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Design and Structural Analysis of Connecting Rod

Adnan Ali Haider[1], Akash Kumar[2], Ajinkya Chowdhury[3], Moin Khan[4], P. Suresh[5]

[1,2,3,4,5] *School of Mechanical Engineering, Galgotias University, Greater Noida, UP-201306*

Abstract - *In this work, design and structural analysis of connecting was performed. Connecting rod is one of the most important parts in engine assembly which transfers energy from piston to crankshaft and convert the linear, reciprocating motion of a piston into the rotary motion of a crankshaft. The connecting rod primarily undergoes tensile and compressive loading under engine cyclic process. The forces acting on connecting rod are: - forces due to maximum combustion pressure, force due to inertia of connecting rod and reciprocating mass. From the viewpoint of functionality, connecting rods must have the highest possible rigidity at the lowest weight. This work addresses the computation of strength and deformation characteristics of a connecting rod. Finite element method is used to analyse the connecting rod's stress and deformation using Ansys software. For this case, a fatigue and structural analysis will be performed. The axial compressive load is greater than the axial tensile load. Therefore, the design is only analyzed for the axial compressive loads. This analysis shows the importance of the solution of the connecting rod deformation in view of the changes in materials at the most important variants of the stress. This variant is frequently overlooked and primary importance is analyzed with the strength. Factor of Safety and the design of connecting rod is checked and analyzed.*

Key Words: Connecting rod, Structural analysis, Titanium, Steel, Gas load, Fatigue, FEA

1. INTRODUCTION

A connecting rod can be of two types H-beam or I-beam or a combination of both. They are used respectively depending on their field of application or use. An I-beam is both light weight and strong but the type of material used limits its capacity to handle load. Whereas an H-beam can handle much more stress without bending. So they are used in high power engines. The connecting rod is subjected to a complex state of loading [6]. It undergoes high cyclic loads of the order of 108 to 109 cycles, which range from high compressive loads due to combustion, to high tensile loads due to inertia. Therefore durability of this component is of critical importance [7]. Due to these 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 is necessary to investigate finite element modelling techniques, optimization techniques, developments in production technology, new materials, fatigue modelling, and manufacturing cost analysis.

2. Literature Review

In a published SAE case study (1997), a replacement connecting rod with 14%weight savings was designed by removing material from areas that showed high factor of safety [1].

Factor of safety with respect to fatigue strength was obtained by performing FEA with applied loads including bolt tightening load, piston pin interference load, compressive gas load and tensile inertia load [2].

In this research, the engine was simulated in MSC/ADAMS/Engine software and forces acting on different parts of crank mechanism were extracted after that connecting rod was simulated in SolidWorks software, meshed in ANSYS software and critical loads were exerted on it finally stress analysis was done [4].

The kinematic and kinetic analyses of the crank mechanism, stress and fatigue analysis, and finally optimization of connecting rod were performed on Samand engine. For this purpose, the slider-crank mechanism was simulated in MSC/ADAMS/Engine software and forces acting on different parts of crank mechanism were extracted after that connecting rod was simulated in ANSYS software, critical loads were exerted on it, stress and fatigue analysis was done. For stress analysis of connecting rod it was modelled and meshed in ANSYS (Ver. 9) software [5].

The von mises stress and total deformation of two different aluminium alloys were compared with the forged steel [6].

Ramani et al focused on the two subjects, first, load and stress analysis of the connecting rod, and second, optimization for weight reduction. In the first part of the study, loads acting on the connecting rod and find out stress-time history at some critical point [7].

The objective of this work is,

i) Geometrical modeling of connecting rod in Solidwork 15.

ii) To check whether the connecting rod material can take the structural stresses induced due to gas pressure.

iii) Investigate the maximum stress of connecting rod using Ansys 15.

3. Materials Used

Connecting rods can be made from various grades of structural steel, aluminum, and titanium. Steel rods are the most widely produced and used as connecting rods. Their applications are best used for daily drivers and endurance racing due to their high strength and long fatigue life [7]. The only problem with using steel rods is that the material is extremely heavy, which consumes more power and adds stress to the rotating assembly. In this work below mentioned materials are taken as connecting rod materials and analysis are performed.

Carbon Steels,

High strength low alloy steel,

Corrosion resistant high strength low alloy steel, and

Quenched and tempered alloy steel.

