Comparison of the Materials for the Connecting Rod in ANSYS by using Fem Tool

Mr. Rupinder Rathore[1] Mr. Sanpreet Singh Arora[2]
[1,2]Department of Mechanical Engineering
[1,2]Baba Banda Singh Bahadur Engineering Collage, Fatehgarh Sahib, Punjab, India

Abstract— Connecting rod is the intermediate link between the piston and the crank. And is responsible to transmit the push and pull from the piston pin to crank pin, thus converting the reciprocating motion of the piston to rotary motion of the crank. Connecting rod, automotive should be lighter and lighter, should consume less fuel and at the same time they should provide comfort and safety to a passenger that unfortunately leads to increase in weight of the vehicle. This tendency in vehicle construction led the invention and implementation of quite new materials which are light and meet design requirements. Lighter connecting rods help to decrease lead caused by forces of inertia in engine as it does not require big balancing weight on crankshaft. In this present work static structure analysis of the connecting rod is done and find out the best material for the connecting rod. Firstly a connecting rod model is creating in SOLIDWORKS software and then it imported in ANSYS software. After it boundary conditions applied on the connecting rod. We have selected three materials for connecting rod analysis (Aluminium Alloy 7068, Magnesium Alloy AZ91 and Titanium Alloy Ti6Al-4V). The automatic meshing of the connecting rod is done after meshing the nodes is creating 4295 and 2203 element of the connecting rod. The axial load applied is 28000 N (Compressive) on the small end of the connecting rod. The big end of the connecting rod is kept fixed. Out of three the minimum displacement and stress is produced in the Titanium Alloy Ti6Al-4V with value 0.00021514 mm and 2.5842e^8 Pa.

Keywords: Solidworks, ANSYS, Connecting Rod, FEM

I. Introduction

Connecting rod for automotive applications are typically manufactured through forging from either wrought steel or powdered metal. They could also be cast. However, castings could have blew-holes which are harmful from durability and fatigue points of view. The fact that forgings produce blow-hole-free and better rods gives them an advantage over cast rods. Within the forging processes, powder forged or drop forged, every process has its own pros and cons. Powder metal manufactured blanks have the benefit of being near net shape, reducing material waste. However, the cost of the blank is high due to the high material cost and advanced manufacturing techniques. With steel forging, the material is cheap and the rough part manufacturing process is cost-effective. Bringing the part to final dimensions under tight tolerance results in high expenditure for machining as the blank usually contains more excess material [2]. A sizeable portion of the US market for connecting rods is currently consumed by the powder metal forging industry. 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 proper fitting of bearings. These holes must be parallel. The upper end of the connecting rod is attached to the piston by the piston pin. If the piston pin is bolted in the piston pin bosses or if it floats in the piston and the connecting rod, the upper hole of the Connecting rod will have a solid bearing of bronze or a similar material. While the lower end of the connecting rod revolves with the crankshaft, the upper end is forced to turn back and forth on the piston pin. Although this action is slight, the bushing is needed because of the high pressure and temperatures. The lower hole in the connecting rod is broken to allow it to be clamped around the crankshaft. The bottom part, or cap, is formed of the same material as the rod and is connected by two bolts. The surface that bears on the crankshaft is generally a bearing material in the form of a separate crack shell. The two parts of the bearing are located in the rod and cap by dowel pins, projections, or short brass screws. Split bearings may be of the accuracy or semi-precision type.

II. Literature Review

Ali Ha et al. [8] proposed that the connecting rod analysis is carried out to check the fatigue life and alternating stress development due to service and assembly loads with variation in load distribution. The results are summarized as follows. Initially the connecting rod is built to the actual dimensions using CATIA software. Axe-symmetric analysis is carried out to find interference effect on the stress behavior in the joint. 8 nodded plane82 elements with quadratic displacement variation is used for accurate results. The contact pair is created with Targe169 and Contac172 elements. Interference is created through geometric built up. The result shows contact pressure development at the interface and higher compressive stress in the bush and tensile stress development in the small end. The results are plotted for radial, hoop and von-misses stresses. Also a three dimensional views are obtained through ANSYS ax symmetric options.

