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Simulation and Modelling of Connecting rod of IC by Using Aluminium Alloy

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A B S T R A C T

Connecting rod is the component of the internal combustion engine. It is play a very important and critical role in the IC engine of any automatic vehicle. According to the number of cylinder, IC engine requires at least one or more connecting rods

The aim of this research work is to determine the best design parameters of the connecting rod to reduce critical buckling stress for existing material AA2618 by implementing the finite element (FEM) method. Also find out the optimize value of the stress for the connecting rod.The role of the connecting rod is to transmit the thrust force which is developed in the cylinder as a consequence of the combustion of the fuel during the power cycle, to the crankshaft for availing the rotating motion to drive an automobile. It acts as a transitional connection among the piston and crankshaft which changes the reciprocating motion of piston into the rotary motion of the crankshaft.

Keywords: Image Connecting Rod, Simulation, Stress, Deformation, Aluminium alloy

1. INTRODUCTION

Connecting rod is endangered to high-cyclic loads because of two types of force with gas forces and inertial forces. The connecting rod has better mechanical properties such as higher strength and rigidity to execute various functions like to bear the external loading, provides a rigid connection with piston using gudgeon pin and with crankshaft using the crank-pin. The connecting rod has four bar link mechanism. The middle part is called shank between big end and small end having the cross section of either "I Section" or "H Section" and either "circular section" or "a rectangular type". Design of segment depends on requirement and the application of the connecting rod. Generally tt is optimized based on the loads bearing and the space availability for it. The length of the connecting rod (l) depends upon the ratio of l / r, where r is the radius of crank.It may be noted that the smaller length will decrease the ratio l / r. This increases the angularity of the connecting rod which increases the side thrust of the piston against the cylinder liner which in turn increases the wear of the liner. The larger length of the connecting rod will increase the ratio l / r. This decreases the angularity of the connecting rod and thus decreases the side thrust and the resulting wear of the cylinder. But the larger length of the connecting rod increases the overall height of the engine. Hence, a compromise is made and the ratio l / r is generally kept as 4 to 5.

The bearings at the two ends of the connecting rod are either splash lubricated or pressure lubricated. The big end bearing is usually splash lubricated while the small end bearing is pressure lubricated. In the splash lubrication system, the cap at the big end is provided with a dipper or spout and set at an angle in such a way that when the connecting rod moves downward, the spout will dip into the lubricating oil contained in the sump.

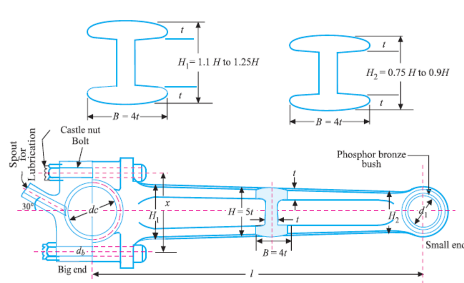


Fig 1 Overview of Connecting rod

Basically, there is two type are forging process are used to manufacture connecting rod first one is powder forged process and another is drop forged process shown in Figure 7. Every process has its advantages and disadvantages. In powder metallurgy process has capability to produce connecting rod with similar shape and size along with very less wastages. But the main disadvantage of powder forged connecting rod is the high material cost and manufacturing cost. In other manufacturing process such as drop forging the cost of material is under economical. The wastage of material in this process is comparatively more because the blank that is used to produce connecting rods includes extra material and is not that economical as it is in powder metallurgy process.R. K. Gupta Connecting rods for automotive applications are usually produced by two different method one is forging from either wrought steel or powdered metal. They can also be cast. Though, castings might have defects such as blow-holes which are damaging from strength and fatigue. The fact that forgings produce blow-hole-free and better rods gives them an advantage over cast rods [1].

During the forging processes, powder forged or drop forged, each process has its own advantages and disadvantages. Powder metal manufactured blanks have the advantage of being near net shape, reducing material waste. However, the cost of the blank is high due to the high material cost and sophisticated engineering methods by Repgen, 1998 [2].

N.P. Doshi [3] They determined the stresses developed in connecting rod under static loading through different loading conditions by using the finite element method. Authors used the Pro E and Ansys software for design and analysis purpose. They designed the connecting rod through machine design method. The authors also compared the developed design with the existing design. Based on conclusion they found that there is possibility of further reduction in mass of connecting rod.

Webster et al. (1983) did three dimensional finite element analysis of a high-speed diesel engine connecting rod. For this investigation they used the maximum compressive load which was measured experimentally. The maximum tensile load which essentially the inertia load of the piston assembly mass. They also find out the load distributions on the piston pin end and crank end. Authors modeled the connecting rod cap separately. They also modeled the bolt pretension using beam elements and multi point constraint equations. The objective of this present work is to determine the safe load of the connecting road with aluminum alloy AA2618 material and attain the optimum design. Also, investigate the effect of structure steel on the deformation, stress and strain of connecting rod.

