DESIGN AND ANALYSIS OF COMPOSITE CONNECTING ROD

1T.R SYDANNA  2B SUNIL KUMAR

1Associate Professor of Mechanical Engineering, Sreenivasa College of engineering & technology, lakshmi puram, Kurnool, Andhra Pradesh 518218
2pg Scholar, Department of Mechanical Engineering, Sreenivasa College of engineering & technology, lakshmi puram, Kurnool, Andhra Pradesh 518218

ABSTRACT

Connecting rod is one of the most important part in automotive engine. Connecting rod is the link between piston and crank shaft. Which it converts reciprocating motion of piston into rotary motion of crankshaft? In internal engines connecting rod is mainly made of steel and aluminium alloys (for light weight and absorb high impact loads) or titanium (for higher performance engines and for higher cost). As a connecting rod is rigid, it may transmit either a push or a pull and so the rod may rotate the crank through both halves of a revolution, i.e. Piston pushing and piston pulling. Earlier mechanisms, such as chains, could only pull. In a few two-stroke engines, the connecting rod is only required to push. In which it undergoes structural deformations. Thus in this project we are designing the connecting rod by using design analysis procedure. Then we are modeling a connecting rod in solid works 2016 design software and doing static structural analysis in ansys work bench 14.5 software. Thus the part which is modeled is converted into IGS file to import in ansys work bench and static structural analysis is carried out pressure load by applying various materials including composite materials, materials used in this project are such as aluminium alloy (which is already existing), 42crmo4, aluminium based composite material reinforced with Boron carbide (Al6061+B4C).

By applying these boundary conditions on connecting rod the unknown variables such as stress, deformation, strain, and maximum shear stress are found using the FEA based software (ANSYS). 42crmo4, Al6061+B4C metals have high strength and low wear tear.

1. INTRODUCTION

In a reciprocating position engine to the connecting rod connects the piston to the crank or crankshaft, alongside the crank they form a simple mechanism converts reciprocating motion into rotating motion. Connecting rod might also convert rotating motion into reciprocating motion. Traditionally to Development of engines they were first using this manner

1.2 Project Background

As a connecting rod is rigid, might transmit either push or pull and then the rod might rotate each halves of a revolution i.e. Piston pushing and piston pulling. Earlier mechanisms used like chains, may solely pull in a very few two-stroke engines, the connecting rod is barely needed to push. Now days, connecting rods are best well-known through their use in a internal combustion piston engines like automotive engines. These are clearly different forms earlier types of the
connecting rods utilized in steam engines and steam locomotives.

Figure 1.1 connecting rod with piston

1.2 objectives of project
The objectives of the project are as follows
(i) To develop structural modeling of connecting rod
(ii) To perform finite element analysis of connecting rod
(iii) Suitable material study
(iv) Study of load factors
(v) Study of stress, strain deformation induced in the connecting rod
(vi) To develop structural optimization model of connecting rod

1.3 Importance of Con Rod in Engine
The connecting rod is that the main part of the engine, additionally backbone of the engine. There is most significant of the connecting rod in an engine.

Connecting rod rotates the crank shaft that helps the engine to manoeuvre on or any of the vehicles to rotate its wheels. It is designed to resist stresses from combustion and piston movement. Connecting rods is toward lighter weight components. It should withstand with greater power loads though it is lower in weight. The main purpose of a connection rod is to provide fluid movement between pistons and a crankshaft and therefore the connecting rod is beneath tremendous stress from the load represented by the piston.

Figure 1.2 connecting rod in engine

When building a high performance engine, great attention is paid to the connecting rods. The most effective feature of a connecting rod ought to be the uniform shape. The cross section of rod beam design ought to be spread and minimize stress load over massive uniformly shaped areas. In operation stress are generated and radiate from one or more source on a component because the rod functions.