Chumbre et al. [13] introduced that finite element analysis of connecting rod was carried out using ANSYS simulation tool. Series of simulations were carried out to understand the effect of material selection in connecting rod design by considering different materials. Wide range of variations was observed in the magnitude of Equivalent von-misses stresses, Equivalent elastic strain, Total deformation and Factor of safety for different materials. To optimize the design of connecting rod minor modifications were done without altering the main dimensions. Weight reduction in the component was observed in the modified design from 129.9 grams to 127.96 grams along with lower magnitude of stresses.

Grass et al. [3] proposed that the complete production process of a connecting rod consisting of several rolling and forging steps has been analyzed numerically and experimentally. Both the numerically predicted geometry of the work piece and the distribution of the surface temperature are close to reality. The employed FEM-software is also capable to study the material flow by monitoring the position of selected properties both governing the performance of the whole component.

Guang Hu et al. [2] proposed that the study proposes a capacitance sensor system for measuring the ungrounded/grounded control rod position in NHR. The FEM and electric model are given. A novel method is proposed to calibrate the helix-electrode capacitance sensor based on the grating linear displacement measuring probe. The experiment results show monotonic functions between the capacitance sensor response and the ungrounded/grounded control rod position. With respect to the helix-electrode capacitance sensor, various positions of the ungrounded/grounded control rod are measured with high accuracy. The capacitances obtained by simulations were compared with experiment results to verify the proposed models. The subsequent quantitative analyses on the data indicate the reliability and accuracy of the apparatus for monitoring control rod position.

Ilman et al. [7] proposed that the connecting rod of a reciprocating air compressor is subjected to complex dynamic loads therefore it is of a critical machine element. Failure of this type of connecting rod was reported to occur at the rounded fillet of the big connecting rod end. The present investigation is aimed to identify the cause of failure and to evaluate fatigue performance of the failed connecting rod. Factors affecting failure including structural design, type of material and dynamic loads were assessed using standard failure analysis method. This method included analysis of chemical composition, micro structural examination using optical microscopy, hardness and tensile tests, scanning electron microscopy (SEM) factor graph and stress analysis.

III. Objective of the Study

1) Study the effects of the loads acting on the connecting rod under the considered loading conditions.
2) Comparison of the materials for chooses the best material for Connecting rod.

IV. Methodology

In our proposed work, we shall prepare the model of connecting in SOLIDWORKS in STEP format and perform statics structural analysis of connecting and evaluate the von-misses stress and deformation occurring in connecting. In our project composite element structural member is analyzed using the software called ANSYS. Normally as in all other analysis software the structure is created and property is allotted to the structure that you had created. Then the load is applied to the structural member as required. At the end best material is choose by comparison of results through graph. The software which is used in this research the detail of software is given blow.

V. Geometric Modeling and Finite Element Analysis

A. *Sketcher:*

Sketcher is utilized to make two-dimensional portrayals of related inside the part. We can a harsh layout of bends, and afterward indicate conditions called imperatives to characterize the shapes all the more decisively and catch our outline part. Each bend is alluded to as a portray object. To make a new portray, picked begin to mechanical outline and sketcher at that point select the reference plane or portray plane in which is to be made.

B. *Modeling:*

SOLIDWORKS software is used to create Connecting rod model. SOLIDWORKS is an interactive computer aided designing and manufacturing system. The cad functions automate the normal engineering, design and drafting capabilities found in today's manufacturing companies. Creation of a 3-D model in SOLIDWORKS can be performed using three workbenches i.e.: sketcher, modeling and assembly.

C. *Finite Element Analysis:*

The Finite Element Analysis (FEA) or Finite Element Method (FEM) is a numerical procedure, which could give close precise answers for complex field issues. Fundamentally this technique includes separating the intricate structures into known number of littler structures or components. This capacity of the strategy is called discretization or cross section, which makes the method more viable in breaking down sporadic molded structures in an assortment verity of designing issues. The conventional item advancement process depends on crucial building conditions and powerful in breaking down customary molded basic issues. However for complex physical issues the outline procedure is more reliant on broad testing, which typically makes the procedure costly. The cutting edge item advancement process with FEA innovation does not kill the item testing process, but rather its capacity to examine complex physical issue effortlessly and successfully can diminish the underlying model testing in the plan phases of the item improvement process.

