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Analysis of Static Structure on Connecting rod with Different Materials Using ANSYS 19.2

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Abstract-- The connecting rod is a critical component in engine construction because it carries energy from the piston to the crankshaft and converts the linear, reciprocating action of the piston into the rotating action of the crankshaft. A connecting rod's purpose is to allow fluid movement between pistons and a crankshaft. The most useful attribute of a connecting rod is that it is homogeneous and lightweight. We are designing a connecting rod in AutoCAD 2021 and doing static structural analysis in ANSYS WORKBENCH 19.2 software for this project. The modelled part is transformed into an igs file for input into ANSYS WORKBENCH 19.2, and static structural analysis is performed at 400 N of force. Further investigation was carried out by examining various materials in order to better understand the changes in equivalent von-mises stress, strain, and total deformation.

Keywords: Connecting rod, ANSYS Workbench 19.2, AutoCAD 2021, Static structural analysis.

1. INTRODUCTION

A connecting rod is an intermediary component that transfers piston linear motion into crankshaft rotational motion. It is divided into three sections: a pin end, a shank region, and a crank end. The piston assembly is linked to the pin end, and the crankshaft is attached to the crankshaft. The connecting rod has two ends: the smaller end is attached to the piston by piston pins or gudgeon pins, and the larger end is connected to the crankshaft through bearing.

The internal combustion engine is essentially a crank-slider system, with the slider in this case being the piston. The piston is contained within a combustion chamber. The expansion of the high-temperature and high-pressure gases produced by combustion imparts direct force to the piston in an internal combustion engine. This force drives the component, known as the connecting rod or crankshaft, over a distance, converting chemical energy into usable mechanical energy.

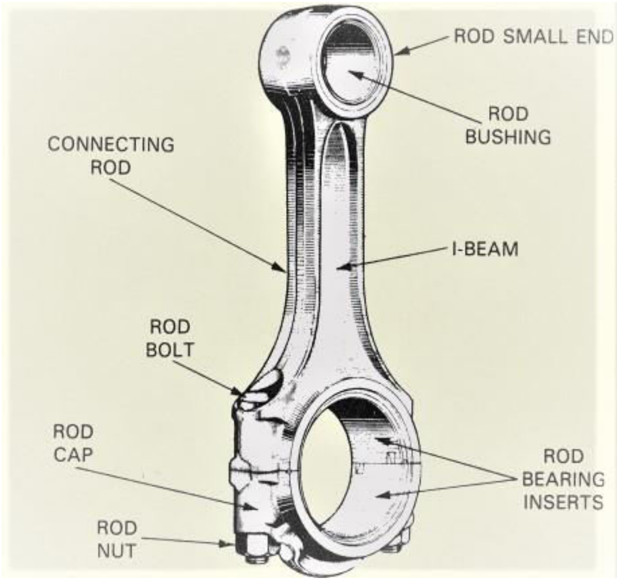

Fig.1.1 various components of a connecting rod.

1.1 Design dimension requirements: The following dimensions must be established while constructing a connecting rod:

- Dimensions of the connecting rod's cross-section,
- Dimensions of the large end of the crank shaft and the small end of the piston pin
- Bolt size for fastening the large end cap
- The thickness of the large end cap.

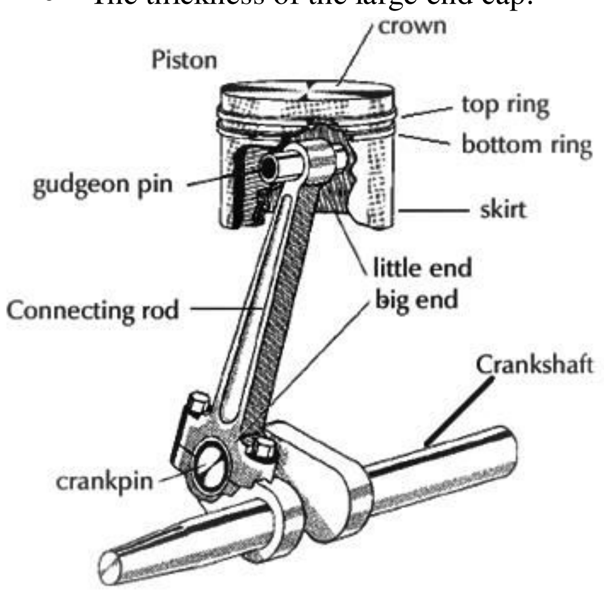

Fig.1.2 Assembly of the connecting rod, piston, and crankshaft

1.2 Forces acting on the connecting rod:

The following are the various forces operating on the connecting rod:

- The force exerted on the piston by gas pressure and the inertia of the reciprocating components,
- Forces due to the connecting rod's inertia or inertia bending forces,
- Frictional force between the piston rings and the piston and
- Friction between the piston pin bearing and the crankpin bearing causes force.

1.3 Classification of connecting rod

Connecting rods are classified according to their cross-sectional shape, such as I-section, H-section, circular section, and so on. Low-speed engines often utilize a circular section, but high-speed engines use I section. From the big end to the small end, the rod generally tapers slightly.

There are many distinct varieties of connecting rods, each with a different cross-section, but there are essentially two sorts.

a) Connecting rod with a nut and bolt:

As illustrated in fig. 1.3, the connecting rod with cap at the larger end is connected by a bolt and nut. This type of connecting rod is most commonly used in multi-cylinder engines. For example, trucks, tractors, and so on.

Fig.1.3 Connecting rod with nut and bolt

b) Connecting rod without nut and bolt

This type of connecting rod is made up of only one piece and is commonly used in single-cylinder engines. Bikes, scooters, and so forth are examples. Figure 1.4 depicts this.

Fig.1.4 Connecting rod without nut and bolt

1.4 Function of connecting rod in an engine

The connecting rod's function is to convey piston thrust to the crankshaft. The function of the connecting rod in converting reciprocating motion to rotational motion. Internal combustion engines have four strokes: intake, compression, expansion or power, and exhaust. Each stroke takes around 180 degrees of crankshaft rotation, thus the entire cycle would need 720 degrees. Every engine stroke has a significant impact on the combustion process.