2. LITERATURE SURVEY
The connecting rod is subjected to a complex state of loading; it undergoes high cyclic loads and the order of 10^8 - 10^9 cycles range from high compressive loads three due to combustion and high tensile loads due to inertia. Therefore, durability of this component is of critical importance. Due to above factors the connecting rod has been the topic of research for different aspects such as production technology, materials, performance simulation, fatigue, etc. For the current study it was necessary to investigate finite element modeling techniques, optimization techniques, developments in production technology, new materials, fatigue modeling, and manufacturing cost analysis. This brief literature survey reviews some of these aspects.

Webster et al. (1983) performed three dimensional finite element analysis of a high-speed diesel engine
connecting rod. In this analysis there used the maximum compressive load how much was measured experimentally, and the maximum tensile load which is essentially in the inertia load of the piston assembly mass and the load distributions on the piston pin end and crank end were determined experimentally. They modeled the connecting rod cap separately, and also modeled the bolt pretension using beam elements and multi point constraint equations. 

repgen (1998), based on fatigue tests carried out on identical components made of powder metal and c-70 steel (fracture splitting steel), in this paper he writes the fatigue strength of the forged steel part is 21% higher than the powder metal component and using the fracture splitting technology results in a 25% cost reduction over the conventional steel forging process. These main factors suggest that a fracture splitting material would be the material of choice for steel forged connecting rods and also mentions two other steels are tested, a modified micro-alloyed steel and a modified carbon steel. Other issues discussed by repgen are the necessity to avoid jig spots along the parting line of the rod and the cap, need of 4 consistencies in the chemical composition and manufacturing process to reduce variance in microstructure and production of near net shape rough part.

Park et al. (2003) investigated micro structural behaviour at various forging conditions and recommend fast cooling for finer grain size and lower network ferrite content. From their research they concluded that laser notching exhibited best fracture splitting results, when compared with broached and wire cut notches. They optimized the fracture splitting parameters as, applied hydraulic pressure, jig set up and geometry of cracking cylinder based on delay time. They compared fracture splitting high carbon micro-alloyed steel (0.7% c) with carbon steel (0.48% c) using rotary bending fatigue test and concluded that the former has the same or better fatigue strength than the later and comparison of these fracture splitting high carbon micro-alloyed steel and powder metal and based on tension-compression 18% higher than the later fatigue.

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 they used the maximum loads in the whole operating range of the engine after a design for fatigue, modified Goodman equation with alternating octahedral shear stress and mean octahedral shear stress was used, optimization they generated an approximate design surface, and performed optimization of this design surface and the objective and constraint functions were updated to obtain precise values in this process was repeated till convergence was achieved also included constraints to avoid fretting fatigue. The mean and the alternating components of the stress were calculated using maximum and minimum 5 values of octahedral shear stress. In this exercise reduced the connecting rod weight by nearly 27%.

3. THEORY OF CONNECTING ROD

The connecting rod in an exceedingly in a very medium speed four stroke engines is subject to an inertia whip loading due to the mass of the con rod swinging concerning the piston pin. (because of the lower speed of a two stroke engine, the whip loading isn’t massive enough to influence the design of the con rod) additional to this, the inertia loads owing to the mass of the reciprocating parts cause a stress reversal from high compressive stress (during power
and compression stroke) to a coffee tensile stress between the exhaust and inlet strokes. This loading of the rod influences its design, and to resist the loading represented on top of, connecting rods are usually forged from a manganese molybdenum steel in an i or h section that reduces its mass from one made from spherical section steel (and so reduces the whip loading) whereas maintaining strength. This can be not continually the case, as is seen from the pictures shown, and infrequently a spherical section rod is of sufficient strength.

![Figure 3.1 parts of connecting rod](image1)

### 3.1 Parts of connecting rod

(i) **Crankpin end**

It consists of two half removable shells (marine type) held together by bolts and nuts. The shells have a lining of bearing metal, white metal or babbitt.

(ii) **Rod shank**

It is also called the body and may take up different forms. It has drilling throughout its length.

(iii) **Gudgeon pin end**

Upper end bearing, top end bearing, or small end bearing, wristpin bearing.

