Design And Analysis of Connecting Rod Using Forged steel

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Abstract – The connecting rod is the intermediate member between the piston and the Crankshaft. Its primary function is to transmit the push and pull from the piston pin to the crank pin, thus converting the reciprocating motion of the piston into rotary motion of the crank. This thesis describes designing and Analysis of connecting rod. Currently existing connecting rod is manufactured by using Carbon steel. In this drawing is drafted from the calculations. A parametric model of Connecting rod is modeled using CATIA V5 R19 software and to that model, analysis is carried out by using ANSYS 13.0 Software. Finite element analysis of connecting rod is done by considering the materials, viz... Forged steel. The best combination of parameters like Von misses Stress and strain, Deformation, Factor of safety and weight reduction for two wheeler piston were done in ANSYS software. Forged steel has more factor of safety, reduce the weight, increase the stiffness and reduce the stress and stiffer than other material like carbon steel. With Fatigue analysis we can determine the lifetime of the connecting rod.

Keywords: connecting Rod, Analysis of connecting rod, four stroke engine connecting rod, forged steel connecting rod, design and analysis of connecting rod.

Nomenclature

\[ A = \text{cross sectional area of the connecting rod.} \]
\[ L = \text{length of the connecting rod.} \]
\[ C = \text{compressive yield stress.} \]
\[ W_c = \text{crippling or buckling load.} \]
\[ I_{xx} = \text{moment of inertia of the section about x-axis} \]
\[ I_{yy} = \text{moment of inertia of the section about y-axis} \]
\[ K_{xx} = \text{radius of gyration of the section about x-axis} \]
\[ K_{yy} = \text{radius of gyration of the section about y-axis} \]
\[ D = \text{Diameter of piston} \]
\[ r = \text{Radius of crank} \]

1. INTRODUCTION

In a reciprocating piston engine, the connecting rod connects the piston to the crank or crankshaft. In modern automotive internal combustion engines, the connecting rods are most usually made of steel for production engines, but can be made of aluminum (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for a combination of strength and lightness at the expense of affordability) for high performance engines, or of cast iron for applications such as motor scooters. The small end attaches to the piston pin, gudgeon pin (the usual British term) or wrist pin, which is currently most often press fit into the con rod but can swivel in the piston, a "floating wrist pin" design. The connecting rod is under tremendous stress from the reciprocating load represented by the piston, actually stretching and being compressed with every rotation, and the load increases to the third power with increasing engine speed. Failure of a connecting rod, usually called "throwing a rod" is one of the most common causes of catastrophic engine failure in cars, frequently putting the broken rod through the side of the crankcase and thereby rendering the engine irreparable; it can result from fatigue near a physical defect in the rod, lubrication failure in a bearing due to faulty maintenance or from failure of the rod bolts from a defect, improper tightening, or re-use of already used (stressed) bolts where not recommended. Despite their frequent occurrence on televised competitive automobile events, such failures are quite rare on production cars during normal daily driving. This is because production auto parts have a much larger factor of safety, and often

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more systematic quality control. When building a high performance engine, great attention is paid to the connecting rods, eliminating stress risers by such techniques as grinding the edges of the rod to a smooth radius, shot peening to induce compressive surface stresses (to prevent crack initiation), balancing all connecting rod/piston assemblies to the same weight and Magnafluxings to reveal otherwise invisible small cracks which would cause the rod to fail under stress. In addition, great care is taken to torque the con rod bolts to the exact value specified; often these bolts must be replaced rather than reused. The big end of the rod is fabricated as a unit and cut or cracked in two to establish precision fit around the big end bearing shell. Recent engines such as the Ford 4.6 liter engine and the Chrysler 2.0 liter engine have connecting rods made using powder metallurgy, which allows more precise control of size and weight with less machining and less excess mass to be machined off for balancing. The cap is then separated from the rod by a fracturing process, which results in an uneven mating surface due to the grain of the powdered metal. This ensures that upon reassembly, the cap will be perfectly positioned with respect to the rod, compared to the minor misalignments which can occur if the mating surfaces are both flat. A major source of engine wear is the sideways force exerted on the piston through the con rod by the crankshaft, which typically wears the cylinder into an oval cross-section rather than circular, making it impossible for piston rings to correctly seal against the cylinder walls. Geometrically, it can be seen that longer connecting rods will reduce the amount of this sideways force, and therefore lead to longer engine life. However, for a given engine block, the sum of the length of the con rod plus the piston stroke is a fixed number, determined by the fixed distance between the crankshaft axis and the top of the cylinder block where the cylinder head fastens; thus, for a given cylinder block longer stroke, giving greater engine displacement and power, requires a shorter connecting rod (or a piston with smaller compression height), resulting in accelerated cylinder wear.

