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EXPERIMENTAL INVESTIGATION OF I.C ENGINE CONNECTING ROD OF BAJAJ PULSAR 150CC

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ABSTRACT:

This project mainly deals with the design and analysis of I.C engine connecting rod. Connecting Rod is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders among other similar mechanisms. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod. For this project, there are two basic requirements. The first requirement is to design of a model of I.C engine connecting rod as per the standard mathematical calculations. The second requirement is to analyze of I.C engine connecting rod by the method, such as following a track, which consists of straight lines and curves. These systems are done by modeling software's like CatiaV5, and analysis is done by Ansys software. Specifications of a product are detailed in terms of the product size, speed range, weight and power consumption. Here the Connecting rod is designed; analyzed and has been studied. Connecting Rod temperature has considerable influence on efficiency, emission, performance of the engine. Purpose of the investigation is measurement of connecting rod transient temperature at several points on the connecting rod, from cold start to steady condition and comparison with the results of finite element analysis. Even though the program worked well, there were some errors that were identified after testing, resulting in increased performance. In this project work has been taken up on the different aspects of materials like Forged Steel Materials and others to cover the research gaps to present the results based on the systematic studies through the connecting rod of the engine, FEA analysis of is to measure temperature at the points where it is not possible to find out practically and to observe the heat flow inside the Connecting Rod.

I.INTRODUCTION

Automobile components are in great demand these days because of increased use of automobiles. The increased demand is due to improved performance and reduced cost of these components. R&D and testing engineers should develop critical components in shortest possible time to minimize launch time for new products. This necessitates understanding of new technologies and quick absorption in the development of new products**.** A piston is a component of reciprocating IC-engines. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod.

As an important part in an engine, piston endures the cyclic gas pressure and the inertial forces at work, and this working condition may cause the fatigue damage of piston, such as piston side wear, piston head/crown cracks and so on. The investigations indicate that the greatest stress appears on the upper end of the piston and stress concentration is one of the mainly reason for fatigue failure. On the other hand piston overheating-seizure can only occur when something burns or scrapes away the oil film that exists between the piston and the cylinder wall.

1.1 Connecting rod

In a reciprocating piston engine, the connecting rod connects the piston to the crank or crankshaft. Together with the crank, they form a simple mechanism that converts reciprocating motion into rotating motion. Connecting rods may also convert rotating motion into reciprocating motion. Historically, before the development of engines, they were first used in this way.

As a connecting rod is rigid, it may transmit either a push or a pull and so the rod may rotate the crank through both halves of a revolution, i.e. piston pushing and piston pulling. Earlier mechanisms, such as chains, could only pull. In a few two-stroke engines the connecting rod is only required to push.

Today, connecting rods are best known through their use in internal combustion piston engines, such as automotive engines. These are of a distinctly different design from earlier forms of connecting rods, used in steam engines and steam locomotives.

II - LITERATURE REVIEW

There is a vast amount of literature related to Finite Element Analysis of shape optimization of connecting rod. The literature review presented here considers the major development in implementation of FEA. The main objective of this study was to explore opportunities for an I.C engine connecting rod.

Nagaraju K L (2016) In his thesis, a connecting rod is demonstrated utilizing Catia v5, discretization utilizing Hyper Mesh and analysis utilizing Nastran. The outcome predicts the most extreme buckling load and basic locale on the interfacing pole. It is imperative to find the basic territory of concentrated stress for fitting adjustments. He discovered the stresses created in interfacing pole under static loading with various stacking states of compression and tension at crank end and pin end of connecting rod. The displacement plot shows a very small value which does not affect the performance of the connecting rod. The linear static analysis of the connecting rod shows that the stress generated in the model is within the acceptable limits or maximum allowable stress. The buckling mode analysis gives the buckling factor greater than 1 and hence it can be concluded that the connecting rod can withstand the load applied.