1.5 Materials used for connecting rod

Connecting rods are primarily manufactured using two methods: drop forging and molding processes. Steel forging techniques produce lighter but more expensive connecting rods. Steel connecting rods have a bronze or brass small end bush and a white metal detachable large-end shell bearing. Lower in weight than steel connecting rods, aluminum alloy connecting rods are preferable over steel connecting rods.

2. LITERATURE REVIEW

Various research articles are examined in order to discover a new approach and new field of study that improves the efficiency, performance, and life of connecting rods.

Boga sudha et. al. "Design and Thermal Analysis of IC Engine's Connecting Rod for Different Heat Conditions" 2018- illustrated connecting rod is the intermediary between the piston and the crankshaft. In this dissertation, the optimum material is chosen by comparing Carbon Steel and Aluminum Alloy. Solid Works, a 3D modelling programme, is used to create the connecting rod. Thermal analysis is carried out using ANSYS software. Thermal analysis can provide us with heat flow estimates, allowing us to choose the optimum material for connecting rods.

Sushil Kushwaha et. al. in "Review on design and analysis of IC engine connecting rod"2018- Discuss the Connecting Rod, which is one of the most important components of an internal combustion engine. The Connecting Rod is intended to transfer power from the engine to the shaft and to transform reciprocating motion into rotary motion. The primary goal of this effort is to alter the present design. Aluminum, aluminum alloy, and aluminum alloy with titanium coating are the materials used in this investigation. Different materials and alloys are evaluated and compared to get the ultimate result of designing a connecting rod with upgraded material and improved mechanical characteristics.

Naman Gupta et. al. in "Modern Optimized Design Analysis of Connecting Rod of an Engine Connecting rod"-2018- dealt with the connecting rod links the revolving piston to the spinning crankshaft, transferring the piston's thrust to the crankshaft. It has two points. A gudgeon pin connects the tiny end to the piston, while a crank pin connects the other end to the crankshaft. The reciprocating motion produced during the transfer of braking power at the piston head exerts a variety of stresses on the connecting rod. It is commonly used to convey force through a machine. As a result, it is critical to minimize the weight while keeping the acceptable limit in mind while producing a stronger connecting rod. This additional study shifts to von misses stress so that we get a better component with less weight, is more cost effective, and produces better results than other components. This article depicts a broad research on three connecting rod designs, as well as a modern construction.

Asadi, et. al. (2010) developed a project load analysis in service, Basic loading conditions for the connecting rod were tested. The following findings may be derived from this study: the highest pressure stress was achieved between the pin end and the rod linkage, and the highest tensile stress was produced in the bottom half of the pin end. Under tensile stress, the crank and piston pin ends are considered to have a sinusoidal distributed loading throughout the contact surface area. This is based on the findings of experiments.

Kuldeep B et. al. they recommended that the connecting rod material be replaced with an aluminum-based composite material strengthened with silicon carbide and fly ash, and they also did connecting rod modelling and analysis. Two materials were considered in the FEA study. FEA software was used to obtain parameters such as von misses stress, von misses strain, and displacements. When compared to the previous material, the new material was discovered to be lighter and stiffer. It resulted in a 43.48 % decrease in Weight, with a 75% decrease in displacement.

Dr. S B Jaju et. al. illustrated for cost and material optimization, they modelled and analysed the connecting rod of a four-stroke single-cylinder engine. They concentrated their research on two topics: static load stress analysis of the connecting rod and weight minimization.

Ram Bansal et. al. the connecting rod's dynamic study was carried out. In his work, they models the connecting rod of a single cylinder-four stroke diesel engine in CATIA V5R18 software and analyses it in ANSYS workbench.

3. METHODOLOGY

3.1 Development tools

To proceed with this investigation, the dimensions of the connecting rod were obtained from the Hero Splendor Plus model. The 3D model of the connecting rod assembly was created in AutoCAD 2021.

a) AutoCAD

AutoCAD is a computer-aided design (CAD) and drafting software programme. Autodesk's initial version was shown at the 1982 Comdex and launched in December of that year. AutoCAD was compatible with CP/M-80 machines. In industry, architects, project managers, engineers, graphic designers, city planners, and other professionals utilize AutoCAD. In 1994, it was backed by 750 training facilities across the world. There are several AutoCAD plugins (add-on programmes) available on the Autodesk Exchange Apps application marketplace. Drawing information may be imported and exported using AutoCAD's DXF, or drawing exchange format. The initial view of AutoCAD 2021 is seen in Figure 3.1.

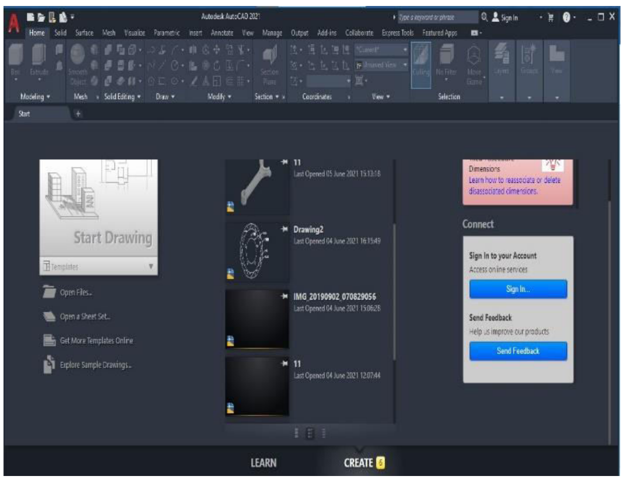

Fig. 3.1 starting view of AutoCAD 2021

b) ANSYS

Ansys, Inc. is an American corporation headquartered in Canonsburg, Pennsylvania. It creates and sells multiphysics engineering simulation software for product design, testing, and operation, and it serves customers all over the world. Ansys Mechanical finite element analysis software is used to analyze computer simulations of architecture, electronics, or mechanical parts in order to analyses strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other properties. Ansys programme, for example, may model how a bridge will hold up after years of traffic, how to best process salmon in a cannery to avoid waste, or how to build a slide that uses less material while maintaining safety. Ansys software's first commercial version, version 2.0, was published in 1971. In 1979, the VAXstation received version 3.0 (the second release). The Apple II was launched in 1980, allowing Ansys to transition to a graphical user interface in version 4 later that year. Version 5 of Ansys, published in 1993, included Compuflo's Flotran fluid dynamics software. Ansys R1 2020, which will be available in January 2020, improves Ansys' simulation process and data management (SPDM), materials information, and electromagnetics product capabilities. The ANSYS 19.2 initializing view is shown in Figure 3.2.