2. METHODOLOGY AND SIMULATION PROCESS

The structural steel and aluminium alloy materials have been selected based on the literature review for connecting rod. The aluminium normally used now a day is in the form of metal matrix composite consists of alloys of aluminium and silicon carbide in form of continuous fiber. This type of metal matrix composite is used widely because there is 25% reduction in weight with stiffness increased by 29% and strength by 20% makes it first choice of manufactures. The cost of MMC connecting rod still makes it unfeasible for mass production volume. Table 1 show chemical composition of the structural steel.

Table 1 Chemical Composition of aluminum alloy

Element	Cu	Mn	Fe	Tin	Nickel	Silicon	Zinc
% of composition	0.6%	0.4%	1.3%	0.15%	0.05%	0.09%	0.035%

2.2 Connecting rod model: Catia V5 software has been used to create the connecting rod model. Catia V5 is widely used modeling software that is applied to develop a varied range of products. It is use to develop the 3D Model of different parts of products. Catia is capable to make assembly of product and it also able to create the part modeling. It has wide application in automotive and aerospace industries for part and tool design. It is a complete design software package which includes CAD/CAM/CAE.

2.3 Design parameters of connecting rod: The design of connecting rod is taken from the Figure 16 shown below. It shows various parts and dimensions of connecting rod.

Table 2 Design parameters for connecting rod

Parameters	Size (mm)
Thickness (t)	5.5
Width (4t)	22
Height (5t)	27.5
Height at the small end (H1)	24.75
Height at the big end (H2)	34.375
Inner dia. of the small end	35
Outer diameter of small end	49
Inner dia. of the big end	45
Outer diameter of big end	63

2.4 Meshing play very important role in the finite element analysis. Meshing divide the one element in to the finite number of element. Generally, as per requirement researcher takes the fine, medium and coarse mesh size. Simulation time is directly proportional to the Mesh size.
Six meshing methods available for 3D geometries:
Tetrahedrons: Patch Conforming (TGrid based) & Patch Independent (ICEM CFD based)
Sweep: Generates prisms or hexahedral
MultiZone : Mainly hexahedral elements
Hex Dominant:
CutCell mesh : Generates Cartesian CutCell mesh

Automatic : Combines Tetrahedral Patch Conforming & Sweep Mesh based on complexity of the geometry
Interoperability between different meshing methods

Finite element mesh was generated using parabolic tetrahedral elements with element length of 2.12 mm. The coarse relevance center has been selected. The initial size seed is active assembly. The smoothing of meshing was medium and transition fast. The span angle center coarse has been used. In the inflation section of meshing, the smooth transition has been used along with 0.272 transition ratio.

2.5 Mesh Size and Distribution
An important aspect of meshing in ANSYS AIM is the size function, which controls how the mesh size is distributed on a face or within a body.
The researcher can enable the Settings > Use predefined settings control to automatically set the fineness of the mesh, or disable it to set individual Global Sizing properties manually. In either case, you can set the Global Sizing > Size function method control according to your preference for mesh size distribution calculations. You determine which refinement mechanisms are activated by selecting Curvature and proximity, Proximity, Curvature, Fixed, or Adaptive. Depending on the selected

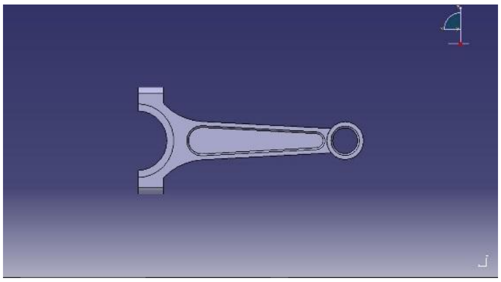


Fig. 2 3D model of the connecting rod

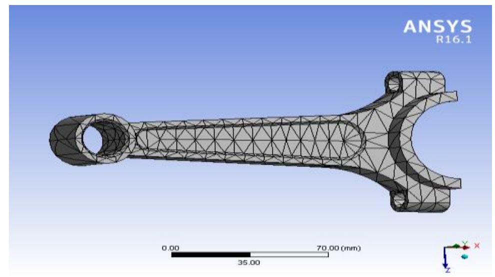


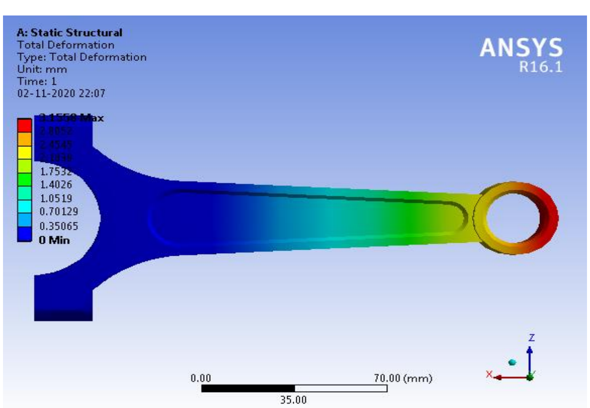
Fig. 3 Meshed3 D model of the connecting rod

