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OPTIMIZATION OF CONNECTING ROD WITH HELP OF FEA

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ABSTRACT

Connecting rod is the important part of an IC Engine it transmits motion of piston to crank shaft and converts translating motion of piston into rotary motion and vice versa.

From application point of view it is necessary that connecting rod must be light in weight and having good strength under fatigue or reverse loading. For this purpose generally material of connecting rod is carbon steel of aluminum alloy.

In this work we take connecting rod of a Mahindra Jeep CJ-340 and change its material from Al360 to PEEK. The modeling of the connecting rod is done on Pro-E wildfire 4.0 and analysis work is done on ANSYS 11.0.

The parameters like Von misses stress, Von messes strain and displacement was obtained from ANSYS software which shows reduction in weight and improvement in strength.

Key words: Connecting Rod, Optimization, Pro-E, ANSYS

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1. INTRODUCTION

The connecting rod is a major link inside a combustion engine. It connects the piston to the crankshaft and is responsible for transferring power from the piston to the crankshaft and sending it to the transmission. There are different types of materials and production methods used in the creation of connecting rods. The most common types of Connecting rods are steel and aluminum. The most common types of manufacturing processes are casting, forging and powdered metallurgy. Connecting rods are widely used in variety of engines such as, in-line engines, V-engine, opposed cylinder engines, radial engines and opposed-piston engines. A connecting rod consists of a pin-end, a shank section, and a crank-end. Pin-end and crank-end pinholes at the upper and lower ends are machined to permit accurate fitting of bearings.

The function of connecting rod is to transmit the thrust of the piston to the crankshaft. Figure shows the role of connecting rod in the conversion of reciprocating motion into rotary motion. A four-stroke engine is the most common type. The four strokes are intake, compression, power, and exhaust. Each stroke requires approximately 180 degrees of crankshaft rotation, so the complete cycle would take 720 degrees. Each stroke plays a very important role in the combustion process. In the intake cycle, while the piston moves downward, one of the valves open. This creates a vacuum, and an air-fuel mixture is sucked into the chamber (Figure 1). During the second stroke compression occurs. In compression both valves are closed, and the piston moves upward and thus creates a pressure on the piston, see Figure 2. The next stroke is power. During this process the compressed air-fuel mixture is ignited with a spark, causing a tremendous pressure as the fuel burns. The forces exerted by piston transmitted through the connecting rod moves the crankshaft, see Figure 3. Finally, the exhaust stroke occurs. In this stroke, the exhaust valve opens, as the piston moves back upwards, it forces all the air out of the chamber and thus which completes the cycle of crankshaft rotation Figure 4.

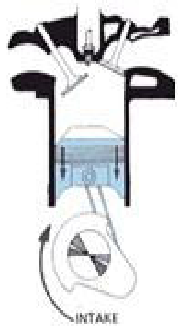

Figure 1 Intake stroke

Figure 2 compression stroke

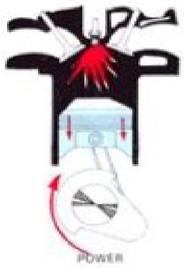

Figure 3 Power stroke

Figure 4 Exhaust stroke

Connecting rods are highly dynamically loaded components used for power transmission in combustion engines. The optimization of connecting rod had already started as early year 1983 by Webster and his team. However, each day consumers are looking for the best from the best. That’s why the optimization is really important especially in automotive industry. Optimization of the component is to make the less time to produce the product that is stronger, lighter and less cost. The design and weight of the connecting rod influence on car performance [5−8]. Hence, it is effect on the car manufacture credibility. Change in the structural design and also material will be significant increments in weight and performance of the engine. Mirehei et al. (2008) were performed the study regarding the fatigue of connecting rod on universal tractor (U650) by using ANSYS software application and the lifespan was estimated. The authors also investigated that the stresses and hotspots experienced by the connecting rod and the state of stress as well as stress concentration factors can be obtained and consequently used for life predictions. Rahman et al. (2008a, 2009a) discuss about FEA of the cylinder block of the free piston engine. The 4 nodes tetrahedral (TET4) element version of the cylinder block was used for the initial analysis. The comparison then are made between TET4 and 10 nodes tetrahedral (TET10) element mesh while using the same global mesh length for the highest loading conditions (7.0 MPa) in the combustion chamber.

2. OBJETIVES

- Main objective of project is reduction in weight of connecting rod.
- Improvement in strength of connecting rod.

