Abstract—The connecting rod is an important part of an I.C. engine. It has to carry the thrust force from piston to the crank shaft. The connecting rod is subjected to high degree of stresses. The main objective of the paper is to replace the conventional material used for connecting rod with a new composite material to reduce its weight. This paper deals with the design of a connecting rod for Hero Splendor vehicle using aluminium fly ash silicon composite. The model of the connecting rod is developed using a modeling software. The static analysis of the designed connecting rod is done using FEM software and the results are compared with the existing material C70 steel. Further a wear test is carried out to check the wear characteristics of the new composite material and compare it with the existing material. By using aluminium fly ash silicon composite weight reduction of the connecting rod is achieved. The designed connecting rod is having higher stiffness to weight ratio than the existing connecting rod.

Keywords—Connecting rod, aluminium fly ash silicon composite, optimization, FEA

I. INTRODUCTION

The internal combustion engine connecting rod is one of the most vital parts of the engine. It converts the reciprocating motion of the piston to rotary motion of the crank shaft. It is subjected to various complex loads due to gas pressure and the inertia forces of the reciprocating parts. The stresses induced into the connecting rod due to the thrust and the pull of the piston are bending stresses, tension and compression in the axial directions. The connecting rod should be able to withstand these forces in adverse environmental conditions. The design and the weight of the connecting rod influence the performance of the engine. In this paper design of the I section of the connecting rod is done for aluminium fly ash silicon composite material for Hero Splendor vehicle. Further a wear test is carried out to check the wear characteristics of the new material.

II. DESIGN OF I SECTION OF CONNECTING ROD

Gas pressure and inertia forces induce axial stresses and bending stresses in the connecting rod. These forces are considered while designing the connecting rod I section. I section is selected for the cross section of the connecting rod to provide maximum rigidity with minimum weight.

A. Pressure Calculations

Consider a 100cc engine:

Engine type air cooled 4-stroke

Bore × Stroke (mm) = 52.4×57.88

Displacement = 97.2 cc

Maximum Power = 5.5kw at 8000rpm

Maximum Torque = 1.05kgm at 4000rpm

Compression Ratio = 9.1:1

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 Ideal gas equation,

\[ PV = m \times R_{specific} \times T \]

Where,

\[ P = \text{Pressure} \]

\[ V = \text{Volume} \]

\[ m = \text{Mass} \]

\[ R_{specific} = \text{Specific gas constant} \]

\[ T = \text{Temperature} \]

But, mass = density \times volume \rightarrow m = 737.22E⁻⁹ \times 97.22 \times 10³ = 0.0716 kg

\[ R_{specific} = \frac{R}{M} \]

\[ R_{specific} = \frac{8.3143}{0.11423} \]

\[ R_{specific} = 72.787 \ Nm/\ kg/\ K \]

\[ P = \frac{(0.0716 \times 72.786 \times 288.85)}{97.2 \times 10³ \times 10⁻⁹} \]

\[ P = 15.48 \ MPa \]

Force acting on the Piston \( F_p \)

\[ F_p = P \times A \]

\[ F_p = 15.48 \times 106 \times 2.1565 \times 10⁻³ \]

\[ F_p = 33398.38 \]

B. Design of I Section

General I Section

**Fig. 1 Standard Dimensions of I Section**

Thickness of the flange and web of the section=t

Width of the section B=4t

Height of the section H=5t

Area of the section \( A = 11t² \)

Moment of inertia about x axis \( I_{xx} = 34.91t4 \)

Moment of Inertia about y axis \( I_{yy} = 10.91t4 \)

Therefore \( I_{xx}/I_{yy} = 3.2 \)

According to Rankine-Gordon formula,

\[ F = \frac{\sigma \times A}{1 + a(\frac{1}{K})^2} \]
Let, $A = \frac{C}{s}$ area of connecting rod
$L = \text{length of connecting rod}$
$\sigma = \text{Compressive yield stress}$
$F = \text{buckling load}$
$I_{xx}$ and $I_{yy} = \text{radius of gyration of the section about } x-x$ and $y-y \text{ axis respectively}$
$T = 3.023 \text{ mm}$
Therefore
Width $B = 4t - 12.092 \text{ mm}$
Height $H = 5t = 15.115 \text{ mm}$
Area $= 11t^2 = 100.523 \text{ mm}^2$
Height at piston end $H_1 = 1.1H - 1.25H$
$H_1 = 1.1 \times 15.115 = 16.625 \text{ mm}$
Height at crank end $H_2 = 0.9H - 0.75H$
$H_2 = 0.8 \times 15.115 = 13.6035 \text{ mm}$
Dimensions of big end
$P = D_i \times D_o \times P_b$
$D_i = 0.81 \times 39 = 31.59 \text{ mm}$
Dimensions of small end
$D_o = 17.75 \text{ mm}$
$D_i = 0.625 \times 17.75 = 11.09375 \text{ mm}$

C. Material Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Al composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate Tensile Strength</td>
<td>422MPa</td>
</tr>
<tr>
<td>Yield Strength</td>
<td>363MPa</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>70GPa</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>0.33</td>
</tr>
<tr>
<td>Density</td>
<td>2611.61 kg/m³</td>
</tr>
</tbody>
</table>

D. Model of Connecting Rod

III. ANALYSIS OF CONNECTING ROD MODEL

For the finite element analysis, 15.48MPa pressure is applied. The meshing and the analysis are carried out using ANSYS software.

A. Equivalent Stresses

B. Total Deformation

C. Equivalent Strain
D. Maximum Shear Stress

**Fig. 8 Maximum Shear Stress in connecting rod for Al fly ash composite**

**Fig. 9 Maximum Shear Stress in connecting rod for C70 steel**

E. FEA Analysis Result Comparison

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameter</th>
<th>Al Composite</th>
<th>C70 Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equivalent Stress</td>
<td>54.199 MPa</td>
<td>101.31 MPa</td>
</tr>
<tr>
<td>2</td>
<td>Total Deformation</td>
<td>0.02946 mm</td>
<td>0.0211 mm</td>
</tr>
<tr>
<td>3</td>
<td>Equivalent Strain</td>
<td>0.000542</td>
<td>0.0005313</td>
</tr>
<tr>
<td>4</td>
<td>Maximum Shear Stress</td>
<td>28.551 MPa</td>
<td>56.416 MPa</td>
</tr>
</tbody>
</table>

From the comparison it is observed that the new material can withstand the adverse conditions in the engine and has better comparative results with respect to old material C70 steel.

IV. CONCLUSION

It can be concluded that the proposed aluminium fly ash composite is better than C70 steel in equivalent stress, shear stress, total deformation and equivalent strain. By changing the composition of the new composite better wear properties can be obtained. Also the mass of connecting rod using C70 steel is 0.1222 kg whereas that of aluminium fly ash composite is 0.054 kg. Hence weight reduction is successful.

References