2. SPECIFICATION OF THE PROBLEM

The objective of the present work is to design and analyses of connecting rod made of Forged steel. Steel materials are used to design the connecting rod. In this project the material (carbon steel) of connecting rod replaced with Forged steel .Connecting rod was created in CATIAV5 R19. Model is imported in ANSYS 13.0 for analysis. After analysis a comparison is made between existing steel connecting rod viz., Forged steel in terms of weight, factor of safety, stiffens, deformation and stress.

![Fig 2.1 Schematic Diagram of Connecting Rod](image)

3. DESIGN OF CONNECTING ROD

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 force, therefore the cross-section of the connecting rod is designed as a strut and the rankine formula is used. A connecting rod subjected to an axial load W may buckle with x-axis as neutral axis in the plane of motion of the connecting rod, or y-axis is a neutral axis. 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 either axis.

According to rankine formulae

\[ W_{cr} \text{ about } x\text{-axis} = \frac{[\sigma_c \times A]}{1+a [\frac{L}{K_{xx}}]^2} = \frac{[\sigma_c \times A]}{1+a [\frac{L}{K_{xx}}]^2} [\because \text{for both ends hinged } L = l] \]

\[ W_{cr} \text{ about } y\text{-axis} = \frac{[\sigma_c \times A]}{1+a [\frac{L}{K_{yy}}]^2} = \frac{[\sigma_c \times A]}{1+a [\frac{L}{K_{yy}}]^2} [\because \text{for both ends fixed } L = l/2] \]

In order to have a connecting rod equally strong in buckling about both the axis, the buckling loads must be equal. i.e.

\[ \frac{[\sigma_c \times A]}{1+a [\frac{L}{K_{xx}}]^2} = \frac{[\sigma_c \times A]}{1+a [\frac{L}{K_{yy}}]^2} [\text{or}] \]
\[
\left[ \frac{l}{K_{xx}} \right]^2 = \left[ \frac{l}{2K_{yy}} \right]^2
\]

\[
K_{xx} = 4K_{yy} \quad \text{[or]} \quad I_{xx} = 4I_{yy} \quad \text{[\because I = A \times K^2]}
\]

This shows that the connecting rod is four times strong in buckling about y-axis than about x-axis. If \( I_{xx} > 4I_{yy} \), then buckling will occur about y-axis and if \( I_{xx} < 4I_{yy} \), then buckling will occur about x-axis. In actual practice \( I_{xx} \) is kept slightly less than \( 4I_{yy} \). It is usually taken between 3 and 3.5 and the connecting rod is designed for buckling about x-axis. The design will always be satisfactory for buckling about y-axis. The most suitable section for the connecting rod is I-section with the proportions shown mfg.

Area of the cross section = 2[4t \times t] + 3t \times t = 11t^2

Moment of inertia about x-axis = 2[4txt] + 3txt = 11t^2

Moment of inertia about x-axis
\[
I_{xx} = \frac{1}{12} \left[ 4t \left( 5t \right)^3 - 3t \left( 3t \right)^3 \right] = \frac{419}{12} \left[ t^4 \right]
\]

And moment of inertia about y-axis
\[
I_{yy} = \frac{2x1}{12} \times t \times \left( 4t \right)^3 + \frac{1}{12} \left( 3t \right)^3 t^3 = \frac{131}{12} \left[ t^4 \right]
\]

\[
I_{xx}/I_{yy} = \frac{419/12}{131/12} = 3.2
\]

Since the value of \( I_{xx}/I_{yy} \) lies between 3 and 3.5 m therefore I-section chosen is quite satisfactory.