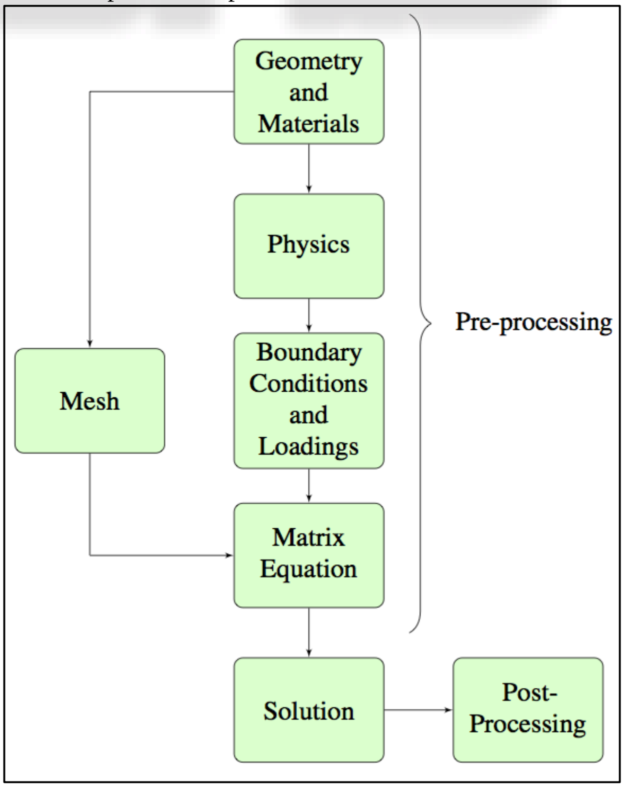

Fig. 1: Finite Element Analysis procedure

D. Mesh Generation:

Cross section is the way toward separating the solids or surfaces into discrete components. It can be either done physically or naturally. If there should arise an occurrence of manual discretization, the model will be worked by determining the directions of every hub and interfacing the hubs to frame the components, which will in the end procure the state of the question being discredited. This procedure can be monotonous and arduous and may not be plausible for extremely complex parts.

VI. RESULTS AND DISCUSSIONS

The results calculate during the statics structure of the connecting rod are discussed below. 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).

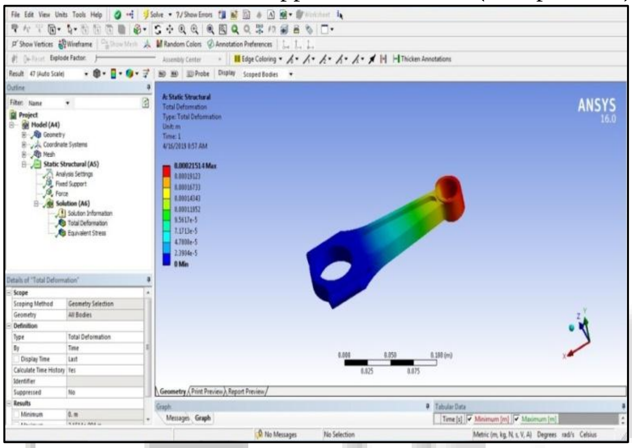

Fig. 2: Total displacement of the connecting rod with Aluminium Alloy 7068 material

We noticed that from the Figure 2 the maximum displacement of the connecting rod. The maximum displacement occurs on the small end of the connecting rod due to compressive force is applied on the small end and big end is fixed. The maximum displacement in the connecting rod by using Aluminium Alloy 7068 material is 0.00021514 m on the small end of the connecting rod. The connecting rod is a vital component of any engine, which undergoes several stresses while in motion. The design of the component and choose best material for the connecting rod is very crucial to improve the durability of the engine and the mechanical efficiency of it.

