COMPARATIVE ANALYSIS AND DESIGN OF CONNECTING ROD

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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 material. In this drawing is drafted from the calculations. A parametric model of Connecting rod is modeled using NX 10.0 software and to that model, analysis is carried out by using ANSYS 16.0 Software. Finite element analysis of connecting rod is done by considering the materials Aluminum 360, Forged Steel, Titanium Alloy, Mild Steel, and Magnesium Alloy. The best combination of parameters like Von misses Stress and strain, Deformation, Factor of safety and weight reduction for four wheelers Connecting Rod were done in ANSYS software.

Keywords: Connecting Rod; NX 10.0; Ansys; FEA;

I - INTRODUCTION:

Internal Combustion engine has many parts like cylinder, piston, connecting rod, crank and crank shaft. The connecting rod is very important part of an engine. Working of the connecting rod is to transmit power of piston to crank pin. Connecting rod has two ends one is pin end and other is crank end. Pin end is attached with piston.

Fig1: connecting rod

The big end (crank end) is attached to the crank pin by a crank shaft. The function of crank shaft is to transmit the reciprocating motion of piston into rotary motion.
II- LITERATURE REVIEW:

1. Sarihan and Song (1990), for the optimization of the wrist pin end, used a fatigue load cycle consisting of compressive gas load corresponding to maximum torque and tensile load corresponding to maximum inertia load. Evidently, they used the maximum loads in the whole operating range of the engine. To design for fatigue, modified Goodman equation with alternating octahedral shear stress and mean octahedral shear stress was used. For optimization, they generated an approximate design surface, and performed optimization of this design surface. The objective and constraint functions were updated to obtain precise values.

3. Yoo et al. (1984) used variational equations of elasticity, material derivative idea of continuum mechanics and an adjoint variable technique to calculate shape design sensitivities of stress. The results were used in an iterative optimization algorithm, steepest descent algorithm, to numerically solve an optimal design problem. The focus was on shape design sensitivity analysis with application to the example of a connecting rod. The stress constraints were imposed on principal stresses of inertia and firing loads. But fatigue strength was not addressed. The other constraint was the one on thickness to bound it away from zero.

4. Hippoliti (1993) reported design methodology in use at Piaggio for connecting rod design, which incorporates an optimization session. However, neither the details of optimization nor the load under which optimization was performed were discussed. Two parametric FE procedures using 2D plane stress and 3D approach developed by the author were compared with experimental results and shown to have good agreements. The optimization procedure they developed was based on the 2D approach.

III - RESEARCH DESIGN OF CONNECTING ROD

3.1. Introduction

NX 10.0 Software mechanical design automation software is a feature-based, parametric solid modeling design tool which advantage of the easy to learn windows graphical user interface. We can create fully associate 3-D solid models with or without while utilizing automatic or user defined relations to capture design intent. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent

3.2 Design procedure of Connecting Rod

For designing the Connecting Rod the following procedure has to be follow.
3.3 Calculation of Connecting Rod
P- Pressure calculation for connecting rod
Engine type 4-strok air cooled
Bore × stroke = 68.5 × 72.0
Displacement = 796cc
maximum power (bhp@rpm) = 48 bhp @ 6000 rpm
maximum torque (Nm@rpm) = 69 Nm @ 3500 rpm
Compression Ratio = 10.3 ± 0.4
Density of Petrol (C₆ H₁₉) = 737.22 kg/M³ = 737.22 E − 9 Kg/MM³
Auto ignition temp. = 280°C (536°F) = 553° k
Mass = Density of petrol × Volume
Mass = 737.22 × 796 = 586,827.12 kg/m³
Molecular Weight of Petrol = 114.228 g/mole = 0.11423 kg/mole

VI - COMPARISON OF MATERIAL

1) **Density of comparison**: The connecting rod has tremendous field of research. In addition to this, automobile construction led the invention and implementation of quite new materials which are light and meet design requirements.

![Density comparison chart](image1)

**Fig7: Density comparison chart**

2. **Weight Comparison**: Compared five materials used for manufacturing of connecting rod these are AL360, Magnesium Alloy, Forged Steel, Titanium, Mild Steel. The modeling and analysis of connecting rod was done.

![Weight comparison chart](image2)

**Fig8: Weight comparison chart**

V - EXPERIMENT METHODOLOGY

![Static Structural Analysis System](image3)

**Fig9: Static Structural Analysis System**
Introduction to Ansys
Ansys is analysis software. It is used to check design feasibility of the design almost in all aspect. Ansys as a software is made to be user-friendly and simplified as much as possible with lots of interface options to keep the user as much as possible from the hectic side of programming and debugging process.

3) **Importing External Geometry**: As design of connecting rod is done on SOLID WORKS is imported as shown below:

![Fig10: First view of static structure](image1)

![Fig11: Importing external geometry](image2)

![Fig12: Generate meshing](image3)
4) **Meshing** After importing the external geometry further function is meshing. Meshing is done for better accuracy in result. It is many types-
   a) Triangular meshing  
   b) Rectangular meshing  
   c) Tetrahedron meshing.....etc.