3. RESULTS AND DISCUSSION

Connecting rod is one of the most critical and important component of internal combustion engine. 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 crankpin and thus convert the reciprocating motion of the piston into the rotary motion of the crank. The usual form of the connecting rod in internal combustion engines. It is always use in vehicle as a continuous cyclic loading. The stress and deformation analysis of connecting rod is vital to know the stress level on connecting rod. In the results and discussion section the FE analysis for stress and deformation for structural steel and aluminum alloy based material has been performed on different parameters of connecting rod. Calculating the stress and deformation for various geometry of connecting rod, can know how much stress will develop on particular geometry of connecting rod.

3.1Static Analysis of aluminum alloy (Al306)

The static analysis of connecting rod has been investigated with respect to aluminum alloy properties and boundary conditions as mentioned in material specifications Table1. The big end of the connecting rod has been fixed supported. The force of 1040 N has applied on the small end. The maximum deformation at the small end side has been observed. The displacements of the connecting rod has been recorded in all three possible direction such as in x- direction, y-direction, z-direction and also find out the total displacement. Figure 4 shown the deformation of the connecting rod. The maximum total deformation 3.15 mm has been observed. The 0.0051 mm, Z direction deformation has been observed as depicts in Figure 5. The equivalent stress in the connecting rod has been shown in Figure 6. The maximum 194.07 N/mm2 stress has been observed as shown in Figure 6. Figure 7 shown the equivalent strain 0.00224441