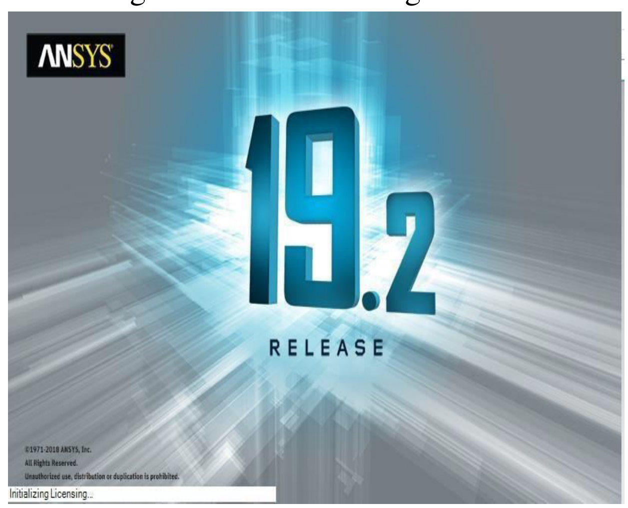

Fig.3.2 Initializing view of ANSYS 19.2

3.2 Materials for connecting rod

Previous research models and data, as well as some practical knowledge, are taken into account for the connecting rod analysis. For manufacturing engines, connecting rods are generally constructed of steel, although they are now primarily made of aluminum alloys for light weight and good impact absorption capabilities. For high-performance engines, it can be constructed of titanium for lightness and strength at a greater cost. Cast iron is also utilized, although because of its weight, manufacturers frequently avoid it.

Aluminum Alloy and Structural Steel were utilized in this investigation, and as is the default material used to model in ANSYS software.

3.3 Input parameters:

The connecting rod model utilized for study is that of a 100cc commercial motorcycle (Hero Splendor Plus). The measurements were performed practically with the use of a Caliper Scale. The engine specs of the Hero Splendor Plus are listed in the table below.

Fig. 3.3 Actual photograph of Hero Splendor plus Connecting Rod.

Specification	Value
Compression Ratio	9.9:1
Displacement	97.2 cc
Cylinders	1
Max. Power	8.02 PS @8000 rpm
Max. torque	8.05 Nm @ 6000 rpm
Bore	50 mm
Stroke	49.5 mm
Valves per cylinder	2
Emission Type	Bs6
Fuel type	Petrol
Spark Plugs	1
Cooling system	Air cooled
No. of gears	4
Gear box type	Manual
Transmission type	Chain drive
Clutch	Wet multiplate

Table.3.1 Specifications of Hero Splendor Plus

Dimension	Value
Total length	120 mm
Maximum width	40 mm
Maximum thickness	15 mm
Shank thickness	8 mm
Inner diameter of the big end	30 mm
Inner diameter of the small end	13 mm
Outside diameter of the big end	40 mm
Outside diameter of the small end	16 mm
length measured between the centres of both ends	95 mm

Table 3.2 the measurements of the connecting rod that has been utilized for analysis.

3.4 Modelling of connecting rod:

Exact modelling of the connecting rod is exceedingly difficult, and some assumptions must still be made in order to mimic any complex system. These assumptions are created by considering the theoretical calculation's difficulties as well as the importance of the parameters utilized and those omitted. Connecting rod modelling is created with AutoCAD 2021. Figure 3.3 depicts a 3D model representation of a connecting rod.

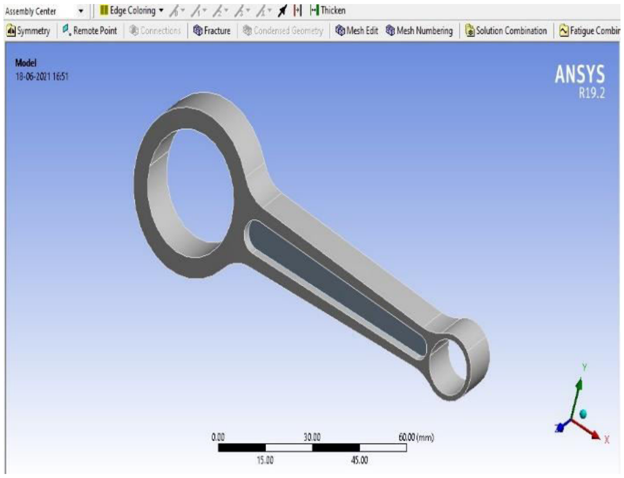

Fig. 3.3 3D view of connecting rod

The model is then converted to the most appropriate and simple-to-access IGES format for use with any other programme. The connecting rod model may be imported from AutoCAD 2021 to ANSYS workbench 19.2 using the IGES format.

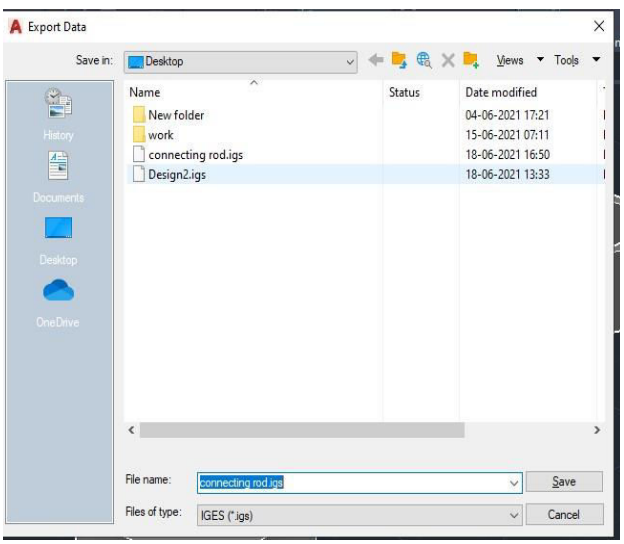

Fig.3.4 Transformation of model

Meshing is used to discretize an item by converting it into a finite number of components. To mesh connecting rods, ANSYS was utilized. The component utilized for meshing has a tetrahedral form, as seen in fig. 3.5.