Akbar H Khan. (2017) studied existing connecting rod is manufactured by using steel 16MnCr5. His paper describes Design, modeling and analysis of connecting rod. In his work connecting rod is replaced by steel alloy SAE 8620 and Aluminum alloy 360 for Discover 100cc motorbike. A 2D drawing is drafted from the calculations. A parametric model of connecting rod is modeled using Creo 2.0 software. Analysis is carried out by using Ansys 15.0 software. By comparing the von mises stresses in the materials of connecting rod he concluded that stresses occurs in the aluminum alloy 360 connecting rod are very less as compared to the steel 16mnCr5 and steel alloy SAE 8620. Instead of using the material Steel 16mnCr5 we can use the either aluminum alloy 360 or steel alloy SAE 8620 to reduce the weight and cost of the material and for better stiffness.

Mohammed Mohsin Ali Ha (2015) modeled Connecting rod using CATIA software and FE analysis is carried out using ANSYS Software. Load distribution plays important role in fatigue life of the structure. Bush failure changes the loading direction and distribution. His study is concentrated around the fatigue life due to concentrated load and cosine type load distribution on the bigger end. 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. Axis-symmetric analysis is carried out to find interference effect on the stress behavior in the joint. 8 noded plane82 elements with quadratic displacement variation are used for accurate results. The contact pair is created with Target69 and Contact72 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 Vonmises stresses. Also a three dimensional views are obtained through Ansys ax symmetric options.

Akbar H Khan (2017) research work investigated Static structural and experimental stress analysis of two wheeler connecting rod using by theoretically, Finite element analysis and using Photo elasticity method. Connecting rod of two wheeler 100 cc petrol engine is taken for the analysis; Finite element analysis includes the Design and modeling of connecting rod using Creo 2.0 and Ansys 15.0 for the Static Structural analysis. Photo elasticity analysis method includes the casting of Photo elastic sheet using Araldite AY 103 and Hardener HY 991 and then connecting rod model is prepared by laser cutting machine. In his research paper static structural analysis is carried out to find the von mises stresses and Stress analysis is carried out to find maximum principle stress and reason behind the failure of connecting rod. Conclusion drawn from his study, It is been observed that the maximum stresses are induces at the fillet section of both ends of the connecting rod and chances of the failure of the connecting rod is found at the fillet sections of both ends of connecting rod. Therefore, to avoid that stresses and failure material need to be added at the fillet sections of connecting rod. By observing the different fringes developed in the connecting rod specimen and by calculating the maximum principle stress at that section we can say that the stresses induced in the small end of the connecting rod are greater than the stresses induced at the big end. Form the Photo elasticity analysis it is found that the stress concentration effect exist at both small end and big end and it is negligible in the middle portion of the connecting rod. Therefore, the chances of failure of the connecting rod may be at fillet section of both ends.

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III - PRINCIPLE OF I.C ENGINE CONNECTING ROD

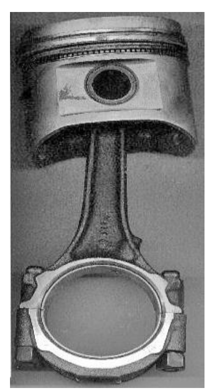
An Internal Combustion Engine (ICE) is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion that is an integral part of the working fluid flow circuit. In an internal combustion engine the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, rotor or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy.

The first commercially successful internal combustion engine was created by Étienne Lenoir around 1859 and the first modern internal combustion engine was created in 1876 by Nicolaus Otto (see Otto engine).

The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described. Firearms are also a form of internal combustion engine.

Internal combustion engines are quite different from external combustion engines, such as steam or Sterling engines, in which the energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids can be air, hot water, pressurized or even liquid sodium, heated in a boiler. ICEs are usually powered by energy-dense fuels such as gasoline or diesel, liquids derived from fossil fuels. While there are many stationary applications, most ICEs are used in mobile applications and are the dominant power supply for vehicles such as cars, aircraft, and boats.

Typically an ICE is fed with fossil fuels like natural gas or petroleum products such as gasoline, diesel fuel or fuel oil. There's a growing usage of renewable fuels like biodiesel for compression ignition engines and bio ethanol or methanol for spark ignition engines. Hydrogenise sometimes used, and can be made from either fossil fuels or renewable energy.



