Finite Element Analysis of Connecting Rod for different materials

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Abstract - *Connecting rod is an engine component that connects the piston to the crankshaft. It converts the linear and down movement of piston into circular motion of crankshaft. This paper presents finite element analysis of connecting rod. Finite Element Analysis is done with the help of ANSYS. We have used three different materials which are structural steel, Al alloy, Ti alloy for the connecting rod. Equivalent elastic strain, total deformation, equivalent stress and strain energy of connecting rod of different materials is calculated and compared..*

***Key Words*: connecting rod, engine, analysis, Ansys, materials.**

1. INTRODUCTION

The connecting rod joins the piston to the crankshaft of a reciprocating piston engine, converting the piston's reciprocating action to rotary motion for the crank. A piston pin, also known as a gudgeon pin, secures it to the piston at its small end. The crankpin journal connects the large end to the crankshaft. They form a basic mechanism with the crank that turns linear motion into rotational motion. A connecting rod's job is to allow fluid movement between pistons and the crankshaft.

During the combustion cycle, the connecting rod must be strong enough to sustain the piston force. It will be subjected to a lot of tensile and compressive loads during the course of its life. A connecting rod can be made out of a variety of materials, including carbon steel, iron base sintered metal, micro-alloyed steel, and graphite cast iron. Steel connecting rods are most typically used in mass-produced car engines. In most high-performance applications, billet connecting rods, which are machined from a solid billet of metal rather than being cast or forged, are used.

Other materials include aluminium alloy, which can be used for lightweight while also absorbing heavy impact without sacrificing durability. Titanium, on the other hand, is a more expensive alternative that is found to reduce weight, whilst cast iron, on the other hand, is found to be less expensive and has extremely low performance applications such as scooters.

2. Literature Review

1. "Design and Analysis of 150CC IC Engine Connecting Rod"-2017 by Amaravathi Rajugopal Varma et al. He designed a connecting rod for a four-stroke single-cylinder engine using two different materials: carbon steel and aluminium alloy in this project. Both designs were created using the CREO 3D modelling software. Structural study of the connecting rod is performed to test the strength of the original and modified models using two materials: aluminium alloy and pressure created in the engine. When loads are applied, modal analysis is used to identify the natural frequencies. The analysis is carried out in order to choose the best material for the connecting rod in order to save money. CREO is used for modelling, and ANSYS is used for analysis.

2. Prof. Vivek C. Pathade used Pro/E Wildfire 4.0 and ANSYS Workbench 11.0 software to conduct a stress analysis of a connecting rod using the Finite Element Method. For comparison and verification of FEA results, the Photo elastic experimental approach is used. He discovered that the stresses created in the tiny end of the connecting rod are higher than the stresses induced in the big end using FEA and Photo elastic Analysis. The photo elastic also reveals that the stress concentration effect exists at both the small and large ends of the connecting rod, but is negligible in the middle. As a result, the connecting rod may fail at both ends' fillet region.

3. VenuGopal Vegi and Leela Krishna Vegi present the design and analysis of a connecting rod in their article. Carbon steel is used in the current connecting rods. A forged steel connecting rod is subjected to finite element analysis. Von Mises stress, strain, deformation, factor of safety, and other parameters were calculated, and it was discovered that forged steel has a higher factor of safety, lower weight, and greater stiffness than carbon steel. Pravardhan S.Shenoy and Ali Fatemi: They performed a dynamic load study and connecting rod optimization.

4. In their study, Wankhade and SuchitaIngale give a review on the design and analysis of a connecting

rod for various materials. CATIA V5 is used for modelling, and ANSYS is used for analysis. Authors suggested high strength carbon fibre for diesel engine connecting rod after comparing several materials such as Al alloys, high strength carbon fibre, and steel.

5. Dipalee Bedse present the design evaluation with the help of FEA for fatigue life of connecting rod. CATIA was used to create a connecting rod model. FEA was carried out with the help of HYPER MESH and FEMFAT. The author determined that simple adjustments in connecting rod geometry, such as increasing neck radius, improve the fatigue life of the connecting rod.

6. G. M. Sayeed Ahmed's project was "Design Fabrication and Analysis of a Connecting Rod with Aluminum Alloys and Carbon Fiber," in which he replaced a forged steel connecting rod with an aluminium alloy and carbon fibre. Pro/E was used to create the Connecting Rod. Aluminum 6061, aluminium 7075, aluminium 2014, and carbon fibre 280 GSM connecting rods are employed, and analysis is performed.