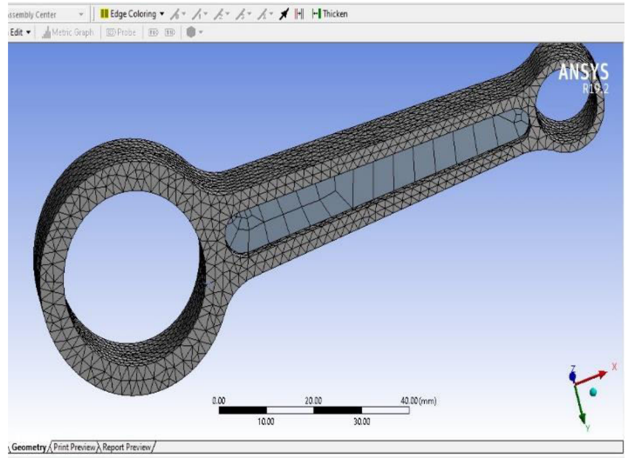

Fig.3.5 Mesh view of connecting rod

4. CALCULATION

4.1 Design for pressure calculation

Consider 100cc Engine

Specifications

Engine type = air cooled 4-stroke

Bore x Stroke (mm) = 50 × 49.5

Displacement = 97.2 CC

Maximum Power = 8.02 bhp @ 8000 rpm

Maximum Torque = 8.05 Nm @ 6000 rpm

Compression Ratio = 9.9:1

Density of Petrol (C8H18) = 747.32 kg/m^3

= $747.32\times10^{-9}\ kg/mm^3$

Auto ignition temp. = 56°F=286.48°K

Mass = Density x volume

= $747.32\times10^{-9} \times 97.2 \times 10^{3}$

= 0.0726395 kg

Molecular weight of petrol = 102.39 g/mole

= 0.10239 kg/mole

From gas equation,

PV= $m \times R_{specific} \times T$

Where,

P = Gas Pressure, Mpa

V = Volume, m^3

m = Mass, kg

T = Temperature, °K

$R_{specific}$ = Specific gas constant = R/M

$R_{specific}$ = 8.3144/0.10239

$R_{specific}$ = 81.2032 Nm/Kg K

P = $m\times Rspecific\times T/V$

P = 0.0726395 × 81.2032 × (286.48/97.2)

= 17.38 × 10^6 Pa = 17.38 MPa

The calculation assumes a maximum pressure of 17.38 Mpa.

4.2 Properties of material

Aluminum Alloy and Structural Steel were utilized in this investigation, and as is the default material used to model in ANSYS software.

Properties	Materials	
	Structural Steel	**Aluminum Alloy**
Young's Modulus,(E) (Pa)	**2×10^{11}**	**1.6×10^{11}**
Poisson's Ratio	**0.31**	**0.34**
Tensile Ultimate strength (Pa)	**4.4×10^8**	**3.6×10^8**
Tensile Yield strength (Pa)	**2.4×10^8**	**2.7×10^8**
Density (Kg/m^3)	**7830**	**2940**

Table: 4.1 Properties of material

4.3 Connecting rod design calculation

Thickness of the section's flange and web = t

B = 4t, the width of the section

Sectional height, H = 5t

Sectional area, A = $11t^2$

Ixx = $32.31t^4$ moment of inertia about the x-axis

Iyy =$10.47t^4$ is the moment of inertia around the y-axis.

As a result, Ixx/Iyy = 3.08.

The length of the connecting rod (L) equals the stroke multiplied by two.

L = 99 mm

Total Force acting F = $F_P - F_I$

Where,

F_P denotes the force applied on the piston.

F_I is an abbreviation for force of inertia.

$FP = (\pi/4)\, D^2 \times$Gas pressure

Where

D is the Bore Diameter

$F_P = (\pi/4) \times 50^2 \times 17.38 = 34125.55$ N

$F_I = m \times \omega^2 \times r\ (cos\emptyset + cos2\emptyset/n)$

Where,

M = Mass

$\omega = 2\pi \times 8000/60 = 837.758\ rad/sec$

n = length of connecting rod (l) / crank radius(r)

= $(2\times stroke)$ / $(stroke2/)$

= 99/24.75

$\therefore n = 4$

At θ=3.3°, the maximum gas load occurs shortly after the dead centre point.

Cos (3.3) = 0.9983≅1

F_I =0.0726395 × $(837.758)^2$ × 0.02475 (1+1/4) =1577.23 N

So, F = 34125.55 – 1577.23 = 32548.32 N

5. RESULTS AND CONCLUSION

5.1 Applied Parameters

Following the modelling of the connecting rod, the IGES format file is opened in ANSYS Workbench 19.2 to create meshing, which is then applied parameters to the connecting rod geometry based on the calculation.

