Design & Modification of Connecting Rod

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Abstract— The paper deals with the stress analysis of connecting rod by Finite Element Method using CREO PARAMETRIC 2.0 and ANSYS Workbench software. The objective of present work is to optimize the material of connecting rod. The design optimization of connecting rod is carried out with a view to reduce deformation, better heat transfer and effect on weight.

Key words: ANSYS, FEM, Connecting Rod, CREO PARAMETRIC, Hero Splendor

I. INTRODUCTION

Connecting rod is the power transmission element which is used to transfer power form piston to the crank shaft in Internal Combustion Engine (IC Engine).In a reciprocating piston engine, the connecting rod or concord connects the crack or crankshaft. Together with the crank, they form a simple mechanism that converts reciprocating motion into rotary motion. Every internal combustion engine requires at least one connecting rod and it must have the highest possible rigidity at the lowest weight for proper functioning. The major stress induced in the connecting rod is a combination of axial and bending stresses in operation. To decrease the material usage in the connecting rod by creating a hollow frame structure in it. Connecting rods are made of Aluminum alloy, C70 Steel and Cast Iron.

II. CALCULATION

A connecting rod is a machine member which is subjected to alternating direct compressive and tensile forces. Since the compressive forces are much higher than the tensile forces, therefore, the cross-section of the connecting rod is designed as a strut and the Rankin's formula is used. A connecting rod, as shown in fig, subjected to an axial load *W* may buckle with *X*-axis as neutral axis (*i.e.* in the plane of motion of the connecting rod) or *Y*-axis as neutral axis (*i.e.* in the plane perpendicular to the plane of motion). The connecting rod is considered like both ends hinged for buckling about *X*-axis and both ends fixed for buckling about *Y*-axis. A connecting rod should be equally strong in buckling about both the axes.

Let, A = cross sectional area of the connecting rod.
l = length of the connecting rod.
σc = compressive yield stress.
F = crippling or buckling load.
I_{xx} and I_{yy} = moment of inertia of the section about x-axis and y-axis respectively. K_{xx} and K_{yy}= radius of gyration of the section about x-axis and y- axis respectively.
Rankin's – Gordon formula,

F about x-axis $=\frac{\sigma_c A}{1+a\left(1/K_{XX}\right)^2}$

A. Pressure Calculation for 100cc Engine

Hero Splendor Specifications Engine type air cooled 4-stroke Bore × Stroke (mm) = 50 × 49.5 = 2475 mm Displacement = 97.2CC

Maximum Power = 7.5ps (5.5 kW)@8000 rpm Maximum Torque = 7.95 Nm@8000rpm Compression Ratio = 9:1
Density of Petrol
C_8H_{18} = 737.22kg/m3= 737.22E-9kg/mm3 Temperature = 60F = 288.855K
Mass = Density × Volume = 737.22E-9×97.2E3 = 0.07165 Kg
Molecular Weight of Petrol 114.228 g/mole
R is universal gas constant.
Mw is molecular weight of petrol
From Gas Equation:- PV=Mrt

$$r = \frac{R}{M_W}$$

= 8.3143 E3/114228E-3
=72.786
Exposed pressure is

$$P = \frac{0.071658 \times 72.786 \times 288.85}{97.2E3}$$

P=0.015499
P=15.5MPa

B. Design Calculation of Cast Iron

Thickness of flange & web of the section= t
Width of section, B=4t
The standard dimension of I -SECTION.