7. Ganta Krishnarjuna Reddy and Badde Naik perform a static structural analysis of various materials used in connecting rods. The connecting rod model was created in SOLID WORKS 2016. ANSYS 14.5 was used to perform static structural analysis on a variety of materials. For the manufacturing of connecting rods, the author found that materials with low stress values are desirable.

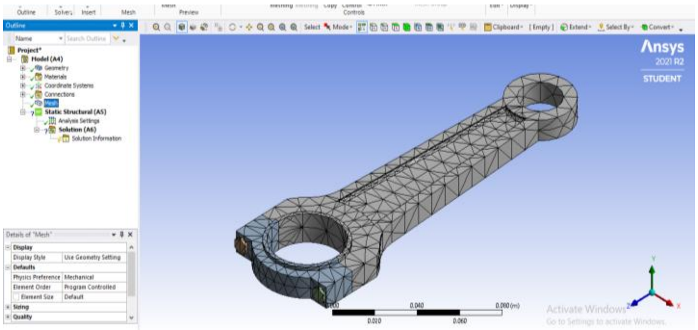
8. Mithilesh and colleagues deliver a work on the design and analysis of connecting rods made of various materials. The parametric model of the connecting rod was created using INVENTOR. ANSYS 15.0 was used for the analysis. Carbon fibre might be utilised to make connecting rods, according to the authors.

9. Ankit Gupta and Mohd. Nawajish - In this project, the existing connecting rod material was replaced with several materials in order to identify the best alternative. The CAD model was created using PRO-E 4.0. ANSYS 10.0 was used for the analysis. The authors suggested using a beryllium alloy to make connecting rods.

10. B. K. Roy-Various connecting rod designs have been analysed in order to determine the best design parameters. The connecting rod model was made in CATIA V5 R19. Finite element analysis was performed using ANSYS 12.0. The author concluded that careful changing of design parameters can result in a suitable connecting rod design.

A vehicle's performance is impacted by the weight and size of the connecting rod. The weight and stress differences generated by changing the connecting rod material and design will be noticeable.

Meshing



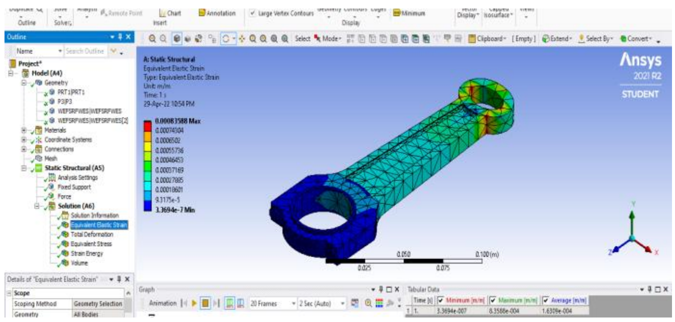
3. FINITE ELEMENT ANALYSIS

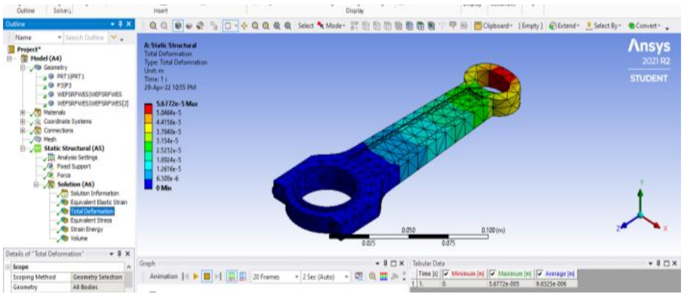
ANSYS was used to do the finite element analysis. For analysis, the prepared 3D model of the connecting rod is imported into ANSYS. Structural steel, Al alloys, and Ti alloys were used in the analysis.
Properties of materials are given in the Table 1