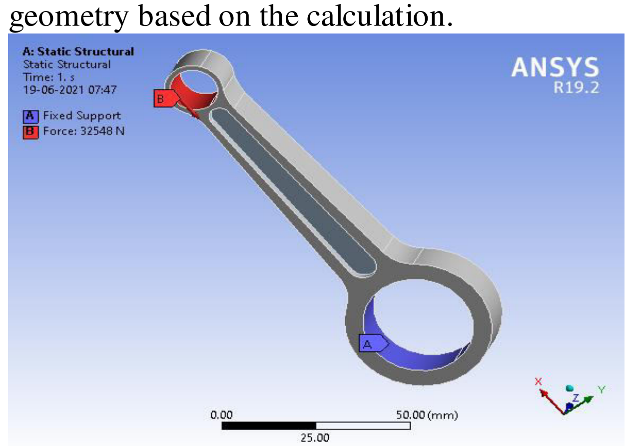

Fig. 5.1 Force and fixed support applied on small end

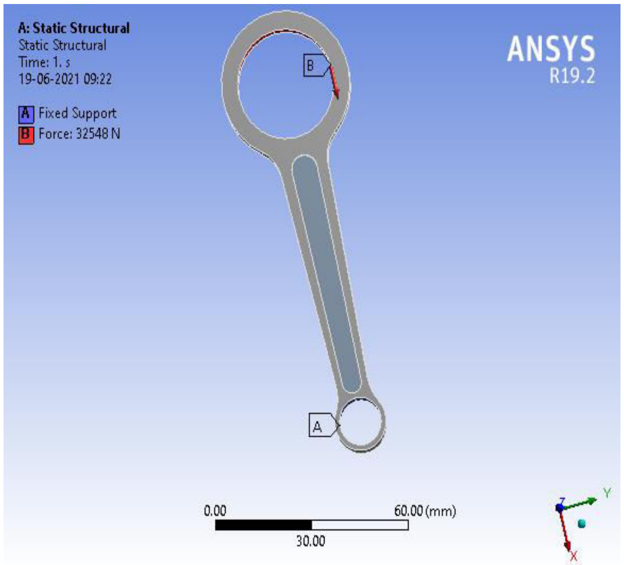

Fig. 5.2 Force and fixed support applied on big end

5.2 Results

a) Structural Steel Connecting Rod Analysis

ANSYS 19.2, evaluate the Value of Total Deformation, Equivalent Stress, maximum shear stress and Equivalent Strain.