Connecting rod

In modern automotive internal combustion engines, the connecting rods are most usually made of steel for production engines, but can be made of T6-2024 and T651-7075 aluminum alloys (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for a combination of lightness with strength, at higher cost) for high-performance engines, or of cast iron for applications such as motor

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scooters. They are not rigidly fixed at either end, so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft. Connecting rods, especially in racing engines, may be called "billet" rods, if they are machined out of a solid billet of metal, rather than being cast or forged.

1. Small end and big end
2. Engine wear and rod length
3. Stress and failure
4. High-performance engines
5. Powder metallurgy
6. Compound rods

IV - MATERIAL PROPERTIES OF CONNECTING ROD FOR PULSAR 150CC

4.1 DIMENSIONS OF CONNECTING ROD

S.No	Parameters	Values
01	Outer diameter of Big end	60.93 mm
02	Inner diameter of big end	46.16 mm
03	Outer diameter of small end	45.29 mm
04	Inner diameter of small end	37.64 mm
05	Length of Connecting Rod	112.8 mm

4.2 MATERIALS PROPERTIES USED FOR CONNECTING ROD IN PULSAR 150CC

1- Magnesium Alloy

Composition

Aluminum	8.3-9.7
Copper	0.03
Magnesium	Bal.
Iron	0.005
Nickel	0.002
Zinc	0.35 - 1.0
Manganese	0.15 - 0.5
Silicon	0.1
Other-Metallic	0.02

2- Beryllium 25 Alloy

Composition

Weight %	Min.	Max.
Be	1.80	2.00
Co + Ni	0.20	0.50
Fe	—	0.10
Cu	—	Balance

3- Forged Steel

Composition

Carbon	0.612 - 0.68%
Sulpher	0.02 - 0.04%
Manganese	0.50 - 1.20%
Phosphorus	0.04%
Chromium	0.90 - 1.20%

V - DESIGN METHODLOGY OF I.C ENGINE CONNECTING ROD

5.1 Introduction to CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Cero Elements/Pro and NX (Unigraphics).

The 3D CAD system CATIA V5 was introduced in 1999 by Dassault Systems. Replacing CATIA V4, it represented a completely new design tool showing fundamental differences to its predecessor. The user interface, now featuring MS Windows layout, allows for the easy integration of common software packages such as MS Office, several graphic programs or SAPR3 products (depending on the IT environment).

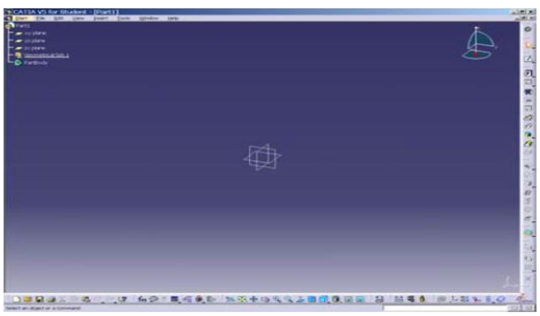

Fig: 5.1: Home Page of CatiaV5

Modeling of I.C engine connecting rod in CATIA V5

This I.C engine connecting rod is designed using CATIA V5 software. This software used in automobile, aerospace, consumer goods, heavy engineering etc. it is very powerful software for designing complicated 3d models, applications of CATIA Version 5 like part design, assembly design.

The same CATIA V5 R20 3d model and 2d drawing model is shown below for reference. Dimensions are taken from. The design of 3d model is done in CATIA V5 software, and then to do test we are using below mentioned software's.

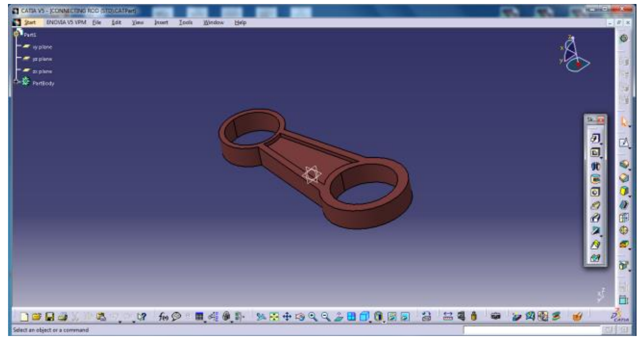

Fig: 5.2: Model design of I.C engine connecting rod in CATIA-V5

VI - ANALYSIS OF I.C ENGINE CONNECTING ROD

6.1 Procedure for FE Analysis Using ANSYS:

The analysis is done using ANSYS. For compete assembly is required, and attached system is to carried out by applying moments at the rotation location along which axis we need to mention. Fixing location is bottom legs of assembly of the craft.