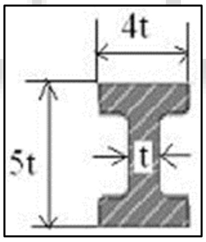

Fig. 1: Standard Dimension of I - Section

Height of section,
H=5t
Area of section,

$$A = 2(4t \times t) + 3t \times t$$

$A=11t^2$
MI of section about x axis:

$$I_{XX} = (2 + \frac{1}{12t(4t)3} + \frac{1}{12(3t)t3})$$

$=131/12t$

$$I_{XX} = \frac{1}{12(4t(5t)3 - 3t(3t)3)}$$

MI of section about y axis:
Iyy = (2+1/12t (4t) 3+1/12 (3t) t) =131/12t4
$I_{xx/} I_{yy}$ = 3.2

$$K_{xx} = \sqrt{\frac{I_{XX}}{A}}$$

$K_{xx} = \sqrt{3.18t^2}$
K_{xx} = 1.7826t
Now,Length of connecting rod (L) = 2 times the stroke
L = 2 *49.5 = 99 mm

Maximum Explosion pressure
P_{max} = 2.5 MPa
σ_c=572MPa
Compressive yield stress the maximum gas force,
$P_{gas}=\frac{\pi}{4}D^2 x P_{max}$
$P_{gas}=\frac{\pi}{4}x50^2x2.5$
= 4908.7385 N
Now according to Rankine's–Gordon formula F about x-axis
$= \frac{\sigma_c}{1+a(\frac{1}{K_{XX}})^2}$
F = P_{gas} x f.s.
F = 4908.7385 x 5
F = 24543.692 N
Rankine Constant,
a = 0.00016
Now,
$F = \frac{\sigma_c}{1+a(\frac{1}{K_{XX}})^2}$
$24543.69 = \frac{572 \times 10^6 \times 11t^2}{1+0.00016 \times \left[\frac{99 \times 10^3}{1.78t}\right]^2}$
Thickness of flange & web of the section
t= 2.1 mm
Width of section B= 4t = 4 x 2.1 = 8.4 mm
Height of section H=5t = 5 x 2.1 = 10.5 mm
Area of section
A= 2(4t×t) +3t×t A=11t²
A= 48.51 mm²
Height at the big end (crank end) = H_2 = 1.1H = 11.55 mm
Height at the small end (piston end) = 0.8 H = 8.4 mm

C. *Design Calculation for ASTM A216 GR WCB*

Now similarly,
Compressive yield stress
$F = \frac{\sigma_C A}{1 + a(^1/_{K_{xx}})}$
σ_c=250MPa
$24543.69 = \frac{250 \times 10^6 \times 11t^2}{1+0.00016 \times \left[\frac{99 \times 10^3}{1.78t}\right]^2}$
$t = 3.06 \times 10^{-3} m$
T=3.06mm≅ $3mm$
Thickness of flange & web of the section = t= 3 mm
Width of section B= 4t 4 x 3 = 12 mm
Height of section H=5t = 5 x 3 = 15 mm
Area of section,
A= 2(4t×t) +3t×t
A =11t²
A = 99 mm²
Height at the big end (crank end) = H_2 = 1.1H = 16.5 mm
Height at the small end (piston end) = 0.8 H = 12 mm

D. *Design Calculation for Aluminum 360*

Now similarly,
Compressive yield stress σ_c= 300 MPa
$F = \frac{\sigma_C A}{1 + a(^1/_{K_{xx}})}$
$24543.69 = \frac{572 \times 10^6 \times 11t^2}{1+0.00016 \times \left[\frac{99 \times 10^3}{1.78t}\right]^2}$
t= 2.08 x 10^{-3} m
Thickness of flange & web of the section
t= 2.9 mm
Width of section B= 4t = 4 x 2.9 = 11.6 mm
Height of section H=5t = 5 x 2.9 = 14.5 mm
Area of section A= 2(4t×t) +3t×t
A =11t²
A = 92.51 mm²
Height at the big end (crank end)
H_2 = 1.1H = 15.95 mm
Height at the small end (piston end) = 0.8 H = 11.6 mm

III. PARAMETERS FOR CREO DESIGN

Length of connecting rod =94.1mm=9.41cm
Outer diameter of big end=39.4mm=3.94cm
Inner diameter of big end=30.0mm=3.00cm
Outer diameter of small end=19.4mm=1.94cm
Inner diameter of small end=13.0mm=1.3cm
For, t=3.0mm=0.3cm
H=15mm=1.5cm
B=12mm=1.2cm