- **Analysis of Big End**

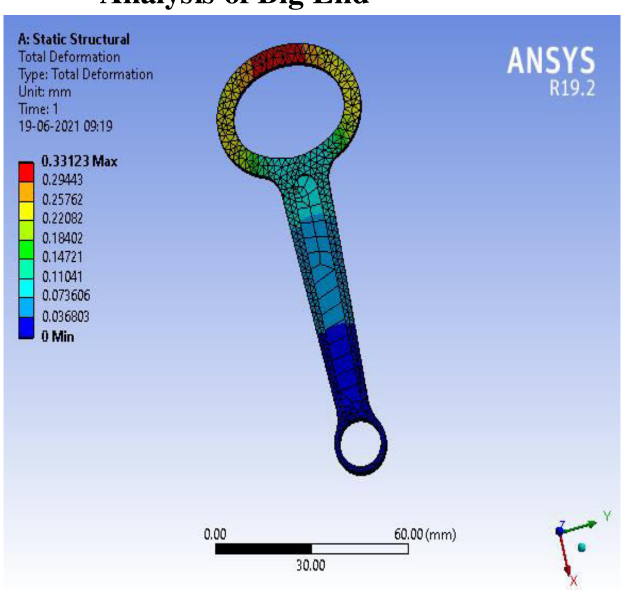

Fig.5.3 Total Deformation

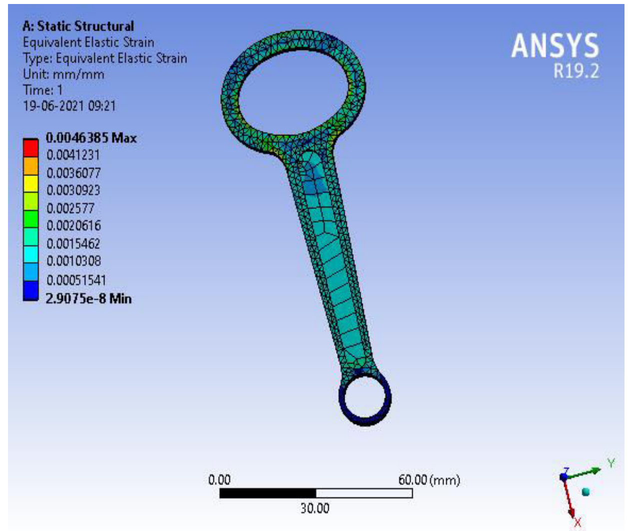

Fig.5.4 Equivalent strain

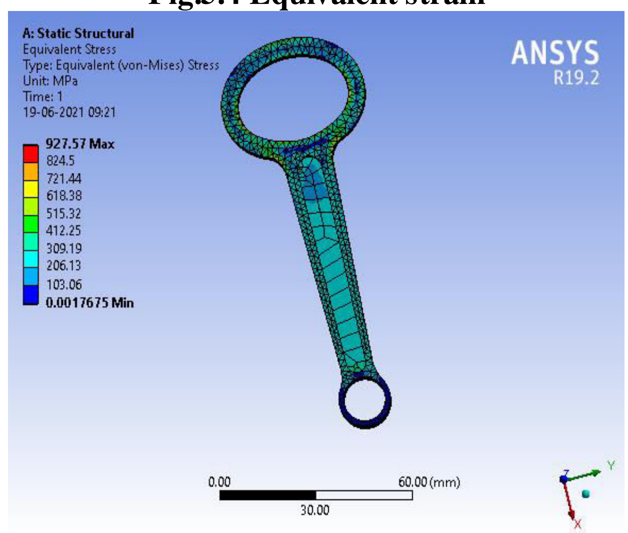

Fig.5.5 Equivalent stress

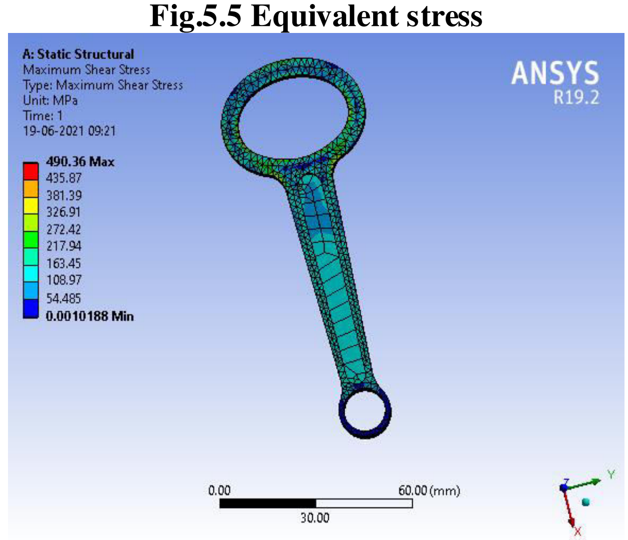

Fig.5.6 Maximum shear stress

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- **Analysis of Small End**

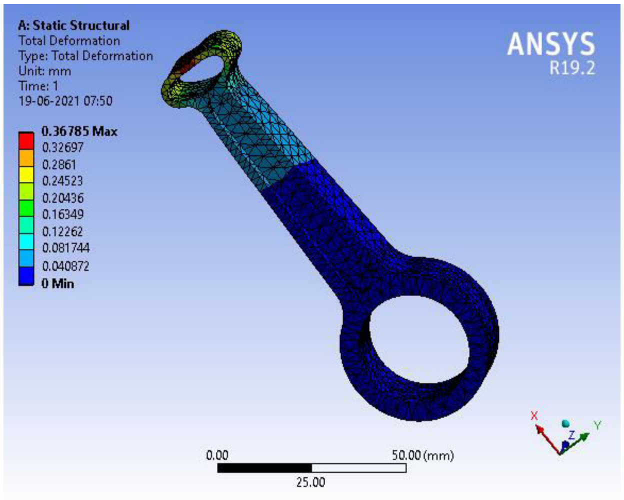

Fig.5.7 Total Deformation

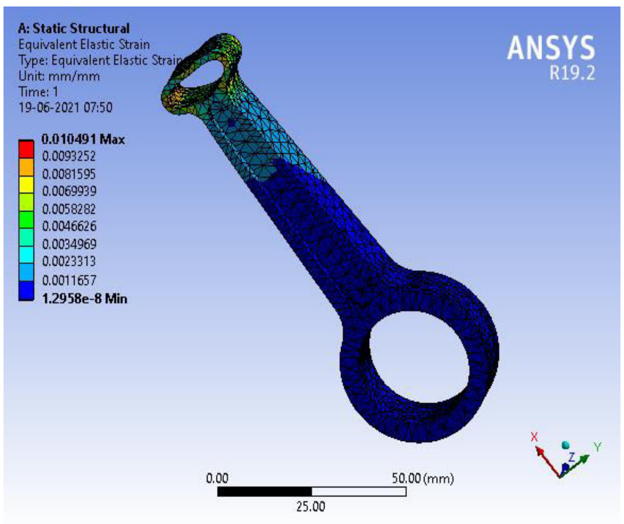

Fig.5.8 Equivalent strain

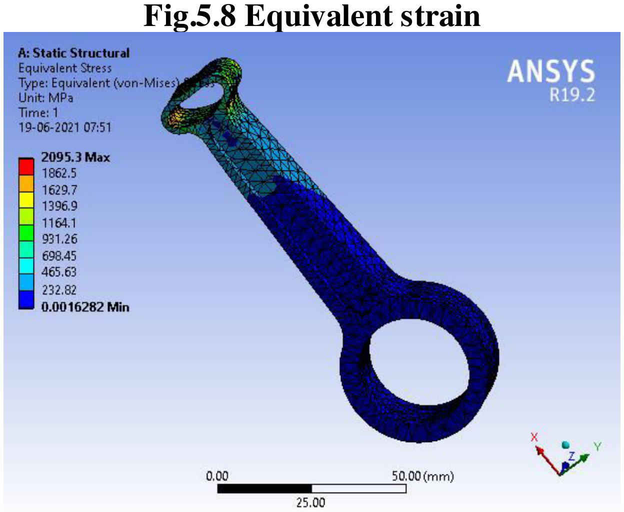

Fig.5.9 Equivalent stress

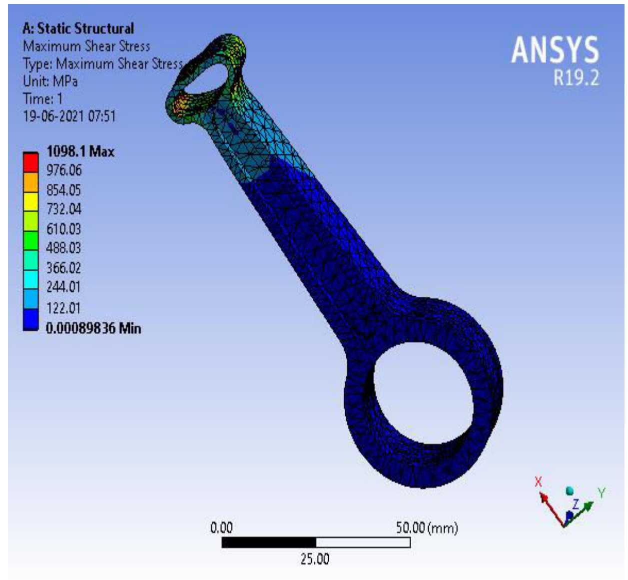

Fig.5.10 Maximum shear stress

b) Aluminum Alloy Connecting Rod Analysis

Determine the value of Total Deformation, Equivalent Stress, Maximum Shear Stress, and Equivalent Strain in ANSYS 19.2.