4. Determination of forces

Table -1: Design specification of connecting rod

S.no.	Parameters	Value
1	Speed of IC Engine	1800 r.p.m
2	Bore Diameter	100mm
3	Mass of reciprocating parts	2.25 kg
4	Factor of safety	6
5	Young's modulus	2.1 X 10^5 MPa
6	Poisson's ratio	0.3
7	Density of material	8000kg/m^3
8	Wall pressure for piston rings(oil rings)	0.137 MPa
9	Number of rings	3
10	Coefficient of friction	0.05
11	Explosion pressure	3.15 MPa
12	Piston pin diameter	29 mm
13	Crank pin diameter	44 mm

4.1 Forces acting on connecting rod

Following are the forces acting on connecting rod

(i) Force on the piston due to gas pressure.

(ii) Force due to inertia of the connecting rod and reciprocating mass.

(iii) Force due to friction of the piston rings and of the piston.

4.2 Forces calculation

i). Force due to gas pressure

Maximum force due to gas pressure,

$$F_a = (\pi \times d^2 \times P_e) / 4$$

$$= (3.14 \times 100^2 \times 3.15) / 4 = 24{,}740N$$

ii). Inertia force due to reciprocating mass

$$F_i = M \times \omega^2 \times r \times (\cos\theta + (r \times \cos\theta) / l)$$

$$= 2.25 \times (2 \times 3.14 \times 1800)^2 \times 22 \times (\cos 0 + (22 \times \cos 0) / 380)$$
$$= 1756N$$

iii). Frictional force

The force of friction due to piston rings and piston is,

$$F_f = h \times \pi \times d \times i \times p_r \times \mu$$

$$=635.23 \times 3.14 \times 100 \times 3 \times 0.137 \times 0.05$$

$$= 4099N$$

iv). Force acting on piston

$$F = F_{gas} + F_{inertia} - F_{friction}$$

$$= 24{,}740+1756-4099$$

$$=22{,}397N$$

V). Force acting on connecting rod

$$F_c = F / \cos\beta \text{ [At top dead center } \beta=0]$$

$$=22{,}397 / \cos 0$$

$$= 22{,}397N$$

5. Modeling of connecting rod

SolidWorks is a 3D solid modelling package which allows users to develop full solid models in a simulated environment for both design and analysis. In SolidWorks, we sketch ideas and experiment with different designs to create 3D models. SolidWorks is used by designers, engineers, and other professionals to produce simple and complex parts, assemblies and drawings. Designing in a modelling package such as SolidWorks is beneficial because it saves time, effort, and money that would otherwise be spent prototyping the design.

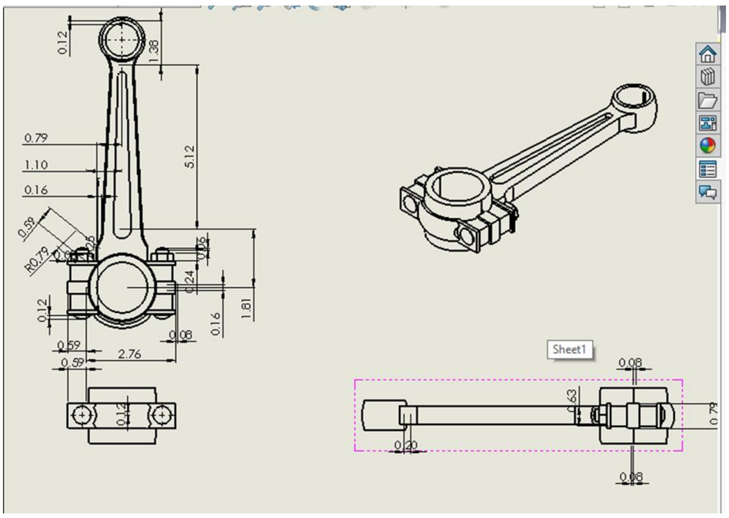
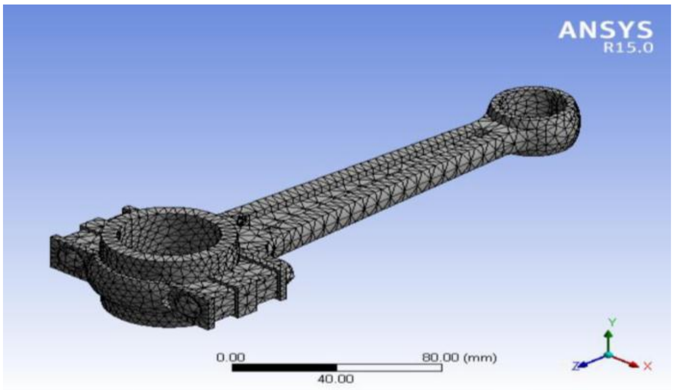


Fig: 1 Dimensions of connecting rod

The basis of FEA relies on the decomposition of the domain into a finite number of sub domains (elements) for which the systematic approximate solutions is constructed by applying the variational or weighted residual method .In effect , FEA reduces the problem to that of a finite number of unknown by dividing the domains into elements and by expressing the unknown field variable in terms of the assumed approximating function within each element . These functions (also called interpolation functions) are defined in terms of the values of the field variables at specifics points, referred to as nodes . Nodes are usually located along the element boundaries and are connected to adjacent elements.