6.2 Preprocessor

In this stage the following steps were executed:

- **Import file in ANSYS window**

  File Menu > Import> STEP > Click ok for the popped up dialog box > Click

  Browse" and choose the file saved from CATIAV5R20 > Click ok to import the file

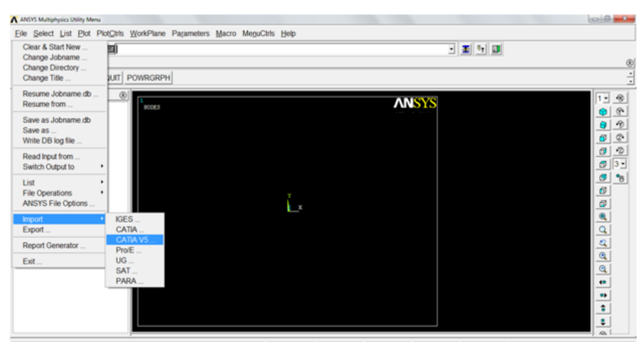

Fig.6.1: Import panel in Ansys.

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Meshing:

Mesh generation is the practice of generating a polygonal or polyhedral mesh that approximates a geometric domain. The term "grid generation" is often used interchangeably. Typical uses are for rendering to a computer screen as finite element analysis or computational fluid dynamics. The input model form can vary greatly but common sources are CAD, NURBS, B-rep and STL (file format). The field is highly interdisciplinary, with contributions found in mathematics, computer science, and engineering.

Meshing is an integral part of the computer-aided engineering (CAE) simulation process. The mesh influences the accuracy, convergence and speed of the solution. Furthermore, the time it takes to create a mesh model is often a significant portion of the time it takes to get results from a CAE solution. Therefore, the better and more automated the meshing tools, the better the solution. From easy, automatic meshing to a highly crafted mesh, ANSYS provides the ultimate solution.

Powerful automation capabilities ease the initial meshing of a new geometry by keying off physics preferences and using smart defaults so that a mesh can be obtained upon first try. Additionally, users are able to update immediately to a parameter change, making the handoff from CAD to CAE seamless and aiding in up-front design. Once the best design is found, meshing technologies from, ANSYS provide the flexibility to produce meshes that range in complexity from pure hex meshes to highly detailed Hybrid meshes.

VII - DISCUSSION ON ANALYSYS RESULT

7.1 Results of Displacement Results:

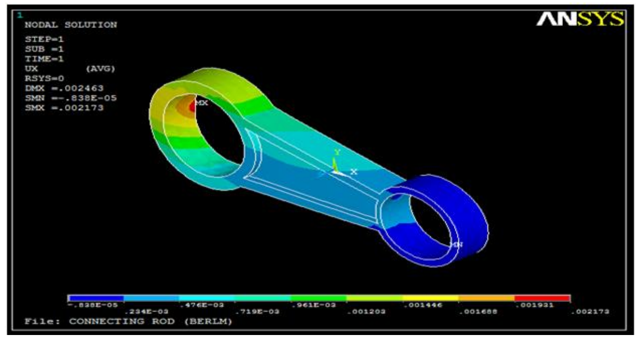

Fig: 7.1: Displacement of Connecting Rod (Beryllium 25 Alloy)

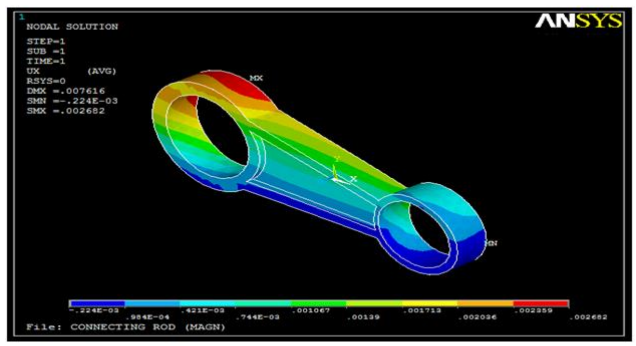

Fig: 7.2: Displacement of Connecting Rod (Magnesium Alloy)