IV. DESIGN & ANALYSIS OF ORIGINAL CONNECTING ROD OF HERO SPLENDOR

A. *Original Geometry of Connecting Rod*

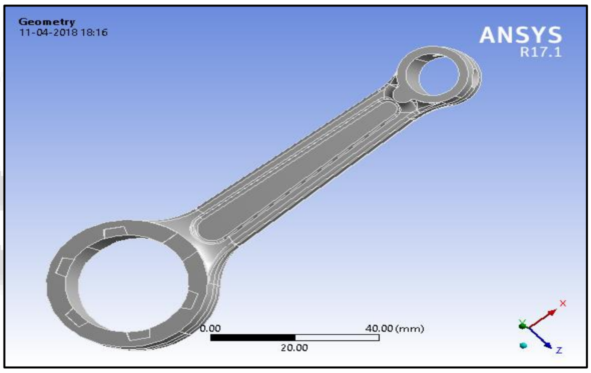

Fig. 1: Original design of connecting rod of Hero Splendor .By using CREO Parametric 2.0, we have made original design of connecting rod of companies parameters are as above

B. *Meshing of Connecting Rod*

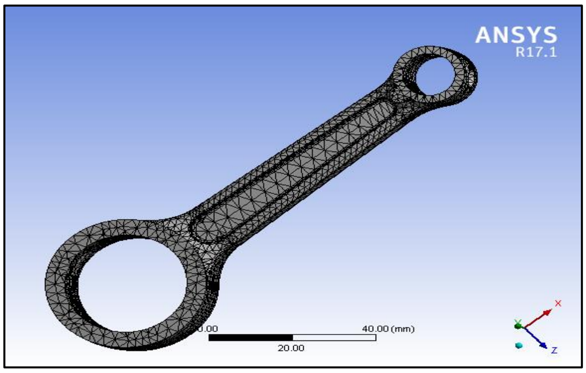

Fig. 2. Original Meshing of connecting rod of Hero Splendor
Information of Meshing is given below:
Relevance Centre:-Fine
Minimum edge Length: 7.442e-0.02mm
Transition ratio: 0.272

Growth rate:-1.2
Nodes:-33925
Elements:-19330

C. Static Structural of Connecting Rod

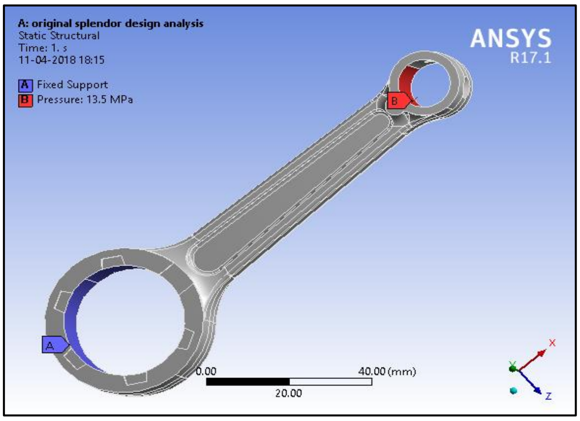

Fig. 3: Static Structural of Connecting Rod

A CREO Parametric model of connecting rod is used for analysis in ANSYS Workbench. Analysis is done with the pressure of 13.5Mpa load applied at the piston end of the connecting rod and fixed at the crank end of connecting rod. It is shown in figure.

V. ANALYSIS RESULTS OF ORIGINAL CONNECTING ROD OF HERO SPLENDOR

For the finite element analysis 13.5Mpa of pressure is used. The analysis is carried out using CREO parametric 2.0 and ANSYS Workbench 17.1 software. The pressure is applied at the small of connecting rod keeping big end fixed. The maximum and minimum stress, strain, deformation and factor of safety are noted from the ANSYS Workbench 17.1

