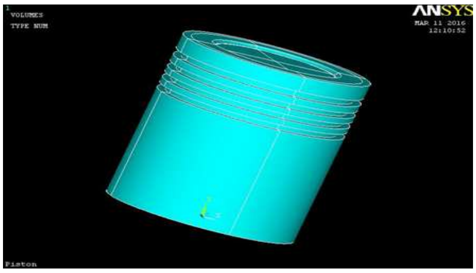
VI FINITE ELEMENT MODEL

Fig 3 CATIA V5R20 Model



The Computer Aided Interactive Three Dimensional Application (CATIA) Model Imported To ANSYS 14

Fig 4 Imported ANSYS Model



MATERIAL	STRESS (Y direction)	VONMISSES STRESS
ALUMINIUM ALLOY	383GPA	151e10
CAST IRON	380GPA	181e10

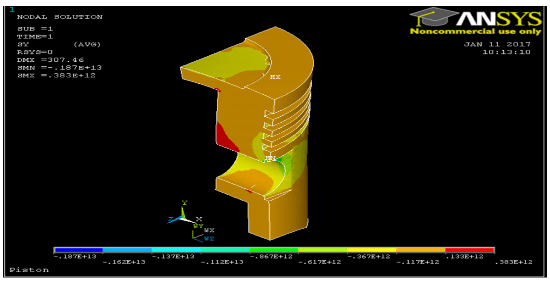
VII-RESULT&DISCUSSIONS

In order to avoid complexity the model was divided in to four equal parts & one part is taken for analysis

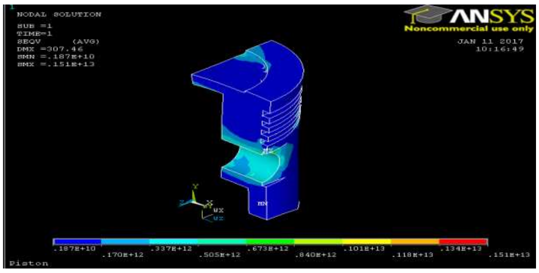
I) STRUCTURAL ANALYSIS

i) Aluminum Alloy

Stress (Y Direction)



Von Misses Stress



Cast Iron

Stress (Y Direction)

Von Misses Stress

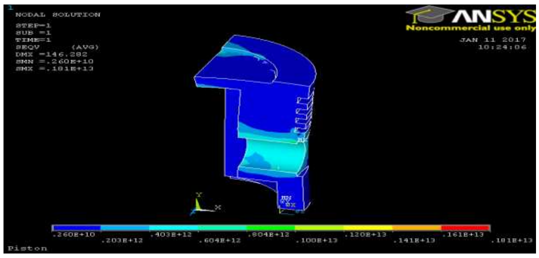
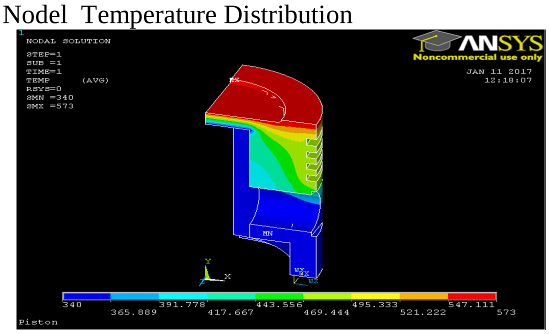