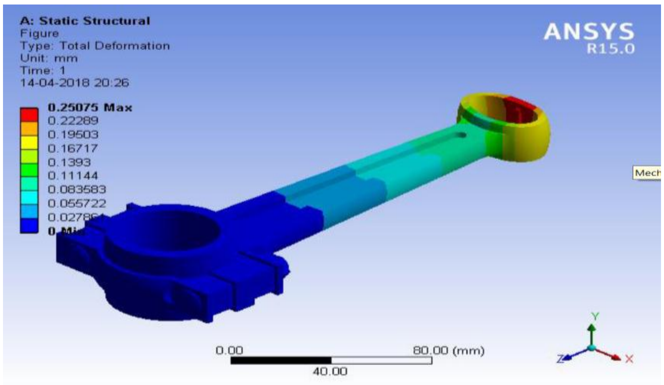


Fig: 2 Meshing of connecting rod

Fig: 3 Deformation in connecting rod

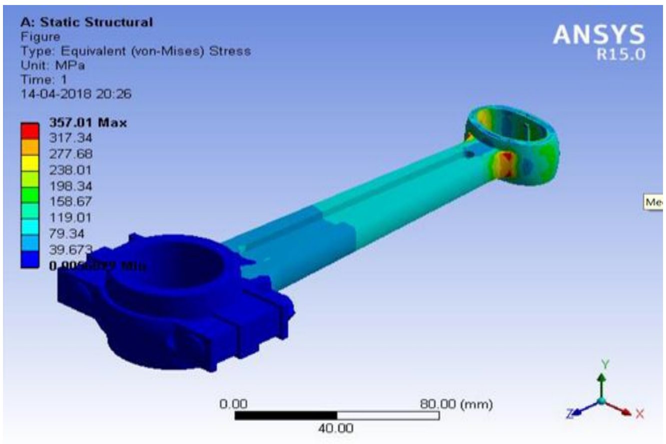


Fig: 4 Equivalent Von Mises Stress

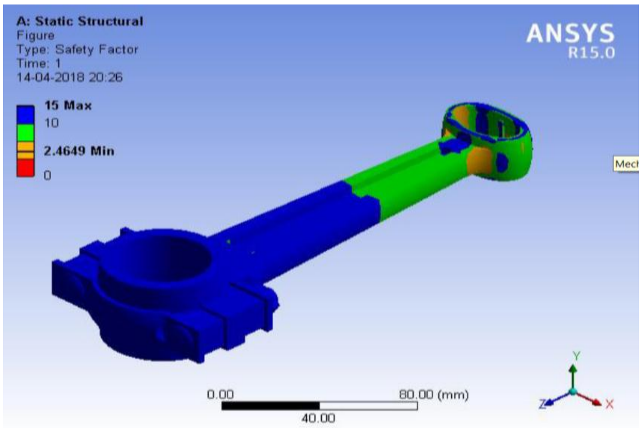


Fig: 5 Factor of Safety

ANSYS Mechanical is a Workbench application that can perform a variety of engineering simulations, including stress, thermal, vibration, thermo-electric, and magneto static simulations. A typical simulation consists of setting up the model and the loads applied to it, solving for the model's response to the loads, the design has 20929 nodes and 11628 elements.

6. Results and comparison

Table 2 Comparison of values

Material	**Max. Deform (mm)**	**Max. Von Mises Stress (Mpa)**	**Weight (Kg)**	**Min. Factor of Safety**
Aluminium 2024-T6	0.39446	356.19	0.3659	0.9688
Aluminium 7075-T6	0.39831	357.8	0.36985	1.4000
Carbon steel :43CrMo4	0.1428	357.8	1.0266	1.5377
Ti-6Al-7v	0.25075	357.01	0.58307	2.4649

It can be concluded from the graph 6, that aluminium 7075 T6 has highest deformation followed by aluminium 2024 T6 then titanium and then carbon steel.

The von mises stress is almost equivalent in aluminium 7075 T6, titanium alloy and carbon steel whereas aluminium 2024 T6 has minimum von mises stress.