- **Analysis of Big End**

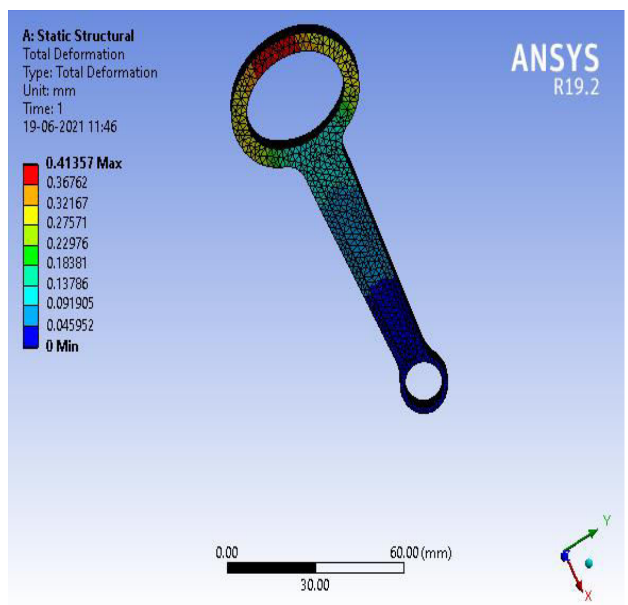

Fig.5.11 Total Deformation

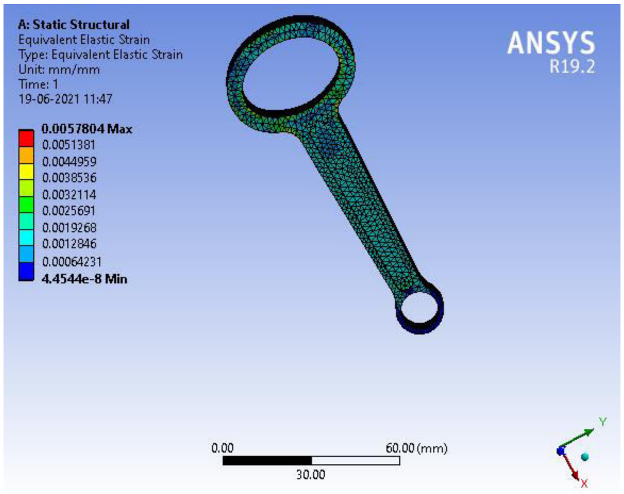

Fig.5.12 Equivalent strain

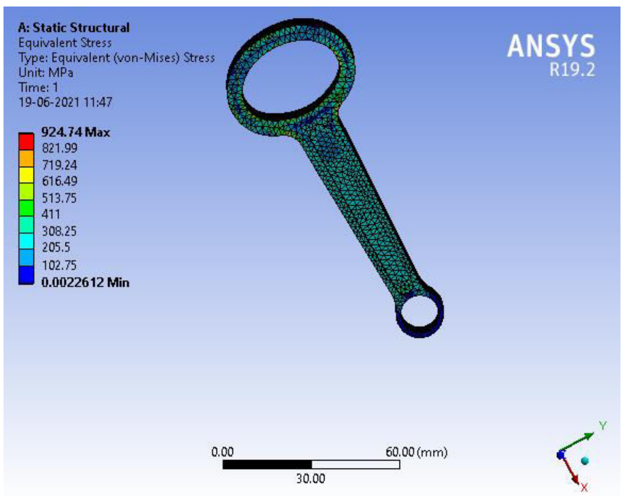

Fig.5.13 Equivalent stress

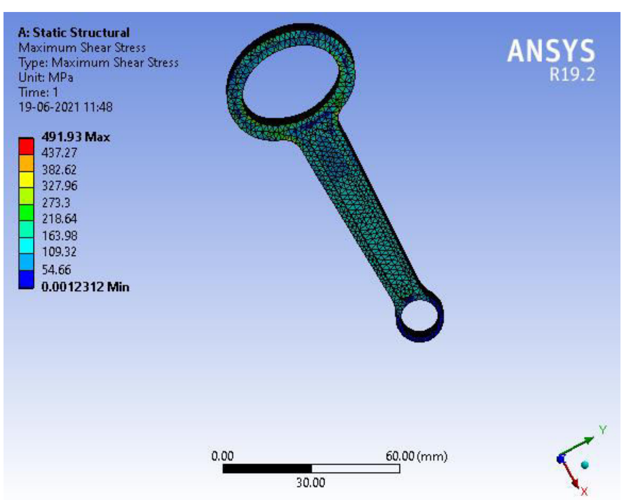

Fig.5.14 Maximum shear stress

- **Analysis of Small End**

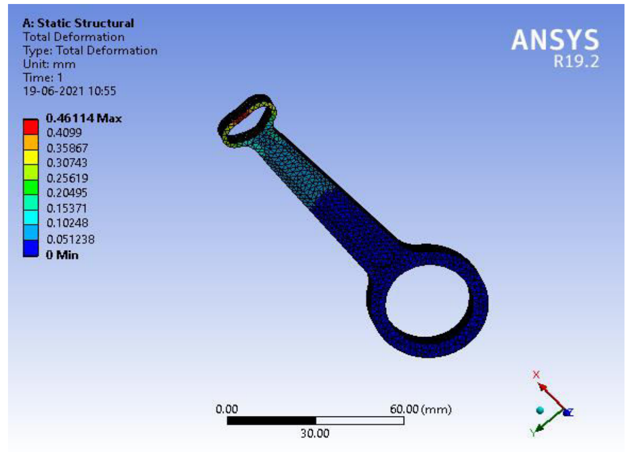

Fig.5.15 Total Deformation

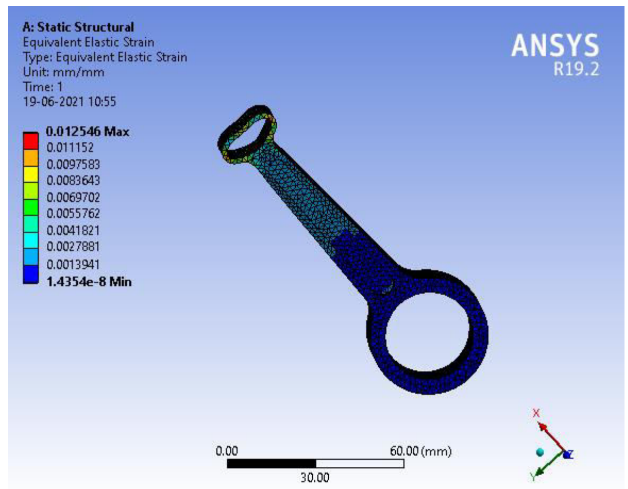

Fig.5.16 Equivalent strain

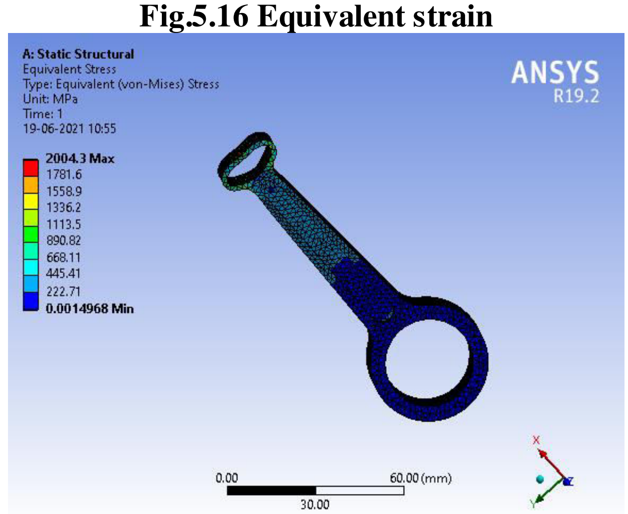

Fig.5.17 Equivalent stress

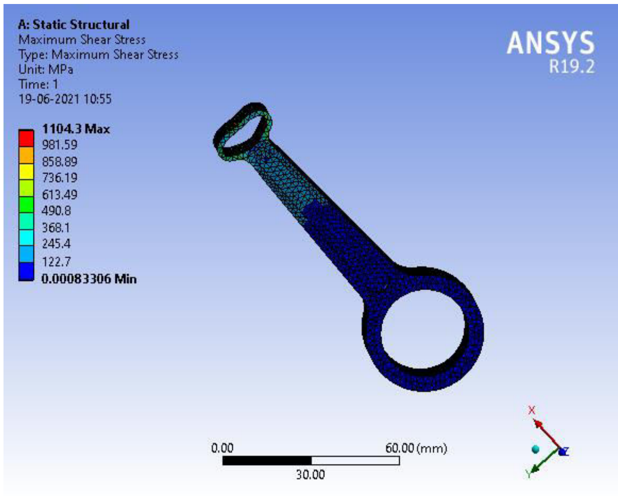

Fig.5.18 Maximum shear stress

5.3 Conclusion

This research examined at the stress, strain, and deformation that connecting rods made of various materials may produce. For Al-Alloy connecting rods, there is a decrease in equivalent stress as compared to structural steel. Structural Steel connecting rod has a shorter lifespan than Al-Alloy connecting rod. By examining various materials, a series of simulations were run to better understand the influence of material selection on connecting rod design.

- **Result of Small End**

Results	Structural Steel		Aluminum Alloy	
Total Deformation	0.36785	0	0.46114	0
Equivalent stress	2095.3	1.62 $\times 10^{-3}$	2004.3	1.49 $\times 10^{-3}$
Equivalent strain	0.010491	1.29 $\times 10^{-8}$	0.012546	1.43 $\times 10^{-8}$
Maximum shear stress	1098.1	8.98 $\times 10^{-4}$	1104.3	8.33 $\times 10^{-4}$
Fatigue Life	10^6		10^8	

- **Result of Big End**

Results	Structural Steel		Aluminum Alloy	
Total Deformation	0.33123	0	0.41357	0
Equivalent stress	927.57	1.76 $\times 10^{-3}$	924.74	2.26 $\times 10^{-3}$
Equivalent strain	0.0046385	2.90 $\times 10^{-8}$	0.0057804	4.45 $\times 10^{-8}$
Maximum shear stress	490.36	1.018 $\times 10^{-3}$	491.93	1.23 $\times 10^{-3}$
Fatigue Life	10^6		10^8	

OBJECTIVES FOR FUTURE WORK