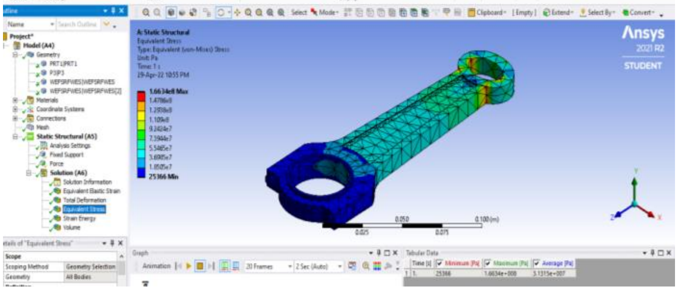
Table 1

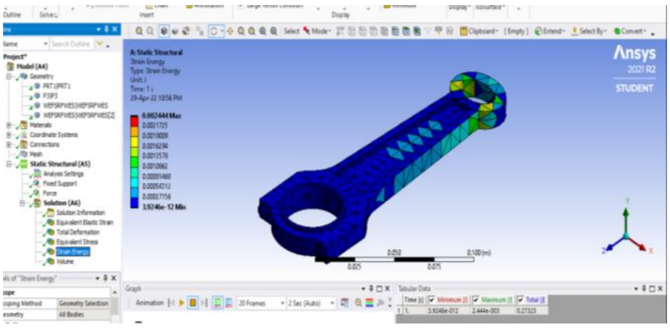
Material	Young's Modulus	Poisson's Ratio	Density(kg/m3)	Tensile Yeild Strength
Structural Steel	200	0.31	7850	250
Al Alloy	71	0.33	2770	280
Ti Alloy	96	0.36	4620	930