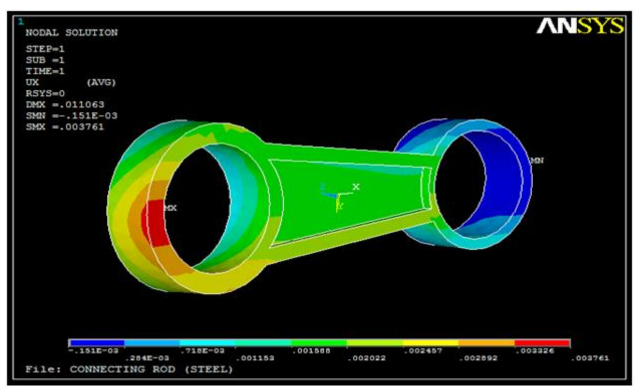

Fig: 7.3: Displacement of Connecting Rod (Forged Steel)

7.2 Results of Stress Results:

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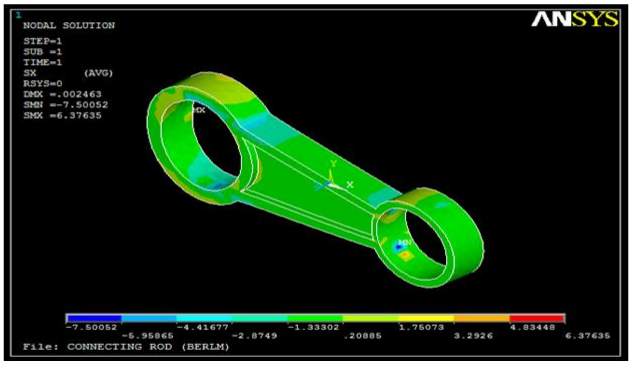

Fig: 7.4: Stress Analysis of Connecting Rod (Beryllium 25 Alloy)

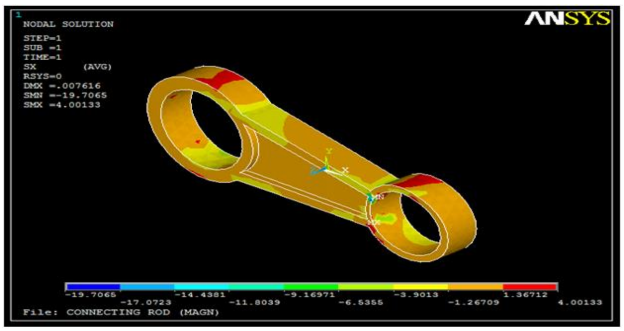

Fig: 7.5: Stress Analysis of Connecting Rod (Magnesium Alloy)

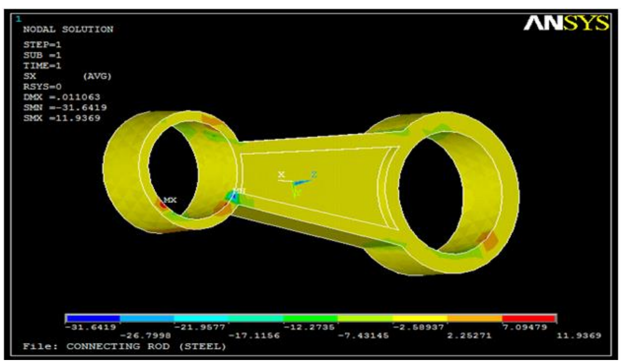

Fig: 7.6: Stress Analysis of Connecting Rod (Forged Steel)

