FINITE ELEMENT ANALYSIS OF CONNECTING ROD USING ANSYS

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Abstract- Connecting rod is the intermediate link between the piston and the crank. And is responsible to transmit the push and pull from the piston pin to crank pin, thus converting the reciprocating motion of the piston to rotary motion of the crank. Generally connecting rods are manufactured using carbon steel and in recent days aluminium alloys are finding its application in connecting rod. In this work connecting rod is replaced by aluminium based composite material reinforced with silicon carbide and fly ash. And it also describes the modeling and analysis of connecting rod. FEA analysis was carried out by considering two materials of connecting rod for 180cc engine. The parameters like von misses stress and displacement were obtained from ANSYS software. Compared to the former material the new material found to have less weight and better stiffness. It resulted in reduction of 39.48% of weight, with 64.23% reduction in displacement.

Keywords- Connecting Rod, Ansys, Composite, Silicon Carbide, Fly Ash, Analysis

I. INTRODUCTION

Connecting rod is the intermediate link between the piston and the crank. And is responsible to transmit the push an pull from the piston pin to crank pin, thus converting the reciprocating motion of the piston to rotary motion of the crank. Connecting rod, automotives should be lighter and lighter, should consume less fuel and at the same time they should provide comfort and safety to passengers, that unfortunately leads to increase in weight of the vehicle. Thistendency in vehicle construction led the invention and implementation of quite new materials which are light and meet design requirements. Lighter connecting rods help to decrease lead caused by forces of inertia in engine as it does not require big balancing weight on crankshaft. Application of metal matrix composite enables safety increase and improves the stiffness by 48.55% and to reduce stress by 7.84%.

Pushpendrakumar Sharma et al, performed the static FEA of the connecting rod using the software and said optimization was performed to reduce weight. Weight can be reduced by changing the material of the current forged steel connecting rod to crackable forged steel (C70). And the software gives a view of stress distribution in the whole connecting rod which gives the information that which parts are to be hardened or given attention during manufacturing stage.

Vivek. C. Pathade et al, he dealt with the stress analysis of connecting rod by finite element method using pro-ewild fire 4.0 and ansys work bench 11.0 software. And concluded that the stress induced in the small end of the connecting rod are greater than the stresses induced at the bigger end. Therefore the chances of failure of the connecting rod may be at the fillet section of both end.

Ram bansal et al, in his paper a dynamic simulation was conducted on a connecting rod made of aluminium alloy using FEA. In this analysis of connecting rod were performed under dynamic load for stress analysis and optimization. Dynamic load analysis was performed to determine the in service loading of the connecting rod and FEA was conducted to find the stress at critical locations.

II. THEOROTICAL CALCULATION OF CONNECTING ROD

1. Pressure calculation:

Consider a 180cc engine

Engine type air cooled 4-stroke

Bore × Stroke (mm) = 63.5 × 56.4

Displacement = 178.6 cm³

Maximum Power = 17.03 bhp at 8500 rpm

Maximum torque = 14.72 Nm at 6500 rpm

Compression Ratio = 9.38/1

Density of petrol at 288.855 K - 737.22 × 10⁻⁹ kg/mm³

Molecular weight M = 114.228 g/mole

Ideal gas constant R = 8.3143 J/mol.k
From gas equation, 
\[ PV = m \cdot R_{\text{specific}} \cdot T \]
Where, 
- \( P \) = Pressure
- \( V \) = Volume
- \( m \) = Mass
- \( R_{\text{specific}} \) = Specific gas constant
- \( T \) = Temperature

But, mass = density * volume 
\[ m = 737.22 \times 9 \times 180 \times 10^{-3} \]
\[ m = 0.1326 \text{ kg} \]

\[ \frac{R_{\text{specific}}}{R} = \frac{M}{M} \]
\[ R_{\text{specific}} = \frac{8.3143}{0.1326} \]
\[ R_{\text{specific}} = 62.702 \]

\[ P = \frac{m \cdot R_{\text{specific}} \cdot T}{V} \]
\[ P = 0.1326 \times 62.702 \times 288.85 \times 10^{-3} \]
\[ P = 13.34 \text{ MPa} \]

\[ P \approx 13 \text{ MPa}. \]

2. Design Calculation of connecting rod:

From standards,
- Thickness of flange and web of the section = \( t \)
- Width of the section \( B = 4t \)
- Height of the section \( H = 5t \)
- Area of the section \( A = 11t^2 \)
- Moment of inertia about x axis \( I_{xx} = 34.91t^4 \)
- Moment of inertia about y axis \( I_{yy} = 10.91t^4 \)
- Therefore \( I_{xx}/I_{yy} = 3.2 \)

So, in the case of this section (assumed section) proportions shown above will be satisfactory.