3.1 Pressure Calculation for 150cc Engine

**Suzuki 150 cc Specifications**

Engine type air cooled 4-stroke

Bore x Stroke (mm) = 57\times58.6

Displacement = 149.5 CC

Maximum Power = 13.8 bhp @ 8500 rpm

Maximum Torque = 13.4 Nm @ 6000 rpm

Compression Ratio = 9.35/1

Density of Petrol C8H18 = 737.22 kg/m³

= 737.22E-9 kg/mm³

Temperature = 60 o F

\[
= 288.855 \text{o K}
\]

Mass = Density \times Volume

\[
= 737.22E^{-9} \times 149.5E^3
\]

= 0.11kg

Molecular Weight of Petrol 114.228 g/mole

From Gas Equation,

\[
PV = Mrt R
\]

\[
= \frac{R_c}{M_w}
\]

\[
= 8.3143/114228
\]

\[
= 72.76
\]

\[
P = \frac{(0.11x72.786x288.85)}{149.5E^3}
\]

\[
P = 15.5 \text{ Mpa.}
\]

3.2 Design Calculations for Existing Connecting Rod

Thickness of flange & web of the section = t

Width of section B = 4t

The standard dimension of I-SECTION.

\[
\text{Fig 3.1 Standard Dimension of I – Section}
\]

Height of section H = 5t

Area of section \( A = 2(4t \times t) + 3t \times t \)

\[
A = 11t^2
\]

M.O.I of section about x axis:

\[
I_{xx} = \frac{1}{12} \left[ 4t \left( 5t \right)^3 - 3t \left( 3t \right)^3 \right]
\]

\[
= \frac{419}{12} \left[ t^4 \right]
\]
MI of section about y axis:

\[ I_{yy} = \frac{2}{12}x^2 \times t \times (4t)^3 = \frac{131}{12}[t^4] \]

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

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

\( L = 117.2 \text{ mm} \)

Buckling load \( W_B \) = maximum gas force \( F \times O.S \)

\[ W_B = \frac{\sigma_c \times A}{(1 + a(L/K_{xx}))^2} \]

\[ = 37663 \text{ N} \]

\( \sigma_c \) = compressive yield stress = 415MPa

\[ K_{xx} = \frac{l_{xx}}{A} \]

\[ K_{xx} = 1.78t \]

\[ a = \frac{\sigma_c}{\pi^2 E} \]

\[ a = 0.0002 \]

By substituting \( \sigma_c, A, a, L, K_{xx} \) on \( W_B \) then

\[ = 4565t^2 - 37663t^2 - 81639.46 = 0 \]

\[ t^2 = 10.03 \]

\[ t = 3.167 \text{ mm} \]

\[ t = 3.2 \text{ mm} \]

Width of section \( B = 4t \)

\[ = 4 \times 3.2 \]

\[ = 12.8 \text{ mm} \]

Height of section \( H = 5t \)

\[ = 5 \times 3.2 \]

\[ = 16 \text{ mm} \]

Area \( A = 11t^2 \)

\[ = 11 \times 3.2 \times 3.2 \]

\[ = 112.64 \text{ mm}^2 \]

Height at the big end (crank end) = \( H_2 \)

\[ = 1.1H \text{ to } 1.25H \]

\[ = 1.1 \times 16 \]

\[ H_2 = 17.6 \text{ mm} \]

Height at the small end (piston end) = 0.9H to 0.75H

\[ = 0.9 \times 16 \]

\[ H_1 = 12 \text{ mm} \]

Stroke length \( l = 117.2 \text{ mm} \)

Diameter of piston \( D = 57 \text{ mm} \)

\( P = 15.5 \text{ N/mm}^2 \)

Radius of crank \( r = \frac{l}{2} \)

\[ = 58.6/2 \]

\[ = 29.3 \]

