DESIGN, ANALYSIS AND FABRICATION OF H-SHAPE CONNECTING ROD

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Abstract- Connecting rod is used to join the piston and the crank. It acts as a very essential element for the whole mechanism. It acts upon by the various forces generated due to the reciprocating and rotating movement of the piston and the crank. It helps in converting the reciprocating motion into the rotating motion and vice-versa. Connecting rods are used in internal combustion engine such as automotive engines. In this study we are going to see the effects of Stresses, Strain and deformation on the H-shape connecting rod. Based upon the results the H-shape connecting rod is compared with the I-shape connecting rod. The analysis is carried out for stress, strain and deformation by the use of which we are going to calculate the weight, stiffness and the factor of safety. CATIA software is used for modeling and analyses are carried out in ANSYS software. After the study the results are used to find the areas prone to maximum stresses.

Keywords- Connecting Rod, CATIA V5R20, ANSYS R15, Forged Steel.

I. NOMENCLATURE

A= cross sectional area of the connecting rod
L=length of the connecting rod
C=compressive yield stress
Wcr = buckling load
Ixx= moment of inertia of the section about x-axis.
Iyy= moment of inertia of the section about y-axis.
Kxx=radius of gyration of the section about x-axis.
Kyy=radius of gyration of the section about y-axis.
D=diameter of piston
r = radius of crank

II. INTRODUCTION

H-Shape connecting rods have a completely different design. An H-Shape connecting rod has two large flat sides that are perpendicular to the Piston pin and the crankshaft journal, with a thin center
section in the middle. This makes the H-Shape connecting rod very stiff so it can handle higher compressive loads without bending.

Forces experienced by the connecting rod are bearing Pressure, buckling load and inertia force. These forces are generated by the weight of the connecting rod and due to the combustion of air-fuel mixture inside the cylinder. It exerts pressure on the piston and then on the connecting rod which results in bending and axial stresses.

In order to know the results by using H-Shape connecting rod instead of I-Shape firstly the calculations are done on the H-Shape connecting rod by rotating the plane of orientation of I-Shape connecting rod and then it is modeled by using CATIA software and finally it is analyze on ANSYS Software to know the results. The ANSYS Software is used for meshing the geometry for nodes and elements. In order to obtain the fine result the fine meshing is done. Loads and boundary constraints are applied during analysis in ANSYS and finally the calculation of the stiffness, weight and factor of safety will be done by using the values of stress, strain, shear stress and deformation those are obtained by analysis.

The extra work done is that after the analysis the connecting rod is fabricated by using forging method and then the testing is performed to get the results in experimental work.

III. SPECIFICATION OF THE PROBLEM

The aim of our project is to design, analyses and fabrication of H-Shape connecting rod made of forged steel. First the connecting rod is modeled by using CATIA V5 R20 Software after that the model is imported in ANSYS R15 Software for analysis. The results obtained by the analysis of H-shape connecting rod are compared by the results of existing I-Shape connecting rod in terms of weight, factor of safety and stiffness.

PRESSURE CALCULATION FOR 150CC ENGINE

- Engine type air cooled 4-stroke
- Bore * stroke(mm) = 57 * 58.6
- Displacement = 149.5cc
- Maximum power = 13.8 bhp@8500 rpm
- Maximum Torque = 13.4Nm@6000rpm
- Compression Ratio = 9.35/1
- Density of petrol = 737.22kg/m3
- Temperature = 288.5 degree k
- \[ M = \text{density} \times \text{volume} = 737.22 \times 10^{-9} \times 149.5 \times 10^3 = 0.11 \text{kg} \]
- Molecular weight of petrol = 114.228g/mole
- From gas equation, \[ P_v = mrt \]
- \[ R = \frac{r}{M} = 8.314/114228 = 72.76 \]
- \[ p = 15.5 \text{ M Pa} \]

IV. DESIGN CALCULATION

Thickness of flange and web of the section = t

<table>
<thead>
<tr>
<th>Width of section = 5t</th>
<th>Height of section = 4t</th>
</tr>
</thead>
<tbody>
<tr>
<td>5t</td>
<td>4t</td>
</tr>
</tbody>
</table>

Height of section = 4t

Area of section \( A = \{ 2(4t \times t) + 3t^2 \} = 11t^2 \)
For h-shape connecting rod the formula used for calculating moment of inertia about x-axis has been changed only.