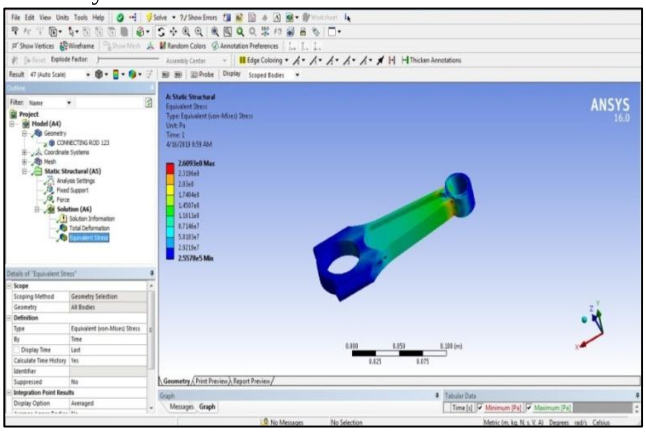

Fig. 3: Stress produced on the connecting rod with Aluminium Alloy 7068 material

We noticed that from the Figure 3 the maximum stress produced on the 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) [5]. The maximum stress produced on the connecting rod is $2.6093e^{8}$ Pa near the small end on the fillet areas. The modern connecting rod is formed of materials that include alloy elements of titanium, aluminium, magnesium, and polymeric connecting rods. Connecting rods for automotive purposes are typically manufactured with forging from either wrought steel or powdered metal. They could also be cast. But, castings could have holes, which are harmful to durability and fatigue points of view. The fact that forgings provide blow-hole-free and better rods gives them an advantage over cast rods.

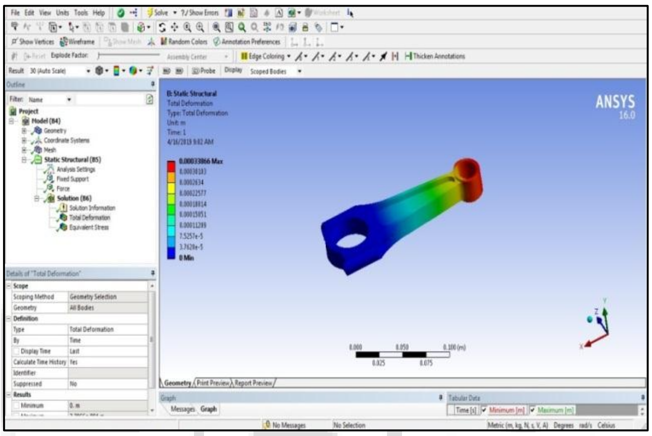

Fig. 4: Total displacement of the connecting rod with Magnesium Alloy AZ91 material

We noticed that from the Figure 4 the maximum displacement of the connecting with material Magnesium Alloy AZ91 material. The maximum displacement occur on the connecting rod is 0.00033866 m on the small end due to big end is fixed.

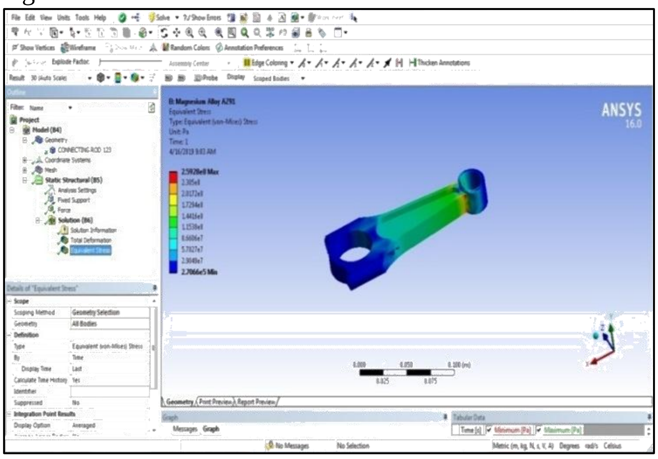

Fig. 5: Stress produced on the connecting rod with Magnesium Alloy AZ91 material

We noticed that from the Figure 5 the maximum stress produced on the 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)

[5]. The maximum stress produced on the connecting rod is $2.5928e^8$ Pa near the small end on the fillet areas. Due to the stresses on the fillet areas the connecting rod material will be fail on the fillet areas. The stress produced in the Magnesium Alloy AZ91 material is less as compared to the Aluminium Alloy 7068 material.