Length of the connecting rod (\( L \)) = 2 times the stroke 
\[ L = 56 \text{ mm} \]

\[ F_p = \frac{\pi d^2}{4} \times \text{gas pressure} \]
\[ F_p = 38003.56 \text{ N} \]

\[ W_B = F_C \times F_S = 38003.06 \times 1.78 = 95007.65 \text{ N} \]

We know that radius of gyration of the section about X-axis, 
\[ k_{xx} = \sqrt{\frac{I_{xx}}{A}} = \sqrt{\frac{34.91t^4}{11t^2}} = 1.78 \text{ t} \]

Radius of crank, 
\[ r = \frac{\text{stroke length}}{2} = \frac{56}{2} = 28 \text{ mm} \]
IV. RESULTS AND DISCUSSION

- **ANALYSIS**
  For the finite element analysis, 13MPa of pressure is used. The analysis is carried out using ANSYS software. The pressure is applied at the small end of connecting rod keeping big end fixed. The maximum and minimum von-misses stress, displacement are noted from ANSYS.

<table>
<thead>
<tr>
<th>Sr no</th>
<th>Material</th>
<th>Tensile load</th>
<th>Compressive load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Old material</td>
<td>79.637</td>
<td>42.882</td>
</tr>
<tr>
<td>2</td>
<td>AL6061-9%SiC-15% fly ash</td>
<td>114.17</td>
<td>60.019</td>
</tr>
<tr>
<td>3</td>
<td>percentage</td>
<td>43.36</td>
<td>39.96</td>
</tr>
</tbody>
</table>

TABLE 2

**COMPARISON OF STRESS AND DISPLACEMENT FOR DIFFERENT MATERIALS**

From fig 7, the maximum stress occurs at the piston end of the connecting rod is 79.637 Mpa. From the fig 8 the maximum stress occurs at the piston end of the connecting rod is 114.17 Mpa.
2. DISPLACEMENT PLOTS

From the fig 9 the maximum stress occurs at the piston end of the connecting rod is 42.882 Mpa. From the fig 10 the maximum stress occurs at the piston end of the connecting rod is 60.019 Mpa.

3. VOLUME, WEIGHT AND STIFFNESS OF THE CONNECTING ROD.

a) Weight of the Connecting Rod.

- For aluminium 360:
The volume of the connecting rod used is 137650 mm$^3$. Therefore the mass of the connecting rod for respective materials are:
  Weight = volume * density
  Weight = 137650 * 2.8e-3
  Weight = 385.42 grams

- For aluminium 6061-9%SiC-15%fly ash
  The volume of the connecting rod used is 89306.72 mm$^3$. Therefore the mass of the connecting rod for respective materials are:
  Weight = volume * density
  Weight = 89306.72 * 2.61161e-3 = 233.233 grams
  Therefore there is net difference of 152.19 grams in the new connecting rod for the same volume, i.e., is 39.48 % reduction in weight.

b) Stiffness of the Connecting Rod

1. For aluminium 360
  Weight of the connecting rod = 385.42 grams
  Deformation = 0.0349 mm
  Stiffness = weight / deformation
  Stiffness = 385.42 / 0.0349
  Stiffness = 11043.55 g/mm

1. For aluminium 6061-9%SiC-15%fly ash
  Weight of the connecting rod = 233.233 grams
  Deformation = 0.0123 mm
  Stiffness = weight / deformation
  Stiffness = 233.233 / 0.0123
  Stiffness = 18962.03 g/mm

CONCLUSION

- Weight can be reduced by changing the material of the current al360 connecting rod to hybrid Alfasic composites.
- the optimised connecting rod is 39.48% lighter than the current connecting rod.
- the new optimised connecting rod is comparatively much stiffer than the former.

REFERENCES