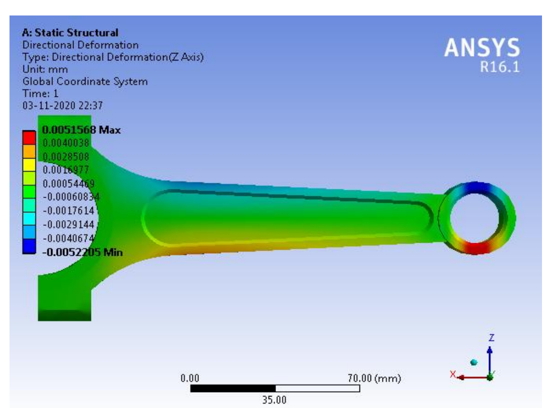


Fig. 4 Total deformation of Aluminum alloy connecting rod

Fig, 5 X directional deformation of Aluminum alloy connecting rod

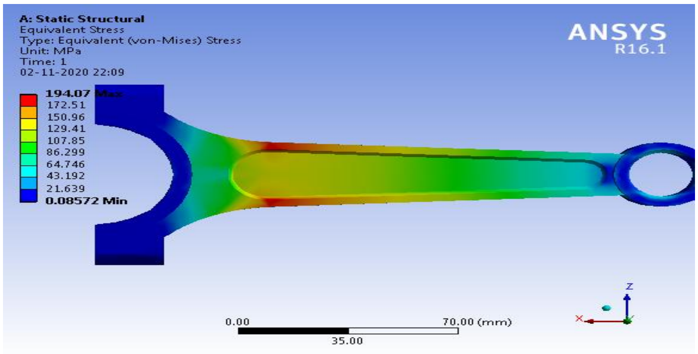


Fig 6 Top view of equivalent stress in connecting rod of Aluminium alloy

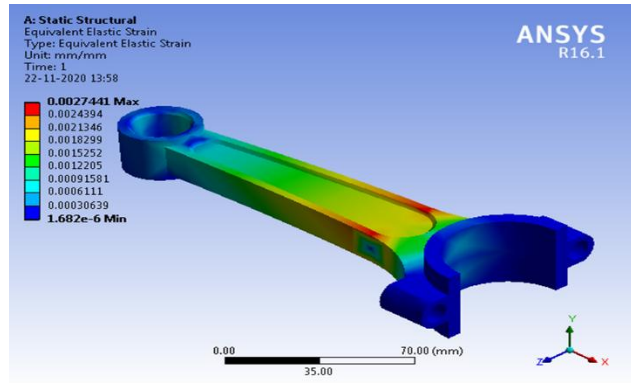


Fig 7 equivalent elastic strain in connecting rod

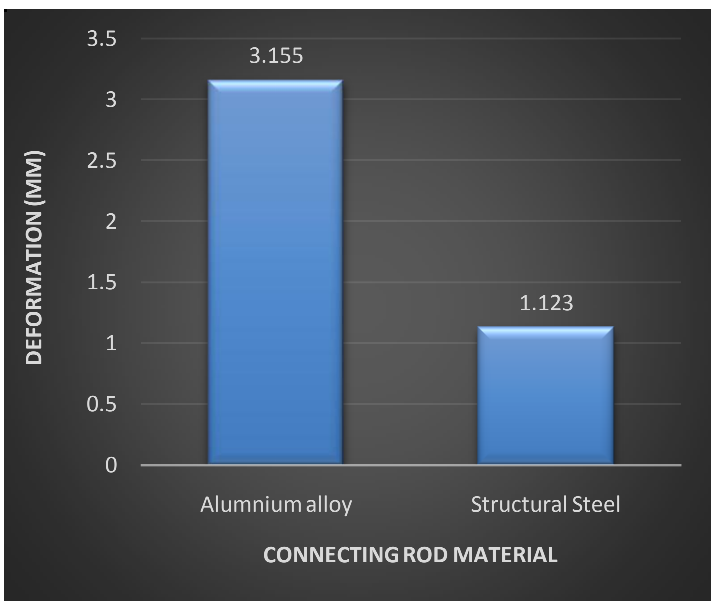


Fig 8 Comparative graph of aluminum and structural steel of deformation

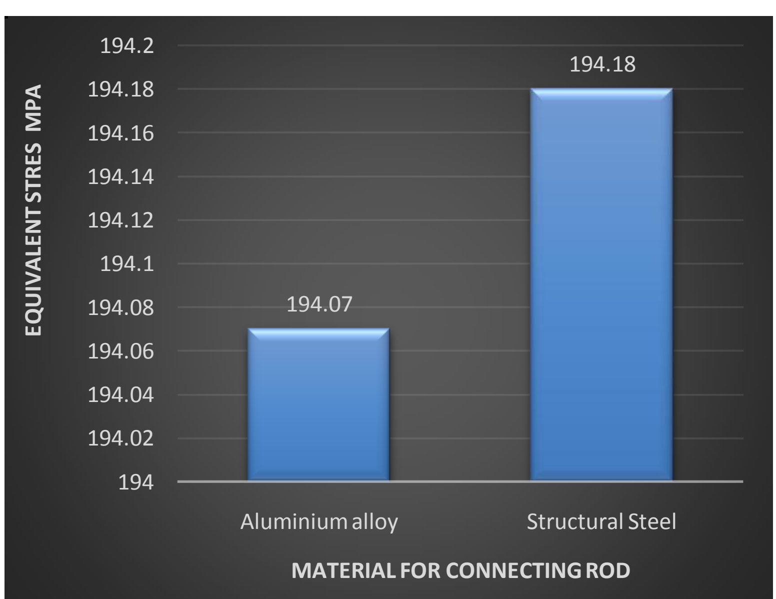


Fig 9 Comparative graph of aluminum and structural steel for stress

Numerical data is for deformation in the global X, Y, and Z directions. These results can be viewed with the model under wireframe display, facilitating their visibility at interior nodes. After applying loads and supports to the model, add a Total Deformation result object, highlight the object, set Scoping Method to Named Selection, and set Named Selection to the Selection object defined above that includes the mesh node criteria. Before solving, annotations are displayed at each selected node as shown below. Any element containing a selected node will display a contour color at the node. If all nodes on the element are selected, the element will display contour colors on all facets. Element facets that contain unselected nodes will be transparent. Stress solutions allow to predict safety factors, stresses, strains, and displacements given the model and material of a part or an entire assembly and for a particular structural loading environment. A general three-dimensional stress state is calculated in terms of three normal and three shear stress components aligned to the part or assembly world coordinate system. The principal stresses and the maximum shear stress are called invariants; that is, their value does not depend on the orientation of the part or assembly with respect to its world coordinate system. Fig. 8 and Fig. 9 shown the comparative analysis between the stress and strain

4. CONCLUSION

In the present work deformation, stress analysis & strain is performed by using aluminium alloy for the connecting rod. First deformation & stress analysis is performed by using structure steel material for the internal combustion engine connecting rod. The connecting rod used for this analysis is taken from a reference paper.
The model of connecting rod for analysis purpose are designed in Catia V5 designing software. After that numerical and FEM analysis are executed to estimate the deformation, Von mises stress and elastic strain is calculated by applying the external force having the value 1040 N of load. After performing the analysis results are obtained from analysis are used to predict the structural behaviour of connecting rod under given load. The following conclusions are drawn from this study:

The maximum total deformation 3.15 mm has been observed. The 0.0051 mm, Z direction deformation has been observed. The maximum 194.07 N/mm2 stress has been observed. The maximum equivalent strain 0.00224441 has been recorded

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