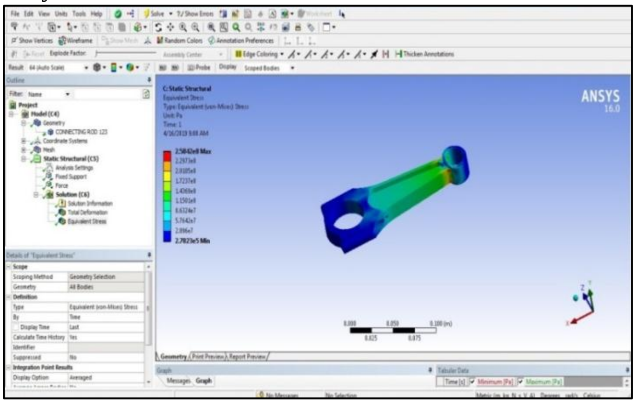

Fig. 6: Total displacement of the connecting rod with Titanium Alloy Ti6AL-4V material

We noticed that from the Figure 6 the maximum displacement produced on the connecting rod with Titanium Alloy Ti6AL-4V material is 0.00015854 m on the small endd due to big end is fixed of the connecting rod. The minimum displacemnt is produced on the big end of the connecting rod therefore the connecting rod material will be fail due to the load on the big end.

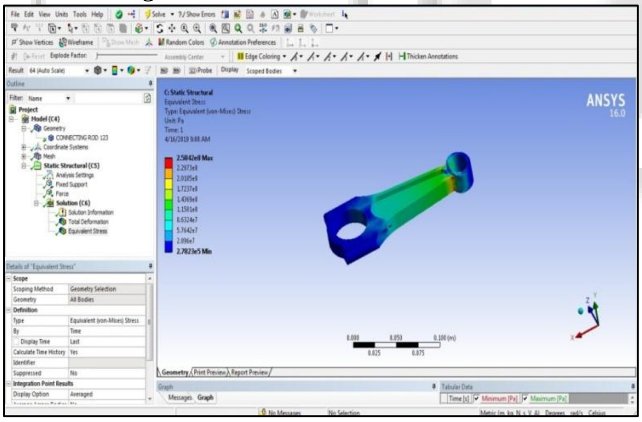

Fig. 7: Stress produced on the connecting rod with Titanium Alloy Ti6AL-4V material

We noticed that from the Figure 7 the maximum stress produced on the connecting rod with value $2.5842e^8$ Pa on the fillet areas. The stress produced in the connecting rod by using Titanium Alloy Ti6AL-4V material is less as compared to the other material. In all the above figures we have notice that minimum stress and displacment produced on the big end due to the big end kept fixed and axial compressive load is applied in the small end. The maximum stress produced in Aluminium Alloy 7068 with value $2.6093e^8$ Pa that is large as compared to the other two materials. But the displacement produced in this material is less as compared to the Magnesium Alloy AZ91. The maximum stress produced in the Magnesium Alloy AZ91 is $2.5928e^8$ Pa that is less as compared to the Aluminium Alloy 7068. But the displacement produced in this material is more as compared to the Aluminium Alloy 7068.

VII. Conclusion

A. From the above results we can see that:

1) The maximum stress produced in Aluminium Alloy 7068 with value $2.6093e^8$ Pa that is large as compared to the other two materials. But the displacement produced in this material is less as compared to the Magnesium Alloy AZ91.
2) The maximum stress produced in the Magnesium Alloy AZ91 is $2.5928e^8$ Pa that is less as compared to the Aluminium Alloy 7068. But the displacement produced in this material is more as compared to the Aluminium Alloy 7068.
3) The minimum stress produced in the Titanium Alloy Ti6Al-4V with value $2.5842e^8$ Pa and displacement is also minimum in this material as compared to the other two materials.

Therefore at the end we can say that Titanium Alloy Ti6Al-4V can be used for connecting rod material because in this material stress and displacement produced is very less.

B. Future scope

Following Recommendations are there for future scope:

1) The whole analysis can be repeated with more materials used for connecting rods.
2) The vibration analysis of connecting rod can be helpful for further study of the vibrations produced in the engine.
3) Transient structure can be done instead of static structure of the connecting rod.