For I –Shape it is \((BH^3-bh^3)/12\)

For H-Shape it is \((BH^3+bh^3)/12\)

For the calculation of \(I_{yy}\) it is same as it is in I-Section that is:

\[I_{yy} = \frac{(2*t^3*H+ t*h)}{12}\]

\[I_{xx} = \frac{(BH^3+bh^3)}{12}\]

\[= \left\{ \frac{t}{2}(4t^3)+(3t)(t^3) \right\}/12 = 2.916t^4\]

\[I_{yy} = \left\{ \frac{(2*(1/12)*4t*(t^3)+(1/12)*t*(3t^3)}{2} \right\} = .916t^4\]

\[I_{xx}/I_{yy} = 3.2\]

Here since \(I_{xx} < 4I_{yy}\) so buckling takes place about x-axis.

\[K_{xx} = (I_{xx}/A)^{0.5}\]

\[= .514t\]

\[K_{yy} = (I_{yy}/A)^{0.5}\]

\[= .288t\]

Length of Connecting rod \((L)\)=2 times the stroke

\[L=117.2mm\]

Buckling load \((W_{cr}) = F_p - F_i\)

\[W_{cr} = \left( \frac{\sigma * A}{(1+a(L/K_{xx})^2} \right) \]

\[= 36343.42N\]

Where,

\[\sigma = 687MPa\text{ (initially for calculation material is taken as high strength steel)}\]

\[a = .0002\]

\[K_{xx} = .514t\]

by substituting the values we get \(t=3.2mm\) and then all the dimensions we get

\[B=5t=16mm\]

\[H=4t=12.8mm\]

\[A=112.64mm^2\]

Width at big end=1.1H-1.25H =17.6mm

Width at small end=9H-.75H=12mm

Ratio of the length of connecting rod to the radius of crank=4

Inner diameter of the small end \(d_1= F_g / (P_b *l_1)\)

\[= 6057.23/(12.5*1.5d_1) = 17.94mm\]

Where design bearing pressure for small end \(P_b1 = (12.5-15.4)N/mm^2\)

Length of the piston pin \(l_1=(1.5-2)d_1\)

Buckling load =maximum gas pressure *FOS \text{ (FOS for steel 4-8)}

\[F_g = 6057.23N\]

Thickness of the bush\((T_b) = (2-5)mm\)

Marginal thickness\((T_m) = (5-15)mm\)

Outer diameter of small end \((d_1 + 2*T_b + 2*T_m)=31.94mm\)

Design bearing pressure for big end \(P_b2 = (10.8-12.6)N/mm^2\)

Inner diameter of the big end \(d_2= F_g/(P_b2*l_2) = 23.88\)

Length of the crank pin \(l_2=(1-1.25)d_2\)

Outer diameter of the big end\((d_2+2*T_b+2*D_b+2*T_m)=47.72mm\)

CALCULATION FOR FORCES ACTING ON CONNECTING ROD

Force on the connecting rod =Max. force on the piston due to gas pressure

\[F_p=3.14/4D^2 * P = 39532.2N\]

Buckling load = Max. Force *FOS

\[F_g = 6057.23N\]

Inertia force of the reciprocating parts

\[F_i = m*r^2/(1+l/l) = 3188.78N\]

Where \(w=(2*3.14*N \text{ max})/60=889.66\text{ rad/sec}\)
r = radius of crank = stroke length/2 = 29.3 mm = 0.0293 m
m = 0.11 Kg

**SPECIFICATIONS OF CONNECTING ROD**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of the connecting rod</td>
<td>3.2</td>
</tr>
<tr>
<td>Width of the section</td>
<td>16</td>
</tr>
<tr>
<td>Height of the section</td>
<td>12.8</td>
</tr>
<tr>
<td>Width at big end</td>
<td>17.6</td>
</tr>
<tr>
<td>Width at small end</td>
<td>14.4</td>
</tr>
<tr>
<td>Inner diameter of the small end</td>
<td>17.94</td>
</tr>
<tr>
<td>Outer diameter of the small end</td>
<td>31.94</td>
</tr>
<tr>
<td>Inner diameter of the big end</td>
<td>23.88</td>
</tr>
<tr>
<td>Outer diameter of the big end</td>
<td>47.72</td>
</tr>
</tbody>
</table>