3. MATERIAL SELECTION

3.1. Comparison between Old & New Material

Table 1 Comparison between Old & New Material

S. No	Properties	Old Material (Al 360)[1]	New Material (PEEK)[2]
1	Ultimate tensile strength (MPa)	303	360
2	Yield strength (MPa)	170	210
3	Youngs modulus (GPa)	60	72
4	Poisson's ratio	0.33	0.337
5	Density (g/cm3)	2.8	1.31
6	Fatigue Strength (endurance Limit) (Mpa)	120	124
7	Thermal Conductivity (W/m-k)	110	87
8	Coefficient of Linear Thermal Expansion (10^{-5} in./in./°F)	11.6	2.6

According to above properties New material suggested is **Polyether ether ketone** (PEEK, 30% Carbon-Fiber Reinforced)

[1]A Comparative Study And Analysis of Connecting ROD By Mohd Nawajish, Mohd Naimuddin, Mayank www.ijetmas.com March 2015, Volume 3 Special Issue, ISSN 2349-4476 [1]

[2]http://www.professionalplastics.com/KETRONPEEK-CA30LSG?&search_id=2091081 [2]

4. MODELING OF CONNECTING ROD

First of all we taken connecting rod of a Mahindra Jeep CJ-340 and with the help of Pro E 4.0 generate a FEM model with Reverse Engineering method.

Figure 5 Actual Model with Scale

Table 2 Geometrical Parameters of Connecting Rod

Name of Part	Value in mm
Length of connecting rod	**160**
Outer diameter of crank end	**90**
Inner diameter of crank end	**55**
Outer diameter of piston end	**46**
Inner diameter of piston end	**30**
Width of connecting rod	**20**
Depth of connecting rod	**40**

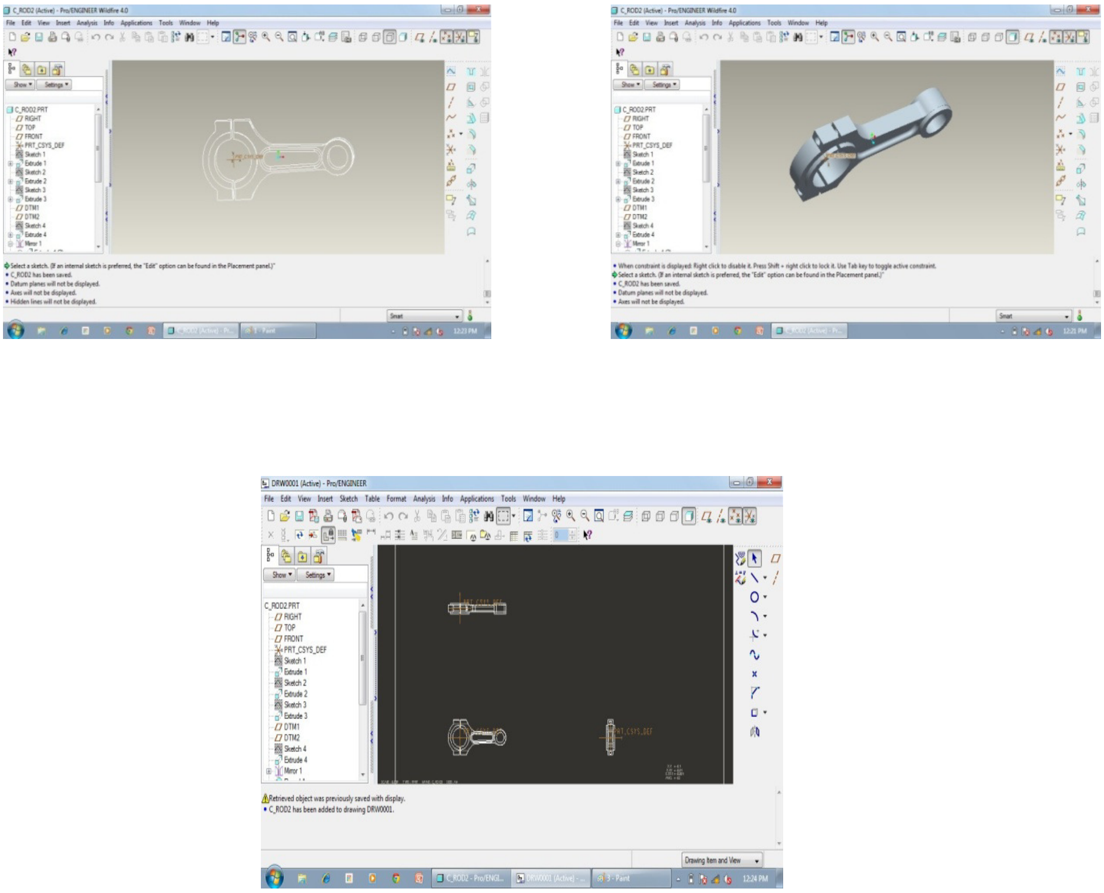

Figure 6: FEM Model of Connecting Rod

5. FINITE ELEMENT ANALYSIS OF CONNECTING ROD

5.1. Load Distribution on Connecting Rod

For static structural analysis, load is applied at the piston end and fixed support is given at the crank end. The analysis is carried out under axial loads. Here the axial load applied is 28000 N (Compressive). The comparisons are done for optimization purpose [3, 4].