A. Strain of Connecting Rod

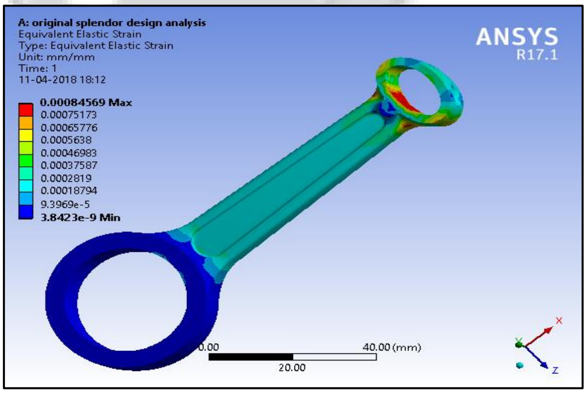

Fig. 4: Strain of Connecting Rod

From the figure, The maximum stress occurs at the piston end of connecting rod is 8.4569e-004 mm/mm and minimum stress occurs at the crank end of the connecting rod is 3.8423e-009 mm/mm.

B. Stress of Connecting Rod

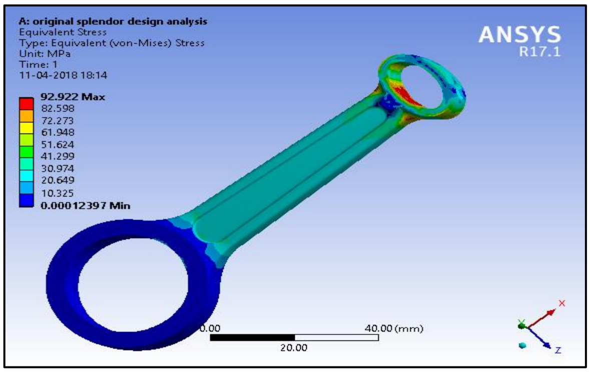

Fig. 5: Stress in Connecting Rod

From the figure the maximum stress occurs at the piston end of the connecting rod is 92.922 MPa and minimum stress occurs at the crank end of the connecting is 1.2397e-004 MPa.

C. Total deformation of connecting rod of Hero Splendor:

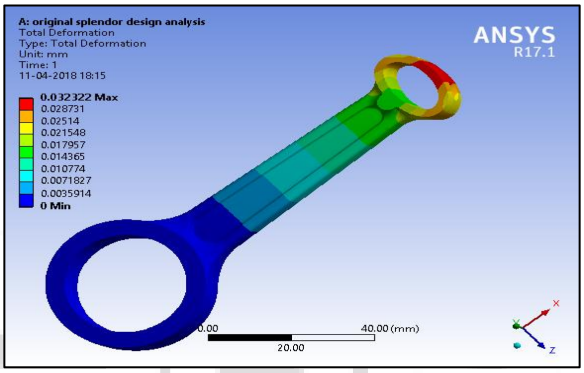

Fig. 6. Total Deformation in Connecting Rod

From the figure the maximum Total Deformation occurs at the piston end of the connecting rod is 0.032322 mm and total deformation occurs at the crank end of the connecting is 0 mm.

VI. DESIGN & ANALYSIS OF MODIFIED CONNECTING ROD OF HERO SPLENDOR

A. Modified Geometry of Conneting Rod:

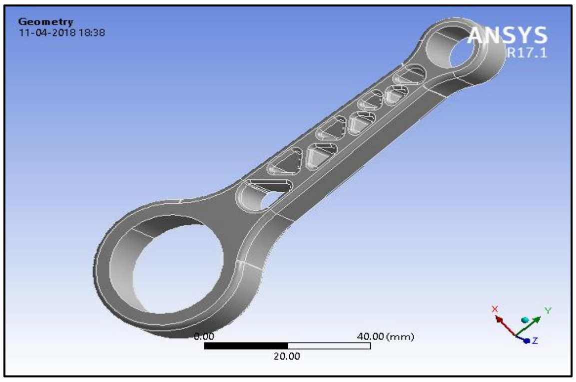

Fig. 7: Modified Design of Connecting Rod of Hero Splendor

By using CREO Parametric 2.0, we have made original design of connecting rod of companies parameters are as original design except inclination angel which is 45°