**MODELING OF CONNECTING ROD**
Model of crankcase bearing lower half

Crankcase upper and lower half
Model of connecting rod

V. ANALYSIS OF THE CONNECTING ROD

Meshing of connecting rod
Fixed Support

Load at boundary condition

Normal stress (X-axis)
Normal stress (Y-axis)

Normal stress (Z-axis)

Equivalent stress
Shear stress (XY-plane)

Shear stress (YZ-plane)

Shear stress (ZX-plane)
Directional deformation (X-axis)

Directional deformation (Y-axis)

Directional deformation (Z-axis)

Total deformation

<table>
<thead>
<tr>
<th>Types</th>
<th>Max(Mpa)</th>
<th>Min(Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalent Stress</td>
<td>589.78</td>
<td>.24164</td>
</tr>
<tr>
<td>Normal Stress(x-axis)</td>
<td>156.85</td>
<td>-196.74</td>
</tr>
<tr>
<td>Normal Stress (y-axis)</td>
<td>376.25</td>
<td>-246.63</td>
</tr>
<tr>
<td>Normal Stress(z-axis)</td>
<td>249.81</td>
<td>-644.3</td>
</tr>
<tr>
<td>Shear Stress(xy plane)</td>
<td>62.547</td>
<td>-61.293</td>
</tr>
<tr>
<td>Shear Stress(yz plane)</td>
<td>201.8</td>
<td>-202.11</td>
</tr>
<tr>
<td>Shear Stress(zx plane)</td>
<td>229.05</td>
<td>-201.82</td>
</tr>
<tr>
<td>Total Deformation</td>
<td>.24107</td>
<td>0</td>
</tr>
<tr>
<td>Directional Deformation(x-axis)</td>
<td>.0035214</td>
<td>-.0034284</td>
</tr>
<tr>
<td>Directional Deformation(y-axis)</td>
<td>.016447</td>
<td>-.016455</td>
</tr>
<tr>
<td>Directional Deformation(z-axis)</td>
<td>0</td>
<td>-.24083</td>
</tr>
</tbody>
</table>
VI. STRESS AND DEFORMATION OF FORGED STEEL

CALCULATION FOR FORGED STEEL
For forged steel:
Density of forged steel = 7.85*10^-6 Kg/mm^3
Volume = 14412 mm^3
Weight of forged steel = Volume * density
= 14412 * 7.85 * 10^-6
= 0.113 Kg
= 0.113 * 9.81 = 1.108 N
Stiffness = weight / deformation
= 1.108 / 0.24107 = 4.596 N/mm

METHODS GENERALLY USED FOR MANUFACTURING THE CONNECTING ROD

FORGING: close die forging

Closed die forging is also known as impression die forging. In impression die work metal is placed between upper and lower dies that attached to the anvil. Usually the hammer die is shaped as well. The hammer is then dropped on the workpiece so that the metal flows and fill the die cavities.

Upsetting:
Fundamentally, impression die forgings produced on horizontal forging machines (upsetters) are similar to those produced by hammers or presses. Each is the result of forcing metal into cavities in dies which separate at parting lines.
Impression of final product

VII. CONCLUSION

From the results of analysis on forged steel on H-shape connecting rod it is found that the weight of H-shape connecting rod made of forged steel is optimized as compared to the weight of I-shape connecting rod made of forged steel which increases the speed of 2-wheeler due to light weight but the H-shape connecting rod has to be replaced after a short interval of time on the regular basis due to less stiffness which increase the chances of break down of connecting rod.

REFERENCES

1. Leela Krishna Vegi, Venu Gopal Vegi. “comparison between existing carbon steel connecting rod and forged steel connecting rod”
2. Amit Kumar, Bhingole P.P. and Dinesh Kumar “ comparison between 42CrMo steel alloy with 20CrMo and 30CrMo steel alloy on weight basis.”
3. Prateek Joshi, Mohammad Umair Zaki. “comparison of new material with the existing materials used for connecting rod”.
4. G.M Sayeed Ahmed, Sirajuddin Elyas Khany, Syed Hamza Shareef. “forged steel connecting rod is replaced by aluminum alloys and carbon fiber to optimize the weight.”

BOOKS

1. Machine design by R.S. KHURMI
2. Design data by K. MAHADEVAN