References

[1] Giovanni Rinaldin, Cosimo Miniussi and Claudio Amadio "Cyclic behavior of masonry walls strengthened by tie rods" Engineering Structures, Volume 184, 2019, ISSN 0141-0296, https://doi.org/10.1016/j.engstruct.2019.01.103.

[2] Guang Hu, Benke Qin and Hanliang Bo "Control rod position measurement with helix-electrode capacitance sensor in nuclear heating reactor" Annals of Nuclear Energy, Volume 120, 2018,ISSN 0306.

[3] H. Grass, C. Krempaszky and E. Werner " 3-D FEM-simulation of hot forming processes for the production of a connecting rod" Computational Materials Science, Volume 36, Issue 4, 2006, ISSN 0927-0256.

[4] Jun-chao Zhu, Han-hua Zhu, Shi-dong Fan, Liang-jun Xue and You-feng Li " A study on the influence of oil film lubrication to the strength of engine connecting rod components" Engineering Failure Analysis, Volume 63, 2016, ISSN 1350-6307, https://doi.org/10.1016/j.engfailanal.2016.02.006.

[5] Kaliappan S, Revanth Raam AP, Charan B, Asswin S, Mohammed Ibrahim SM6, Dr. T. Mothilal and M.D. Rajkamal "Modal and kinematic analysis of a connecting rod for different materials" International Journal of Pure and Applied Mathematics Volume 119 No. 12 2018, 14599-14608.

[6] Lucjan Witek and Paweł Zelek "Stress and failure analysis of the connecting rod of diesel engine, Engineering Failure Analysis" Volume 97, 2019, ISSN 1350-6307, https://doi.org/10.1016/j.engfailanal.2019.01.004.

[7] M.N. Ilmanand R.A. Barizy "Failure analysis and fatigue performance evaluation of a failed connecting rod of reciprocating air compressor" Engineering Failure Analysis, Volume 56, 2015, ISSN 1350-6307.
[8] H Mohammed Mohsin Ali and Mohamed Haneef "Analysis of Fatigue Stresses on Connecting Rod Subjected to Concentrated Loads at the Big End" Materials Today: Proceedings, Volume 2, Issues 4–5, 2015, ISSN 2214-7853.
[9] R. Luri, C.J. Luis, D. Salcedo, J. León, J.P. Fuertes and I. Puertas "FEM Analysis of the Isothermal Forging of a Connecting Rod from Material Previously Deformed by ECAE" Procedia Engineering, Volume 63, 2013, ISSN 1877-7058, https://doi.org/10.1016/j.proeng.2013.08.209.
[10] S.V. Uma Maheswara Rao, T.V. Hanumanta Rao, K. Satyanarayana and B. Nagaraju "Fatigue analysis of sundry i.c engine connecting rods" Materials Today: Proceedings, Volume 5, Issue 2, Part 1, 2018, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2017.12.073.
[11] Saharash Khare, O.P. Singh, K. Bapanna Dora and C. Sasun "Spalling investigation of connecting rod, Engineering Failure Analysis" Volume 19, 2012, ISSN 1350-6307, https://doi.org/10.1016/j.engfailanal.2011.09.007.
[12] Sharma Manoj and Shashikant "Optimization of connecting rod with help of fea" Volume 6, Issue 7, July 2015, pp. 51-57, Article ID: 30120150607007.
[13] Vinayak Chumbre, Vinayak Kallannavar, Anilkumar Shirahatti, Ratan Patil and Shirish M. Kerur "Design and Comparative Analysis of Connecting Rod using Finite Element Analysis" ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue IV, April 2018-Available at www.ijraset.com.
[14] Xiaolei Zhu, Jing Xu, Yang Liu, Bo Cen, Xiaofeng Lu and Zhuo Zeng "Failure analysis of a failed connecting rod cap and connecting bolts of a reciprocating compressor" Engineering Failure Analysis, Volume 74, 2017, ISSN 1350-6307, https://doi.org/10.1016/j.engfailanal.2017.01.016.