B. Meshing of Modified Connecting rod

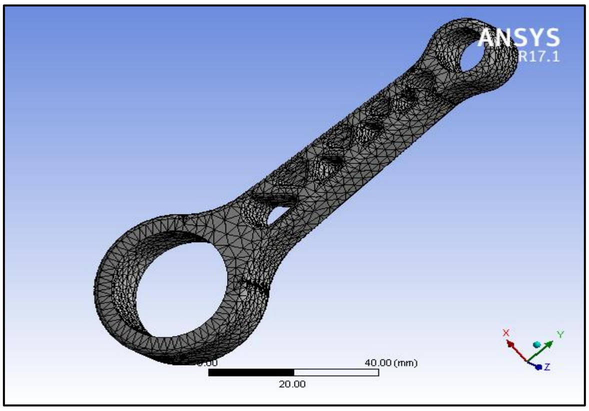

Fig. 8: Meshing of Modified Connecting Rod of Hero Splendor

Information of Meshing is given below:
Relevance Centre: Fine
Minimum edge Length: 7.442e0.02mm
Transition ratio: 0.272
Growth rate: 1.2
Nodes: 27213
Elements:-15153

C. Static structural of modified connecting rod

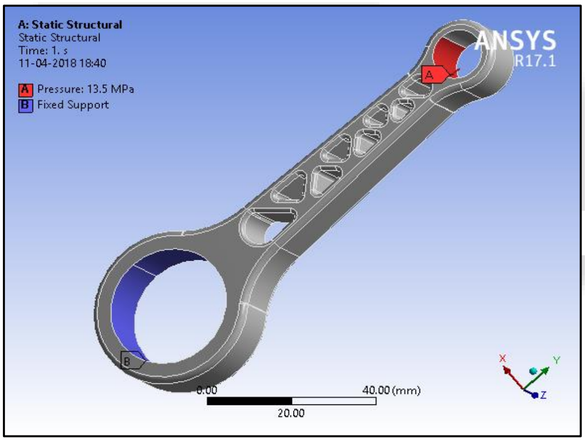

Fig. 9: Static Structural of Connecting rod

A CREO Parametric model of connecting rod is used for analysis in ANSYS Workbench. Analysis is done with the pressure of 13.5Mpa load applied at the piston end of the connecting rod and fixed at the crank end of connecting rod. It is shown in figure.

VII. Analysis of Modified Connecting Rod of Hero Splendor

For the finite element analysis 13.5Mpa of pressure is used. The analysis is carried out using CREO parametric 2.0 and ANSYS Workbench 17.1 software. The pressure is applied at the small of connecting rod keeping big end fixed. The maximum and minimum stress, strain, deformation and factor of safety are noted from the ANSYS Workbench 17.1

A. Strain of Modified connecting rod

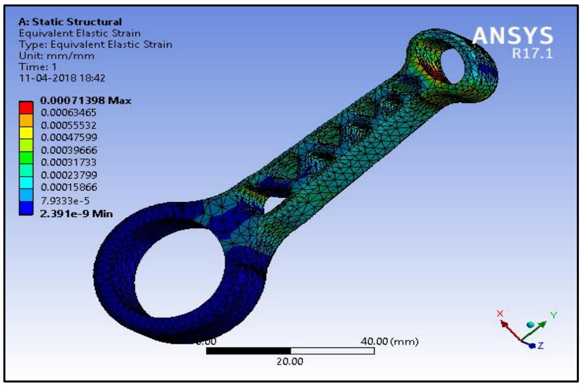

Fig. 10: Strain of connecting rod

From the figure, The maximum stress occurs at the piston end of connecting rod is 6.1348e-004 mm/mm and minimum stress occurs at the crank end of the connecting rod is 2.3657e-009 mm/mm.

