DESIGN, ANALYSIS AND OPTIMIZATION 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 220cc 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 17.35% of weight.

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 anpull from the piston pin to crank pin, thus converting the reciprocating motion of the piston to rotary motion of the crank. Connecting rod, automobiles 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. This tendency 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 advances that leads to effective use of fuel and to obtain high engine power. Honda Company had already started the manufacturing of aluminum connecting rods reinforced with steel continuous fibers. By carrying out these modifications to engine elements will result in effective reduction of weight, increase of durability of particular part, will lead to decrease of overall engine weight, improvement in its traction parameters, economy and ecological conditions such as reduction in fuel consumption and emission of harmful substances into atmosphere. K. Sudershankumar et al, described modeling and analysis of Connecting rod. In his project carbon steel connecting rod is replaced by aluminium boron carbide connecting rod. Aluminium boron carbide is found to haveworking factory of safety is nearer to theoretical factory of safety, to increase the stiffness by 48.55% and to reducetress by 7.84%.

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.

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.

Ram bansal et al, in his paper a dynamic simulation was conducted on a connecting rod made of aluminum 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 an FEA was conducted to find the stress at critical locations.

II. THEOROTICAL CALCULATION OF CONNECTING ROD

1. Pressure calculation:
Consider a 220cc engine,
Engine type air cooled 4-stroke
Bore × Stroke(mm) = 67×62.4
Displacement=220 cm³
Maximum Power = 20.8 Bhp at 8500rpm
Maximum torque= 19.12 Nm at 7000rpm
Mechanical efficiency of the engine (η) = 80 %.

\[ \eta = \frac{\text{Brake Power (B.P.)}}{\text{Indicated Power (I.P.)}} \]
1. For AL360 MATERIAL

\[ B.P. = \frac{2\pi NT}{60} = \frac{2\pi \times 19.12 \times 7000}{60} = 14.015 \text{ kW} \]
\[ I.P. = \frac{P \times A \times L \times N}{\eta} = 17.518 \text{ kW} \]
\[ I.P. = P \times A = \frac{3.2}{4} \times D^2 \times L \times N \]
\[ 17.518 \times 1 \times 1000 = P \times \frac{3.2}{4} \times 0.0624^2 \times 0.0624^2 \times 7000 \]
\[ \text{So, } P = 13.65 \times 10^5 \text{ N/m}^2 \text{ or } P = 1.365 \text{ MPa} \]

Maximum Pressure, \( P_{\text{max}} = 10 \times P \)
\[ = 10 \times 1.365 \]
\[ = 13.65 \text{ MPa} \]

2. Design Calculation of connecting rod:

In general

\[ \text{Fig. 1: I Section for connecting rod} \]

From standards,

\( \text{Tensile load} = 2 \times \text{stroke} \times \text{L} = 124.8 \text{ mm} \)
\( \text{Fc}= (\pi \text{d}^2 / 4) \times \text{gas pressure} \)
\( \text{Fc}= 48125.154 \text{ N} \)
\( \text{WB} = \text{FC} \times \text{F.S.} = 48125.154 \times 1.78 = 85662.77 \text{ N} \)

We know that radius of gyration of the section about x axis,
\[ K_{x x} = \frac{I_{x x}}{A} = \frac{34.91 t^4}{11 t^4} = 3.2 \]

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 
\[ \text{L} = 124.8 \text{ mm} \]
\( \text{Fcc} = (\pi \text{d}^2 / 4) \times \text{gas pressure} \)
\( \text{Fcc} = 48125.154 \text{ N} \)
\( \text{WB} = \text{FC} \times \text{F.S.} = 48125.154 \times 1.78 = 85662.77 \text{ N} \)

We know that radius of gyration of the section about X-axis,
\[ K_{x x} = \frac{I_{x x}}{A} = \frac{34.91 t^4}{11 t^4} = 3.2 \]

Radius of crank,
\[ r = \frac{2 \times \text{stroke length}}{2} = 31.2 \text{ mm} \]

Length of Connecting Rod = \( 2 \times \text{stroke} \times \text{L} = 124.8 \text{ mm} \)

\[ \text{Equivalent length of the connecting rod for both ends hinged, } L_{e} = l = 124.8 \text{ mm} \]