6. RESULTS AND DISCUSSIONS

6.1. Static Structural Analysis of Connecting Rod

Static structural analysis of connecting rod under compressive loading is carried out using ANSYS 11.0 software.

Figure 7: Meshing Model of Connecting Rod

6.2. FEM analysis against Compressive Load

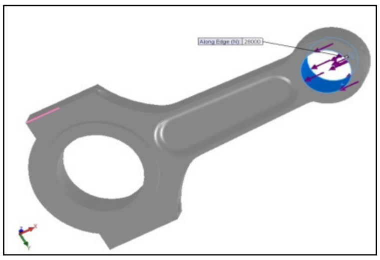

Figure 8 Application of Compressive Force

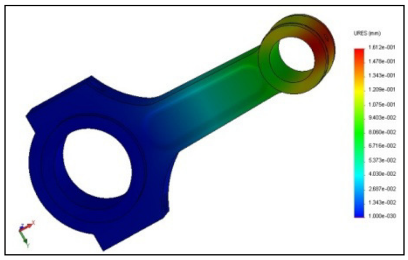

Figure 9 Deformation against Compressive Load

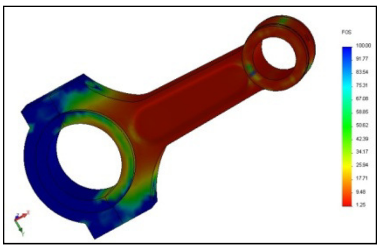

Figure 10 Factor of Safety against Compressive Load

Figure 11 Von Misses stress against Compressive Load

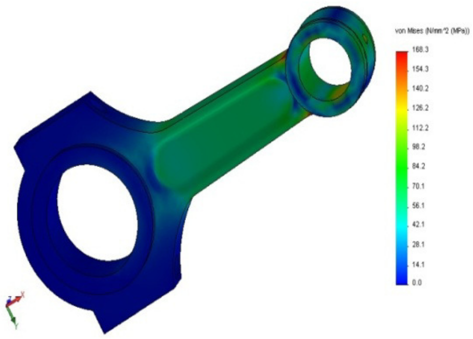

Figure 12 Von Misses strain against compressive load

6.3. Result analysis against Compressive Load

Table 3 Result against compressive load

Von Misses Stress(Mpa)	168.6	168.3	0.18%
Von Misses Strain(mm/mm)	2.209E-03	1.848E-03	16.34%
Displacement(mm)	0.1935	0.1612	16.69%
Min. F.O.S.	1.01	1.25	23.76%

Table 4 Comparison of Mass and Volume

Properties	**Old Material**	**New Material**
Mass (grams)	537.07	251.27
Volume (millimeters³)	191810.60	191810.60
Surface area (millimeters²)	49170.85	49170.85
Center of mass: (millimeters)	X = 1868.34, Y = -0.05, Z = -0.00	X = 1868.34, Y = -0.05, Z = -0.00
Moments of inertia: (grams * millimeters²)	Ixx = 327864.55 Ixy = -52670.18 Ixz = -142.40	Ixx = 153393.77 Ixy = -24642.1 Ixz = -66.62
	Iyx = -52670.18 Iyy= 1877037723.08 Iyz = 0.27	Iyx = -24642.12 Iyy = 878185506.1 Iyz = 0.13
	Izx = -142.40 Izy = 0.27 Izz = 1877308841.58	Izx = -66.62 Izy = 0.13 Izz = 878312350.88

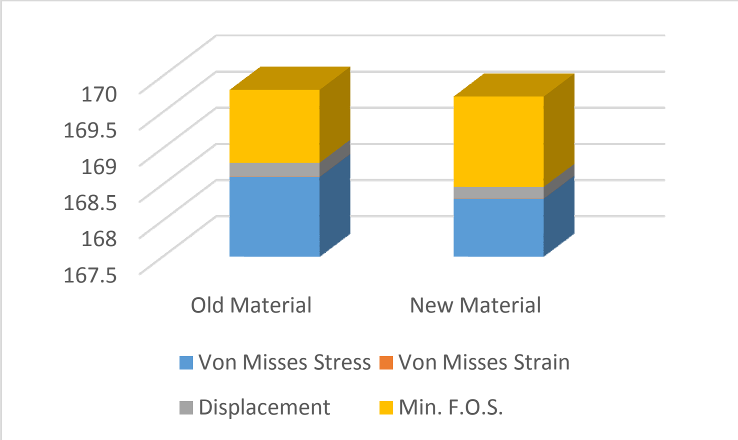

Figure 13 Comparison of Stress between old and new material

7. CONCLUSION

Solid modeling of connecting rod for four stroke four cylinders has been done using FEA tool Pro E 4.0, and analysis has been done on ANSYS 11 workbench. On the basis of this study following conclusion has been made:

- Reduction in weight of connecting rod (aproxx. 46.7%).
- Improvement in strength of connecting rod (aproxx. 23.76%).

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