Structural Steel

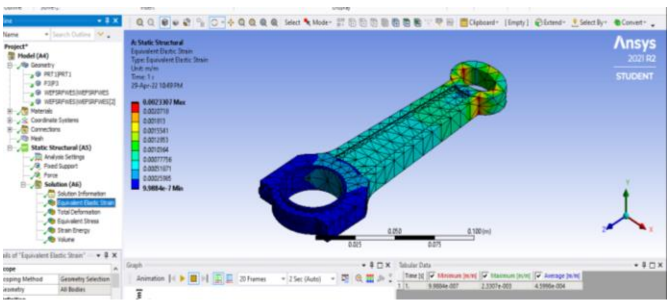


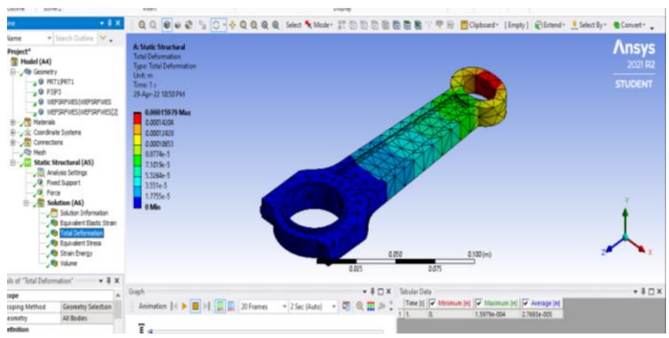


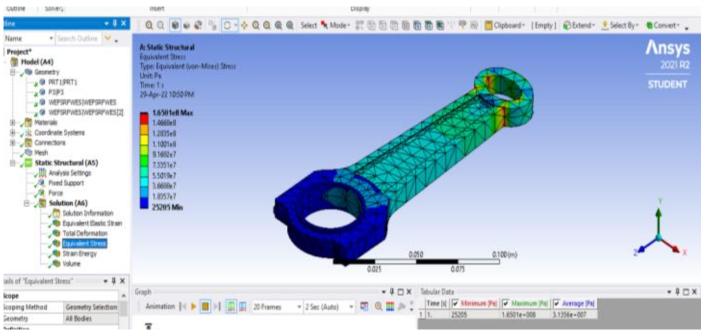


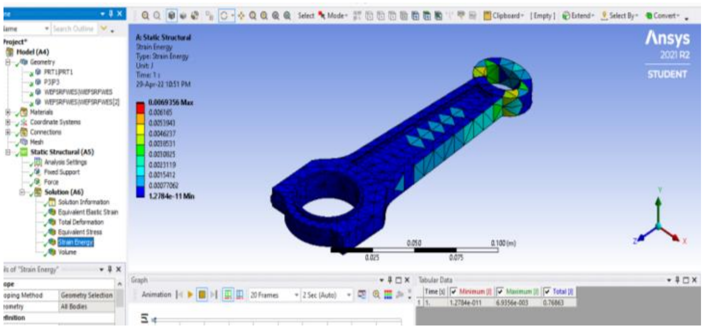


Al Alloy

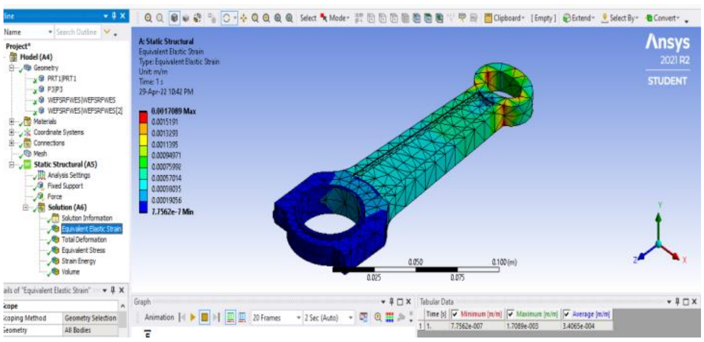


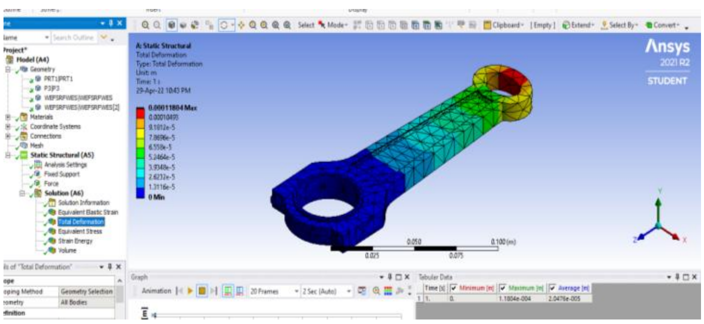


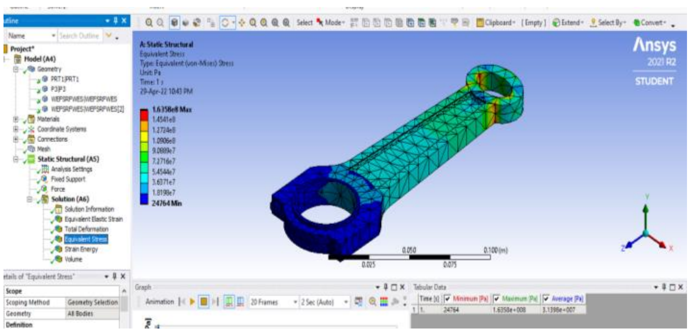


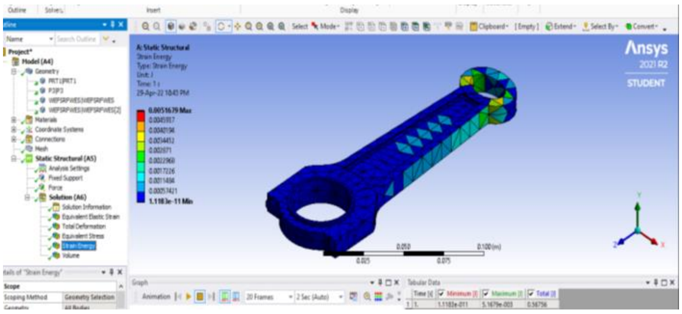


Ti Alloy









4. Results

Materials	Equivalent elastic Strain	Total Deformation	Equivalent Stress	Strain Energy
Structural Steel	1.6309e-004	9.8325e-006	3.1315e+007	0.27323
Al Alloy	4.5998e-004	2.7693e-005	3.1356e+007	0.76863
Ti Alloy	3.4065e-004	2.0476e-005	3.1398e+007	0.56756

5. CONCLUSIONS

The same load was applied on the all there connecting rod under research and it was found that the maximum equivalent elastic strain was observed in Al Alloy and minimum in Structural Steel. The maximum deformation was observed in Structural Steel and minimum in Ti Alloy. The maximum equivalent stress was observed in Ti alloy and minimum in Structural Steel. Strain energy was maximum in Al Alloy and Minimum in Structural Steel. In the research, Aluminium alloy was found to be best material among the three as it has the minimum mass and high strength to weight ratio.

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