![Figure 3.2 Parts of connecting rod and nomenclature](image2)

### 3.2 Types of connecting rods

- **Marine type**
- **Fixed centre design**
- **Fork and blade type**
- **Articular type**

### 3.3 Working of a connecting rod

The main work of connecting rod is to convert reciprocating motion into rotating motion and vice versa. Pushing and pulling a piston which can transmit the energy. That rotates the rod and crank. It will be known as the heart of the engine.

![Figure 3.3 Working of a connecting rod](image3)

A connecting rod performs piston pushing and piston pulling operations mainly so that the mechanism of
an engine works. This provides power to engine to start and move the equipment within which it's used.

3.4 Lubrication of a connecting rod
The connecting rod consists of two parts: the main beam wherever a hole is machined for the gudgeon pin. The beam additionally features a machined oil squirt hole on the higher cap mounting face. A cap, that bolts to the most beams round the crankshaft. Two-shell type bearings placed between the crankshaft and connecting rod give the proper oils clearance once the cap is torque properly. The bearings have passageways, which permit controlled oil from the crankshaft passages, to be forced out of the squirt hole, up into the within the cylinder area. This oil lubricates the gudgeon pin, cylinder wall, and piston rings.

3.5 applications of a connecting rod:
Connecting rods or con rods are employed in various situations. It’s most commonly used in the engines of automobiles. Connecting rod employed in all kinds of vehicles like cars, trucks and bikes wherever combustion engine is employed. All commercial vehicles that use this kind of engine, there connecting rods are used. Even construction instrumentality like bulldozers, road rollers (earth movers) use internal combustion engines. Thus, in epoch all quite machines essentially depend on piston, connecting rods and crank shafts. These are necessary for correct functioning of an internal combustion engine.

4. DESIGNING OF A CONNECTING ROD BY USING SOLID WORKS

4.1 Introduction To Solidworks:
Solidworks 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

A Solid Works model consists of parts, assemblies, and drawings.
- Typically, we begin with a sketch, create a base feature, and then add more features to the model. (One can also begin with an imported surface or solid geometry).
- We are free to refine our design by adding, changing, or reordering features.

4.2 Design procedure of connecting rod
For designing the connecting rod the following procedure has to be follow

![Sketch & extrude]

Sketch & extrude
5. ANALYSIS DEFINITION & STEPS:

The steps needed to perform an analysis depend on the study type. You complete a study by performing the following steps:

- Create a study defining its analysis type and options.
- If needed, define parameters of your study. A parameter can be a model dimension, material property, force value, or any other input.
- Define material properties.
- Specify restraints and loads.
- The program automatically creates a mixed mesh when different geometries (solid, shell, structural members etc.) exist in the model.
- Define component contact and contact sets.
- Mesh the model to divide the model into many small pieces called elements. Fatigue and optimization studies use the meshes in referenced studies.
- Run the study.
- View results.

5.1 Analysis on connecting rod by using ansys 14.5 work bench software

The analysis of connecting rod models are carried out using ANSYS software using Finite Element Method. Firstly the model files prepare in the SOLIDWORKS SOFTWARE. Then are exported to ANSYS software as an IGES files as shown in figure.
5.2 Materials and their properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (kg/m³)</th>
<th>Young’s modulus (GPa)</th>
<th>Poisson’s ratio</th>
<th>Shear modulus (GPa)</th>
<th>Bulk modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al alloy</td>
<td>2770</td>
<td>0.7E+11</td>
<td>0.33</td>
<td>2.69E+10</td>
<td>6.96E+10</td>
</tr>
<tr>
<td>42CrMo4</td>
<td>7800</td>
<td>2.1E+11</td>
<td>0.3</td>
<td>8.07E+10</td>
<td>1.75E+10</td>
</tr>
<tr>
<td>Al6061-T6</td>
<td>2860</td>
<td>1.95E+11</td>
<td>0.32</td>
<td>7.30E+10</td>
<td>1.80E+10</td>
</tr>
</tbody>
</table>