5. **Working on Mode**
   a) After meshing we go to SET UP we click on CONNECTING and see like this-
   b) In Details of CONNECTING click on assignment we see there are importing materials.
   c) Then we select one of them for further implementation.
   d) Static Structural Setting: In static structure Analysis we have to fixed one part then right click on static structure then go to insert and further click on fixed support and apply on one part of the connecting rod.

8) **Definition of Stress:** To define stress various theories have been already assigned in the ansys like Von-Mises, Maximum principal etc. In this project Von-Mises used as stress theory.
9) **Strain**: There are many types of strain in ANSYS such as von-mises, maximum principle strain, and maximum shear strain. In this project, we discuss only von-mises strain.

![Strain in model](image)

**VI - Comparison of Different Materials**

1) **Strain comparison**

![Strain comparison chart](image)

2. **Stress comparison**

![Stress comparison chart](image)

3. **Deformation comparison**

![Deformation comparison chart](image)
VII - RESULT AND DISCUSSION

A. Analysis of Connecting Rod of Forged Steel

Fig20: Equivalent Strain Analysis

Fig21: Equivalent Deformation Analysis

Fig22: Equivalent Stress Analysis

Table 4.2 Result and Analysis Forged Steel

<table>
<thead>
<tr>
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<th>Minimum</th>
<th>Maximum</th>
</tr>
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<tbody>
<tr>
<td>Stress</td>
<td>1.224.4 Pa</td>
<td>1.105e-007Pa</td>
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<tr>
<td>Strain</td>
<td>1.8385e-008 m/m</td>
<td>1.1477e-004 m/m</td>
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<tr>
<td>Deformation</td>
<td>0.m</td>
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</tbody>
</table>

B. Analysis of Connecting Rod of Magnesium Alloy

Fig23: Equivalent Stress Analysis
Table 4.2 Result and Analysis Magnesium Alloy

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<td>Deformation</td>
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C. Analysis of Connecting Rod of Titanium

Fig24: Equivalent Strain Analysis

Fig25: Equivalent Deformation Analysis

Fig26: Equivalent Strain Analysis

Fig27: Equivalent Stress Analysis
Fig25: Equivalent Deformation Analysis

Table 4.2 Result and Analysis Titanium

<table>
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<tbody>
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<tr>
<td>Strain</td>
<td>1.8385e-008 m/m</td>
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<tr>
<td>Deformation</td>
<td>0.m</td>
<td>5.9771e-005m</td>
</tr>
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D. Analysis of Connecting Rod of Mild Steel

Fig26: Equivalent Stress Analysis

Fig27: Equivalent Strain Analysis

Fig28: Equivalent Deformation Analysis
Table 4.2 Result and Analysis Mild Steel

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<td>Deformation</td>
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<td>9.9771e-006 m</td>
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</table>

E. Analysis of Connecting Rod of Aluminum 360

Fig29: Equivalent Strain Analysis

Fig30: Equivalent Stress Analysis

Fig31: Equivalent Deformation Analysis

<table>
<thead>
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<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>Stress</td>
<td>1224.4 Pa</td>
<td>1.1015e+007 Pa</td>
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<tr>
<td>Strain</td>
<td>1.8385e-008 m/m</td>
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</tr>
<tr>
<td>Deformation</td>
<td>0 m</td>
<td>5.9771e-006 m</td>
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VIII – CONCLUSION

1. Solid modeling of connecting rod was made in NX 10.0 according to production drawing specification and analysis under the effect of tensile and compressive loads in terms of pressure is done in ANSYS Workbench.
2. It is the conclusion of this study that the connecting rod can be designed and optimized under a load range comprising compressive load as one extreme load and tensile load.
3. The section modulus of the connecting rod should be high enough to prevent high bending stresses due to inertia forces.
4. Weight of connecting rod is reduced, Thereby reduces the inertia force by comparing the results of three different materials used for connecting rod analysis it is found that equivalent von mises stress for all the materials is approximately same.
5. Maximum von mises stress, Maximum von mises strain and Maximum displacement are minimum in connecting rod.
6. Comparing the different data it is observed that stress, strain and displacement is minimum in connecting rod.

IX - FUTURE SCOPE

1. When we use this design of connecting rod our component life increase and minimizing maintenance.
2. Vibrational analysis can be done at ansys for minimizing the premature failure.
3. Thermal analysis can be done of connecting rod to minimize the thermal stress effect on connecting rod.
4. Design modification can be done to minimize the weight of connecting rod.
5. Work on the internal coating of hard material inside the both ends can be done to minimize the wear failure in connecting rod.

X-REFERENCES

8. Books
   1. Design data by PSG.
   3. Machine design by R.S. KHURMI, J.K GUPTA