Table: 3 structural analysis result

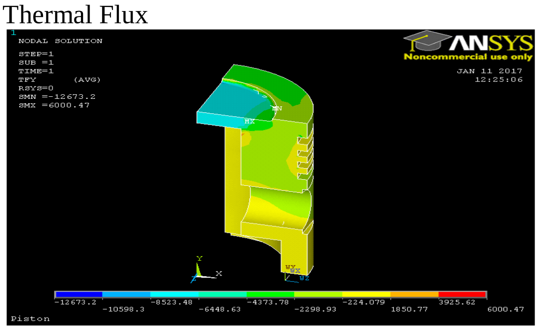
II) THERMAL ANALYSIS

i)Aluminum alloy

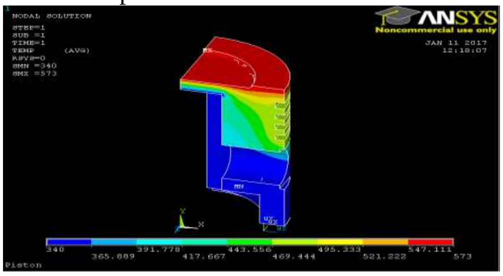
Nodel Temperature Distribution



Thermal Flux

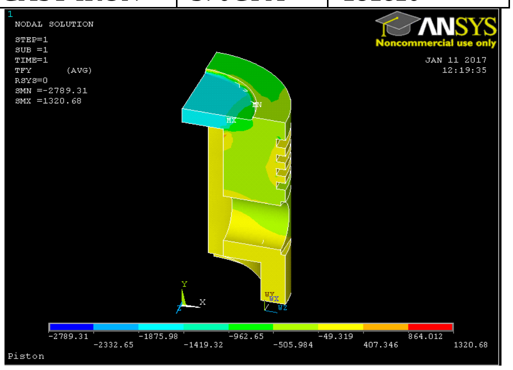


ii) Cast Iron
Nodel Temperature Distribution



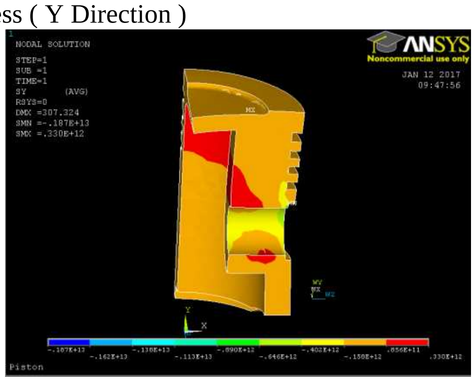
Thermal Flux

MATERIAL	STRESS (Y direction)	VONMISSES STRESS
ALUMINIUM ALLOY	330GPA	151e10
CAST IRON	370GPA	181e10

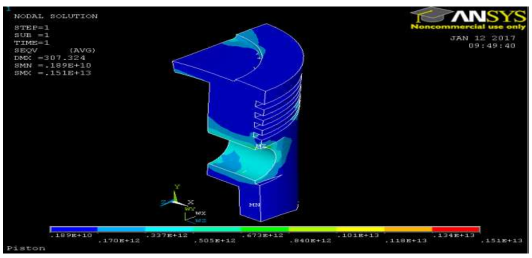


III THERMO MECHANICAL ANALYSIS

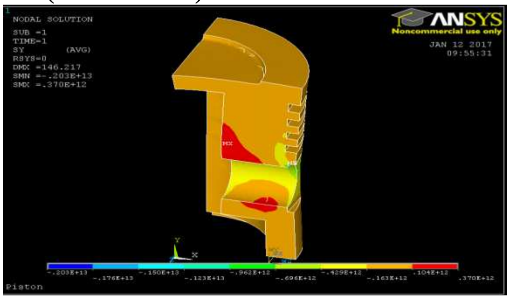
<u>i) Aluminum Alloy</u>
Stress (Y Direction)



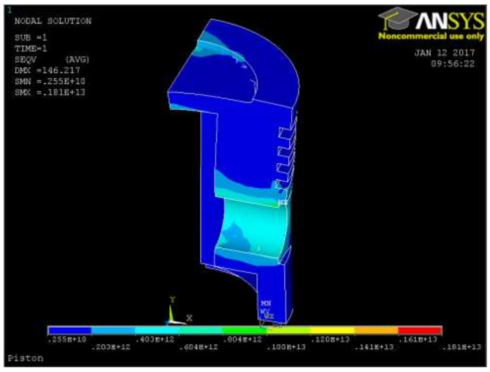
Von Misses Stress



ii) Cast Iron
Stress (Y Direction)



Von Misses Stress



VIII CONCLUSION

It is concluded from the above study that using CATIA software design and modeling become easier. here material used for piston is aluminum alloy and cast iron because it is withstand more temperature compare other materials .finding temperature distribution of piston is very significant because the piston easily damage due to high temperature .the maximum temperature acted through the piston head and the minimum temperature is on the piston skirt . Here hero splendor pro bike piston analyzed the structural, thermal and thermo mechanical analysis is done by using ANSYS software shown above different results cast iron sustain high pressure and temperature compare to the aluminum alloy hence cast iron is quality material for hero splendor pro bike piston so the cast iron pistons are used for moderately rated engines with piston speeds below 6.5 m / s

IX REFERENCES

1)RS Khurmi and JK Gupta “Machine Design” Eurasia publishing house (pvt.) ltd. Ram Nagar, New Delhi -110055, http://www.simpopdf.com, 2005

2) S.S. Feng et al., An experimental and numerical study of finned metal foam heat sinks under impinging air jet cooling, International Journal of Heat and Mass Transfer 77 (2014) 1063–1074.

3) M.M. Haque et al., “Effect of superheating temperatures on microstructure and properties of strontium modifiedaluminium–silicon eutectic alloy” Journal of Materials Processing Technology 162–163 (2005) 312–316

4)M.X. Calbureanu et al.,, "The finite element analysis of the thermal stress distribution of a piston head"International Journal OF Mechanics, Issue 4, Volume 7, 2013, pp- 467-474.

5)S.Srikanth Reddy et al., Thermal Analysis and Optimization of I.C. Engine Piston Using Finite Element Method,International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 12, December2013, pp 7834-7843.

6)A. R. Bhagat et al., Thermal Analysis and Optimization of I.C. Engine Piston Using finite Element Method, International Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol.2, Issue.4, July-Aug 2012 pp-2919-2921.

7)Vinay V. Kuppast et al., "Thermal Analysis of Piston for the Influence on Secondary motion", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622, Vol. 3, Issue 3, May-Jun 2013,pp.1402-1407

8)Bhaumik Patel, AshwinBhabhor (2012) "thermal analysis of a piston of reciprocating air compressor" IJAERS,ISSN: 2249–8974, PP. 73-75..

9) Shigley, Joseph Edward, Theory of Machines and Mechanisms, Tata McGraw Hill, New York, 2003