5.3 Load & fixed support

• Fixed support

Mesh Type: Tetrahedral
No. of nodes: 16190
No. of elements: 8821

6. STRUCTURAL ANALYSIS RESULTS

6.1 Material: Al Alloy

Maximum Stress
Total Deformation
Maximum Strain

5.3 Meshing

Meshing is probably the most important part in any of the computer simulations, because it can show drastic changes in results you get. Meshing means you create a mesh of some grid-points called ‘nodes’. It's done with a variety of tools & options available in the software. The results are calculated by solving the relevant governing equations numerically at each of the nodes of the mesh. The governing equations are almost always partial differential equations, and Finite element method is used to find solutions to such equations. The pattern and relative positioning of the nodes also affect the solution, the computational efficiency & time.
Maximum Shear Stress

6.2 Material: 42crmo4
Maximum Stress
Total Deformation
Maximum Strain
Maximum Shear Stress

6.3 Material: Al6061+B4C
Maximum Stress
Total Deformation
Maximum Strain
Maximum Shear Stress

RESULT TABLE

<table>
<thead>
<tr>
<th>Materials</th>
<th>Max Stress (N/mm²)</th>
<th>Total Deformation (mm)</th>
<th>Max strain</th>
<th>Maximum shear stress (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al – Alloy</td>
<td>27.241</td>
<td>0.0020414</td>
<td>0.00039726</td>
<td>14.231</td>
</tr>
<tr>
<td>42 CrMo4</td>
<td>27.399</td>
<td>0.0061567</td>
<td>0.00135</td>
<td>14.285</td>
</tr>
<tr>
<td>Al6061+B4C</td>
<td>27.295</td>
<td>0.00074167</td>
<td>0.0001449</td>
<td>14.25</td>
</tr>
</tbody>
</table>
For comparisons of the results obtained the cumulative graph can be made for stress of Connecting rod and shear stress respectively can as shown above.

**CONCLUSION**

- Modeling and analysis of connecting rod is done
- Modeling of connecting rod is done in solid works 2016 design software
- The file is saved as IGS to import in ansys workbench
- The analysis in ansys is extremely important prior to the fabrication of connecting rod.
- The static structural analysis has carried out in the ansys 14.5 software package for connecting rod by different materials like aluminium alloy, 42crmo4 and Al6061+B4C.
- The material properties and brief explanation about composites has given.
- The utmost stress, strain and deformation values of static analysis are tabulated.
- From load applied 3mpa on the connecting rod by assigning materials, in general aluminium alloy is used for the connecting rods but 42CrMo4 and Al6061+B4C are new composite materials. From results we can conclude that Al6061+B4C is showing less stress and low deformation values compared to the 42CrMo4.
- Hence the materials with low stress values are also preferable for the fabrication of connecting rod.

**REFERENCES**

- Pravardhan s. Shenoy et al. “dynamic load analysis and optimization of connecting rod”. In his thesis.
- Gvsssharma and p.srinivasrao”process capability improvement of an engine connecting rod machining process.”
- Suraj pal, sunilkumar,”design evaluation and optimization of connecting rod parameters using fem” international journal of
engineering and management research vol-2 ,issue-6, dec 2012.

- S.shaari, m.m.rahman, m.m.noor, k. Kadirgama and a.k. amirruddin “design of connecting rod of internal combustion engine: a topology optimization approachm”. National conference in mechanical engineering research and post graduate studies( 2ndncmer 2010) 3-4 dec 2010, pp 155-166.
- Bhuptanik.m “structural analysis of bush bearing for small end connecting rod using – pro mechanica” issn 0975-0668x nov 12 to oct 13, vol-02, 2344-02

AUTHORS

1. T.R SYDANNA
Associate Professor of Mechanical Engineering,
SREENIVASA COLLEGE OF ENGINEERING & TECHNOLOGY, Near Sakshi paper,NH44
Gooty Road, Lakshmi puram, Kurnool, Andhra Pradesh 518218
Email id: sydanna.com@gmail.com

2. B SUNIL KUMAR
Department of Mechanical Engineering,
SREENIVASA COLLEGE OF ENGINEERING & TECHNOLOGY, Near Sakshi paper,NH44
Gooty Road, Lakshmi puram, Kurnool, Andhra Pradesh 518218
Email id: sunilmec91@gmail.com