B. Stress of Modified Connecting Rod

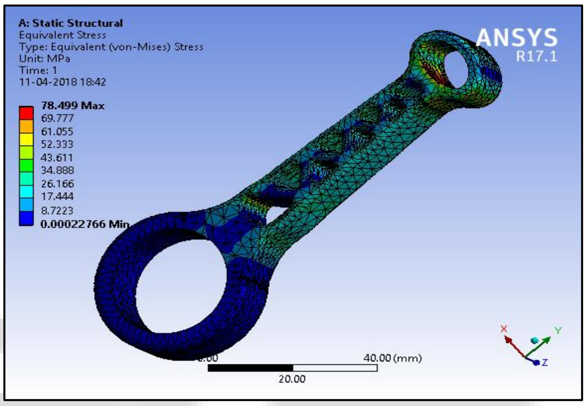

Fig. 11: Stress in Connecting Rod

From the figure the maximum stress occurs at the piston end of the connecting rod is 67.466 MPa and minimum stress occurs at the crank end of the connecting is 1.4197e-004 MPa.

C. Total Deformation of Modified Connecting rod:

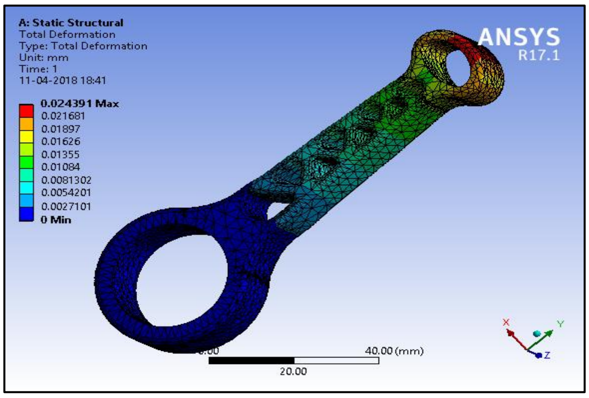

Fig. 12: Total Deformation in Connecting Rod

From the figure the maximum Total Deformation occurs at the piston end of the connecting rod is 0.024391 mm and total deformation occurs at the crank end of the connecting is 0 mm.

VIII. MATERIAL DATA

A. Grey Cast Iron

Density	7.2e-006 kg mm^{-3}
Coefficient of Thermal Expansion	1.1e-005 C^{-1}
Specific Heat	4.47e+005 mJ kg^{-1} C^{-1}
Thermal Conductivity	5.2e-002 W mm^{-1} C^{-1}
Resistivity	9.6e-005 ohm mm
Compressive Ultimate Strength	820 MPa
Tensile Ultimate Strength	240 MPa
Young's Modulus	1.1e+005 MPa
Poisson's Ratio	0.28
Bulk Modulus	83333 MPa
Shear Modulus	42969 MPa

IX. CONCLUSION

Less deformation is achieved, heat transfer rate is better, new unique design, for weight reduction need to take lighter alloy which results in increase of cost. Also high surface to volume ratio exhibit in new design which give more heat dissipation

REFERENCES

[1] Kuldeep B, Arun L.R, Mohammed Faheem, "Analysis and optimization of connecting rod using Alfasic composites", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 6, pp 2480-2487, June 2013.
[2] Ambrish Tiwari, Jeetendra Kumar Tiwari, Sharad Kumar Chandrakar, "Fatigue Analysis of Connecting Rod Using FEA to Explore Weight and Cost Reduction Opportunities for a Production of Forged Steel Connecting Rod", International Journal of Advanced Mechanical Engineering, Volume 4, Issue 7, pp. 783-802, 2014.
[3] VenuGopalVegi, Leela Krishna Vegi "Design And Analysis of Connecting rod using forged steel", International Journal of Scientific & Engineering Research, vol. 4, Issue 6, June 2013.
[4] VikasGupta,OmPrakash, Vinod Mittal "Optimizing the Design of Connecting rod under Static and Fatigue Loading" International journal of Research in Management, Science &Technology (IJRMST) Vol. 1, issue. 1, June 2013.
[5] Afzal, A. and A. Fatemi, "A comparative study of fatigue behavior and life predictions of forged steel and PM connecting rods". SAE Technical Paper. 2004