Maximum force on the piston due to pressure

\[ F_1 = \frac{\pi}{4D^2} \times P \]

\[ = \pi/4 \times (57)^2 \times 15.469 \]

\[ = 39473.16 \text{ N} \]

Maximum angular speed \( \omega_{max} = \frac{[2\pi N_{max}]}{60} \)

\[ A = \pi r^2 \]

\[ \omega_{max} = \frac{[2\pi \times 8500]}{60} \]

\[ \omega_{max} = \pi r^2 \]
\[ = 768 \text{ rad/sec} \]

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

\[ N = \frac{l}{r} = \frac{112}{29.3} = 3.8 \]

Maximum Inertia force of reciprocating parts

\[ F_{im} = Mr (W_{max})^2 r (\cos \theta + \frac{\cos^2 \theta}{n}) \quad \text{(Or)} \]

\[ F_{im} = Mr (W_{max})^2 r (1+ \frac{1}{n}) \]

\[ = 0.11 \times (768)^2 \times (0.0293) \times (1+ (1/3.8)) \]

\[ F_{im} = 2376.26 \text{N} \]

Inner diameter of the small end \( d_1 \)

\[ d_1 = \frac{F_g}{P_{b1} \times l_1} \]

\[ = \frac{6277.167}{12.5 \times 1.5d_1} \]

\[ = 17.94 \text{mm} \]

Where,

Design bearing pressure for small end \( p_{b1} = 12.5 \) to 15.4N/mm²

Length of the piston pin \( l_1 = (1.5 \text{ to } 2) \times d_1 \)

Outer diameter of the small end = \( d_1 + 2t_b + 2t_m \)

\[ = 17.94 + 2 \times 2 + 2 \times 5 \]

\[ = 31.94 \text{mm} \]

Where,

Thickness of the bush \( t_b \) = 2 to 5 mm

Marginal thickness \( t_m \) = 5 to 15 mm

Nominal diameter of bolt \( d_b \) = 1.2 x root diameter of the bolt

\[ = 1.2 \times 4 = 4.8 \text{mm} \]

### 3.3 Specifications of connecting rod

<table>
<thead>
<tr>
<th>Table 3.3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sno</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
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<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
</tbody>
</table>

### 4. MODELING OF CONNECTING ROD

**Making of Stem**

![Fig 4.1 Making of Stem Pad](http://www.ijser.org)

Length of the crank pin \( l_2 = (1.0 \text{ to } 1.25) \times d_2 \)

Root diameter of the bolt \( = \left( \frac{2F_{im}}{\pi \times S_t} \right)^{1/2} \)

\[ = \left( \frac{2 \times 6277.167}{\pi \times 56.667} \right)^{1/2} \]

\[ = 4 \text{mm} \]

Outer diameter of the big end = \( d_2 + 2t_b + 2d_b + 2t_m \)

\[ = 23.88 \times 2 + 2 \times 4 + 2 \times 5 \]

\[ = 47.72 \text{mm} \]

Where,

Thickness of the bush \( t_b \) = 2 to 5 mm

Marginal thickness \( t_m \) = 5 to 15 mm

Nominal diameter of bolt \( d_b \) = 1.2 x root diameter of the bolt

\[ = 1.2 \times 4 = 4.8 \text{mm} \]
5. ANALYSIS OF THE CONNECTING ROD

Modified Connecting Rod (Forged Steel)

Fig 5.1 Meshing of Connecting Rod in Tetrahedral
Fig 5.2 Loads at Boundary Conditions

Fig 5.3 Equivalent Stress

Fig 5.4 Normal Stress (X-Axis)

Fig 5.5 Normal Stress (Y-Axis)

Fig 5.6 Normal Stress (Z-Axis)

Fig 5.7 Shear Stress (XY Plane)

Fig 5.8 Shear Stress (YZ Plane)

Fig 5.9 Shear Stress (ZX Plane)
TABLE 5.1
Stresses and Deformation of Forged Steel