In this area, much has been accomplished and more remains to be accomplished. This dissertation is mainly concerned with static structural issues. We need to identify buckling load and dynamic analysis of connecting rod for future scope and optimization purposes. A lot is being stated these days regarding vibration studies of mechanical components that play a key role in their failure. As a result, the investigation may be expanded to include a vibration examination of the connecting rod.

REFERENCES

Vivek C. Pathade, Bhumeshwar Patle and Ajay N. Ingale, "Stress analysis of I.C. engine connecting rod by FEM," International Journal of Engineering and Innovative Technology, Vol-1, Issue-3, pp. 12-15, March 2012.

K. Sudershn Kumar et al., "Modeling and Analysis of Two Wheeler Connecting Rod", International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.5, Sep-Oct. 2012, pp-3367-3371.

Shahrukh Shamim, "Design and comparative analysis of connecting rod using finite element method," International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 9, September- 2014.

Swatantra Kulkarni, Ashwani Mishra, imanshu Arora, Rajinder Singh, Prabhjot Singh & Ramanpreet Singh, "Global Journal of Researches in Engineering: A Mechanical and Mechanics Engineering, Vol. 14 Issue 3 Version 1.0, 2014.

Dr. N. A. Wankhade, Suchita Ingale, "Review on Design and Analysis of Connecting Rod Using Different Material", International Journal of Engineering Science and Computing (IJESC), Vol. 7 Issue 5, May 2017, Pg. 12237-12242.

Puran Singh, Debashis Pramanik, Ran Vijay Singh, "Fatigue and Structural Analysis of Connecting Rod's Material Due to (C.I) Using FEA", International Journal of Automotive Engineering and Technologies (IJAET), Vol. 4 Issue 4, 2015, Pg. 245– 253.

Nikhil U.Thakare, Nitin D. Bhusale, Rahul P.Shinde,Mahesh M.Patil, "Finite Element Analysis Of Connecting Rod Using Ansys", International Journal of Advances in Science Engineering and Technology, Vol. 3 Issue 2, April 2015.

Dr S B jaju, P G Chakra, "Modeling and Optimization of Connecting rod of Four Stroke Single Cylinder Engine for Optimization of cost and material".