7.3 Results of Strain Results:

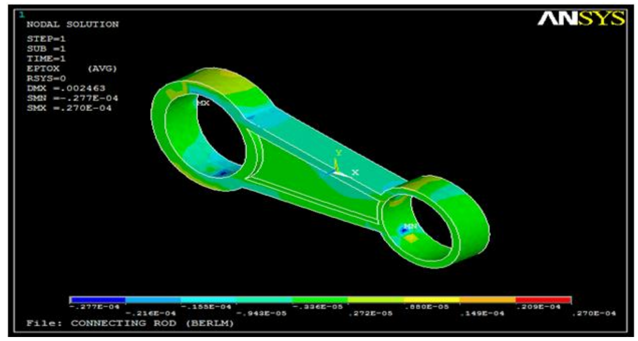

Fig: 7.7: Strain Analysis of Connecting Rod (Beryllium 25 Alloy)

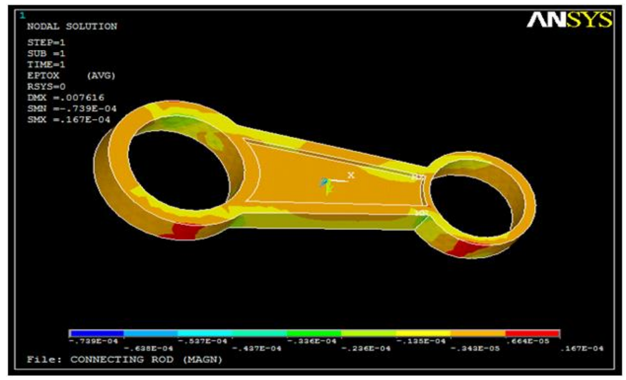

Fig: 7.8: Strain Analysis of Connecting Rod (Magnesium Alloy)

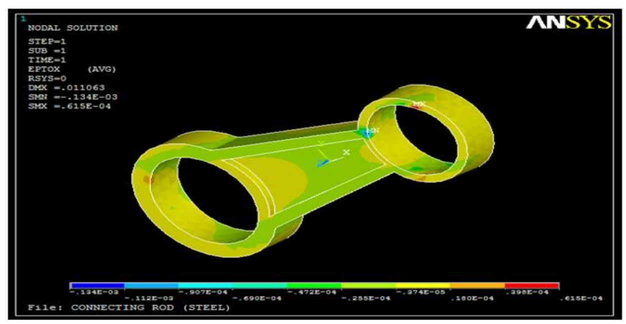

Fig: 7.9: Strain Analysis of Connecting Rod (Forged Steel)

VIII - CONCLUSION

A highly nonlinear model for the dynamic behavior is considered. A parametric study to investigate the influence of the control parameters on the dynamic response is conducted. The control parameters that influence the transient response are found to be dimensioning equation is developed to predict the settling time of the response. Based on the developed equation, the Optimum values of the control parameters are obtained. As shown above figures the displacement of the design is meshed and solved using Ansys and displacement are given below. This is showing us that clearly each component in assembly.

S. No	Displacement	Value
01	Connecting Rod (Beryllium 25 Alloy)	0.0021 mm
02	Connecting Rod (Magnesium Alloy)	0.0026 mm
03	Connecting Rod (Forged Steel)	0.0037 mm

The maximum stress is coming, this solution solving with the help of Ansys software so that the maximum Stress are given below.

S. No	Max Stress	Value
01	Connecting Rod (Beryllium 25 Alloy)	6.376 MPa
02	Connecting Rod (Magnesium Alloy)	4.001 MPa
03	Connecting Rod (Forged Steel)	11.936 MPa

The maximum Strain is coming, this solution solving with the help of Ansys software so that the maximum Strain are given below. So we can conclude our design parameters are approximately correct.

S. No	Max Strain	Value
01	Connecting Rod (Beryllium 25 Alloy)	0.270E-04 MPa
02	Connecting Rod (Magnesium Alloy)	0.167E-04 MPa
03	Connecting Rod (Forged Steel)	0.615E-04 MPa

Magnesium Alloy is used in high performance engines. It is light and strong, but comes at a higher cost. And now a day's, all the IC engine Connecting Rods are being made up of Steel. Therefore, according to the above analysis, Beryllium alloy have obtained less deflection among the above materials be used for these as an alternative. It has exceptional stiffness and has brittle at room temperature and a reasonably high melting point. The modulus of elasticity of beryllium is approximately 50% greater than that of steel. The design of the Connecting Rod mechanism worked flawlessly in analysis as well, all these facts point to the completion of our objective in high esteem.

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