For AL360 MATERIAL

Now according to Rankine’s formula, we know that buckling load (WB),
\[ 85662.77 = 7.35 \text{ mm} (\alpha = 0.002) \]

Thus, the diameter of crank, \( d = \frac{\text{length of the connecting rod}}{\text{radius of gyration}} \)
\[ \text{Width of the section, } B = 4 \times 4 \times 7.35 = 29.4 \text{ mm} \]

Height of the section, \( H = 5 \times 5 \times 7.35 = 36.75 \text{ mm} \)

Depth near the big end,
\[ H_1 = 1.2H = 1.2 \times 36.75 = 44 \text{ mm} \]

Depth near the small end,
\[ H_2 = 0.85H = 0.85 \times 36.75 = 31.23 \text{ mm} \]

2. FOR ALUMINIUM 6061-9-% SIC-15% FLY ASH

Now according to Rankine’s formula, we know that buckling load (WB),
\[ 85662.77 = \frac{363+11t^2}{1+0.0624^2} = 5.254 \text{ mm} \]

Width of the section, \( B = 4 \times 4 \times 5.254 = 21.01 \text{ mm} \)

Height of the section, \( H = 5 \times 5 \times 21.01 = 26.27 \text{ mm} \)

Depth near the big end,
\[ H_1 = 1.2H = 1.2 \times 26.27 = 31.52 \text{ mm} \]

Depth near the small end,
\[ H_2 = 0.85H = 0.85 \times 26.27 = 22.32 \text{ mm} \]

### MATERIAL PROPERTIES USED FOR ANALYSIS

#### TABLE 1

<table>
<thead>
<tr>
<th>Sr no</th>
<th>Material</th>
<th>Tensile load (MPa)</th>
<th>Compressive load (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AL360</td>
<td>124.06</td>
<td>84.389</td>
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<tr>
<td>2</td>
<td>AL6061</td>
<td>120.84</td>
<td>80.983</td>
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</tbody>
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#### TABLE 2

<table>
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<tr>
<th>Sr no</th>
<th>Material</th>
<th>Tensile load (MPa)</th>
<th>Displacement (mm)</th>
<th>Compressive load (MPa)</th>
<th>Displacement (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AL360</td>
<td>0.07584</td>
<td>10.914</td>
<td>84.389</td>
<td>5.254</td>
</tr>
<tr>
<td>2</td>
<td>AL6061</td>
<td>0.07486</td>
<td>10.914</td>
<td>80.983</td>
<td>5.254</td>
</tr>
</tbody>
</table>

#### 1. VON-MISES STRESS PLOTS:

\[ \text{Fig. 2: Von-mises stress for tensile load Al-360} \]
From the fig 13 the maximum displacement occurs in the connecting rod is 0.048535 mm. From the fig 14 the maximum displacement occurs in the connecting rod is 0.046828 mm.

IV. 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 2.6805e5 mm$^3$. Therefore the mass of the connecting rod for respective materials are:
     \[
     \text{Weight} = \text{volume} \times \text{density} \\
     \text{Weight} = 2.6805e5 \times 2.8e-3 \\
     \text{Weight} = 750.54 \text{ grams}
     \]
   - For aluminium 6061-9%SiC-15%fly ash
     The volume of the connecting rod used is 2.3751e5 mm$^3$. Therefore the mass of the connecting rod for respective materials are:
     \[
     \text{Weight} = \text{volume} \times \text{density} \\
     \text{Weight} = 2.3751e5 \times 2.61161e-3 \\
     \text{Weight} = 620.28 \text{ grams}
     \]
     Therefore there is net difference of 130.26 grams in the new connecting rod for the same volume.

V. RESULT

- For aluminium 360
  Weight of the connecting rod = 750.54 grams
  Deformation = 0.07584 mm
- For aluminium 6061-9%SiC-15%fly ash
  Weight of the connecting rod = 620.28 grams
  Deformation = 0.074086 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 17.33% lighter than the current connecting rod. Deformation can be reduced by changing the material of the current Al360 connecting rod to hybrid.

REFERENCES