<table>
<thead>
<tr>
<th>Sno</th>
<th>Types</th>
<th>Max (Mpa)</th>
<th>Min (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equivalent stress</td>
<td>38.298</td>
<td>4.0317e-9</td>
</tr>
<tr>
<td>2</td>
<td>Normal stress (x-axis)</td>
<td>25.283</td>
<td>-15.692</td>
</tr>
<tr>
<td>3</td>
<td>Normal stress (y-axis)</td>
<td>28.088</td>
<td>-15.485</td>
</tr>
<tr>
<td>4</td>
<td>Normal stress (z-axis)</td>
<td>1.1978</td>
<td>-0.85736</td>
</tr>
<tr>
<td>5</td>
<td>Shear stress (xy plane)</td>
<td>20.166</td>
<td>-20.183</td>
</tr>
<tr>
<td>6</td>
<td>Shear stress (yz plane)</td>
<td>0.91522</td>
<td>-0.96534</td>
</tr>
<tr>
<td>7</td>
<td>Shear stress (zx plane)</td>
<td>0.7183</td>
<td>-0.72013</td>
</tr>
<tr>
<td>8</td>
<td>Total deformation</td>
<td>0.0025932</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>Directional deformation (x-axis)</td>
<td>0.0005354</td>
<td>-0.0025925</td>
</tr>
<tr>
<td>10</td>
<td>Directional deformation (y-axis)</td>
<td>0.0016764</td>
<td>-0.007687</td>
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<tr>
<td>11</td>
<td>Directional deformation (z-axis)</td>
<td>0.00013292</td>
<td>-0.0001347</td>
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</tbody>
</table>

TABLE 5.2
Mechanical properties for forged steel

<table>
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<tr>
<th>Sno</th>
<th>Mechanical Properties</th>
<th>Forged Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Density (g/cc)</td>
<td>7.7</td>
</tr>
<tr>
<td>2</td>
<td>Average hardness (HRB)</td>
<td>101</td>
</tr>
<tr>
<td>3</td>
<td>Modulus of elasticity (Gpa)</td>
<td>221</td>
</tr>
<tr>
<td>4</td>
<td>Yield strength, YS (Mpa)</td>
<td>625</td>
</tr>
<tr>
<td>5</td>
<td>Ultimate strength, Su (Mpa)</td>
<td>625</td>
</tr>
<tr>
<td>6</td>
<td>Percent reduction in area, %, RA</td>
<td>58</td>
</tr>
<tr>
<td>7</td>
<td>Poison ratio</td>
<td>0.29</td>
</tr>
</tbody>
</table>
6. CHEMICAL COMPOSITION OF FORGED STEEL
Forged Steel 0.61-0.68%C, 0.2-0.4%S, 0.5-1.2%Mn, 0.04%S, 0.04%P, 0.9-1.2%Cr

7. CALCULATION

7.1 Calculation for factor of safety of connecting rod

\[ f.s = \frac{\sigma_m}{\sigma_y} + \frac{\sigma_v}{\sigma_e} \]

For Forged Steel

\[ \sigma_{\text{max}} = 38.298 \quad \sigma_{\text{min}} = 4.0317 \times 10^{-9} \]

\[ \sigma_m = \frac{\sigma_{\text{max}} + \sigma_{\text{min}}}{2} = 19.149 \]

\[ \sigma_y = 625 \text{ Mpa} \]

\[ \sigma_v = \frac{\sigma_{\text{max}} - \sigma_{\text{min}}}{2} = 19.149 \]

\[ \sigma_e = 0.6 \times 625 = 375 \]

\[ \frac{1}{f.s} = 0.081 = 12.23 \]

Factor of safety [F.S] = 12.23

7.2 Calculation for Weight and Stiffness

For Forged Steel:

Density of forged steel = \(7.7 \times 10^{-6}\) kg/mm³

Volume = 41050 mm³

Deformation = 0.0025932 mm

Weight of forged steel = volume \times density

\[ = 41050 \times 7.7 \times 10^{-6} \]

\[ = 0.31 \text{ kg} \]

\[ \sigma_u = 827 \text{ Mpa} \]

\[ \sigma_e = \sigma_u \times 0.5 \]

\[ = 827 \times 0.5 \]

\[ = 413.5 \text{ Mpa} \]

\[ \sigma'_{e} = \sigma_e \times k_a \times k_{sr} \times k_{sz} \]

\[ \sigma'_{e} = 413.5 \times 0.8 \times 1.2 \times 1 \]

\[ = 396.96 \text{ Mpa} \]

\[ S_f = \frac{f.s\sigma_{\text{v}}}{1 - \frac{f.s\sigma_{\text{m}}}{\sigma_{\text{u}}}} \]

\[ = \frac{12.23 \times 19.149}{1 - \frac{12.23 \times 19.149}{827}} \]

\[ = 3.1 \times 9.81 = 30 \text{ N} \]

Stiffness = \[
= \frac{\text{weight}}{\text{deformation}}
= \frac{3.10}{0.0025932}
= 1195.74 \text{ N/mm} \]

7.3 Fatigue calculation

Result for fatigue of connecting rod:

\[ N = 1000 \left( \frac{\sigma_{\text{y}}}{0.9\sigma_{\text{u}}} \right)^3 \left( \frac{\sigma_{\text{e}}'}{0.9\times \sigma_{\text{u}}} \right) \]

Where,

\[ N \quad \text{ = No. of cycles} \]

\[ \sigma_{\text{u}} \quad \text{= Endurance Limit} \]

\[ \sigma_{\text{y}} \quad \text{= Ultimate Tensile Stress} \]

\[ \sigma_{\text{e}}' \quad \text{= Endurance limit for variable axial stress} \]

\[ k_a \quad \text{= Load correction factor for reversed axial load} = 0.8 \]

\[ k_{sr} \quad \text{= Surface finish factor} = 1.2 \]

\[ k_{sz} \quad \text{= Size factor} = 1 \]

\[ \sigma_{\text{e}}' = \sigma_e \times k_a \times k_{sr} \times k_{sz} \]

\[ S_f = \frac{f.s\sigma_{\text{v}}}{1 - \frac{f.s\sigma_{\text{m}}}{\sigma_{\text{u}}}} \]

For Forged Steel

\[ \sigma_{\text{u}} = 827 \text{ Mpa} \]

\[ \sigma_{\text{e}} = \sigma_{\text{u}} \times 0.5 \]

\[ = 827 \times 0.5 \]

\[ = 413.5 \text{ Mpa} \]

\[ \sigma_{\text{e}}' = \sigma_{\text{e}} \times k_a \times k_{sr} \times k_{sz} \]

\[ \sigma_{\text{e}}' = 413.5 \times 0.8 \times 1.2 \times 1 \]

\[ = 396.96 \text{ Mpa} \]

\[ S_f = \frac{f.s\sigma_{\text{v}}}{1 - \frac{f.s\sigma_{\text{m}}}{\sigma_{\text{u}}}} \]
\[ \frac{234.193}{0.7160} = 326.713 \text{Mpa} \]

\[ N = 1000 \left( \frac{\sigma_l}{0.9\sigma_u} \right)^{\frac{3}{8}} \left( \frac{\sigma'_{e}}{0.9\sigma_u} \right) \]

\[ N = 1000 \left( \frac{326.713}{0.9(827)} \right)^{\frac{3}{8}} \left( \frac{436.96}{0.9(827)} \right) \]

\[ N = 8500 \times 10^3 \text{ cycles} \]

**CONCLUSION**

By checking and comparing the results of materials in finalizing the results are shown in below.

**Considering the parameters,**

1. ANSYS Equivalent stress for the both the materials are same.
2. For the forged steel material factor of safety (from Soderberg’s) and stiffness is increased compared to existing carbon steel.
3. The weight of the forged steel material is less than the existing carbon steel.
4. From the fatigue analysis life time of the connecting rod can be determined.
5. And also no. of cycles for forged steel \((8500 \times 10^3)\) is more than the existing connecting rod \((6255 \times 10^3)\).
6. When compared to both of the materials, forged steel is cheaper than the existing connecting rod material.

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**REFERENCES**


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