Weight of connecting rod formed by different material is max. in carbon steel followed by titanium alloy then by aluminium 7075 T6 and then by aluminium 2024 T6.

From the figure 7, it can be observed that titanium has the greatest factor of safety, preceded by carbon steel, aluminium 7075 T6 and then aluminium 2024 T6.

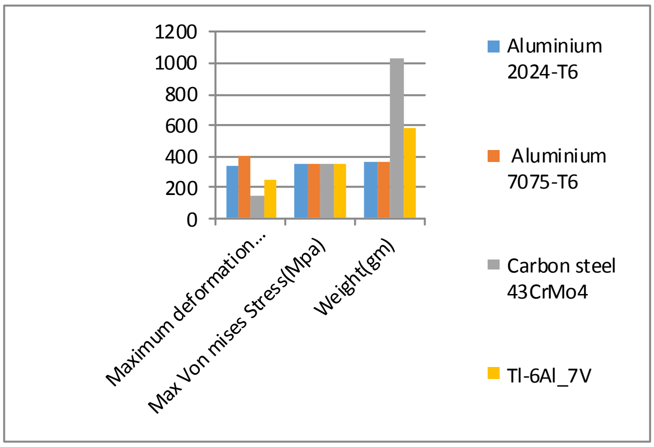


Fig: 6 Comparison of values for different materials

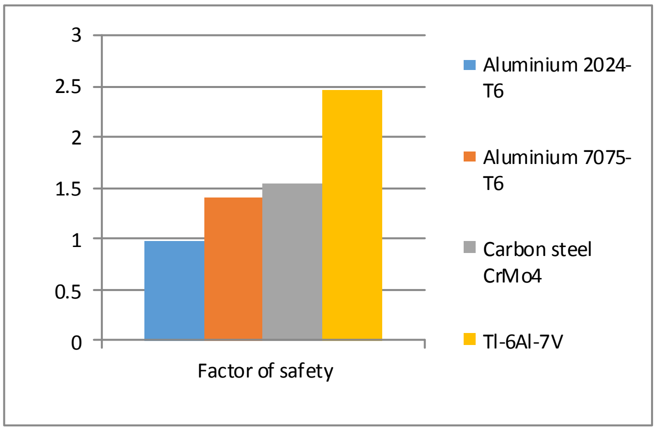


Fig: 7 Factor of Safety

7. Conclusion

From the above work it is clear that titanium alloy is the best for manufacturing of connecting rod. As it has the best Factor of Safety with regard to its weight and minimum deformation.

Aluminium alloy 7075-T6 is second choice for production although it has a lower factor of safety than titanium alloy but the weight of connecting rod is much lower than titanium alloy.

It can also be observed that aluminium alloy 2024-T6 is not effective as its factor of safety is low and product may fail.

It can also be concluded that although carbon steel has greater factor of safety but as it increases the weight of the product so it is not effective.

REFERENCES

1. Balasubramaniam, B., Svoboda, M., and Bauer, W., 1991, "Structural optimization of I.C. engines subjected to mechanical and thermal loads," Computer Methods in Applied Mechanics and Engineering, Vol. 89, pp. 337-360.

2. Bhandari, V. B., 1994, "Design of Machine Elements," Tata McGraw-Hill. Clark, J. P., Field III, F. R., and Nallicheri, N. V., 1989, "Engine state-of-the-art a competitive assessment of steel, cost estimates and performance analysis," Research Report BR 89-1, Automotive Applications Committee, American Iron and Steel Institute.

3. Puran Singh, Debashis Pramanik, Ran Vijay Singh, "International Journal of Automotive Engineering and Technologies", Vol. 4, Issue 4, pp. 245– 253,2015.

4. Mohammad Ranjbarkohan, Mohammad Reza Asadi and Behnam Nilforooshan Dardashti, Australian Journal of Basic and Applied Sciences, 5(12): 2084-2089, 2011.

5. Mohammad Reza Asadi Asad Abad, Mohammad Ranjbarkohan and Behnam Nilforooshan Dardashti Australian Journal of Basic and Applied Sciences, 5(12): 1830-1838, 2011.

6. R A Savanoor, Abhishek Patil, Rakesh Patil and Amit Rodagi, Int. J. Mech. Eng. & Rob. Res. 2014 ,ISSN 2278 – 0149 Vol. 3, No. 3.

7. Ramani et al Int. Journal of Engineering Research and Applications, Vol. 4, Issue 3(Version 1), March 2014, pp.216-220

8. Design and analysis of a connecting rod https://www.researchgate.net/publication/321964919_design_and_analysis_of_a_connecting_rod,2018.