Static and Model Analysis of Connecting Rod For 6011a And 7075 Aluminum Material

S Sridhar[1], Basawaraj S Hasu[2]
[1, 2] Dept of Mechanical Engineering
[1, 2] AVN Institute of Engineering & Technology, Hyderabad, India

Abstract- *The connecting rod is connecting member between the piston and the Crankshaft. The main function of the connecting rod is transmitting the to and fro motion from the piston pin to the crank pin, thereby converting the reciprocating motion of the piston into rotary motion of the crank. This paper is aimed at designing and Analysis of connecting rod. Currently existing connecting rod is manufactured by using Forged steel. In this paper the structural static analysis is performed on the connecting rod by applying the operating pressure as per calculations done. The 3D model of the connecting rod was modeled using CATIA software. The model is then converted into parasolid format and imported into Ansys classic to do the analysis. The analysis was performed for 3 different materials (Forged steel, 6110A (AlMg0.9Si0.9MnCu) Aluminum and 7075-T6 Aluminum). From the analysis deflections and stresses were plotted and compared. From the analysis results the factor of safety, Weight and Stiffness calculations were also carried out and compared. Later the analysis is also extended to modal analysis to find the natural frequencies of the connecting rod for 3 different materials (Forged steel, 6110A (AlMg0.9Si0.9MnCu) Aluminum and 7075-T6 Aluminum).*

Keywords- Factor of safety, Structural strength, Material.

I. INTRODUCTION

Connecting rod is the middle connection between the cylinder and the crank. What's more, is capable to transmit the push and pull from the piston pin to crank pin, accordingly changing over the responding movement of the cylinder to revolving movement of the crank. Interfacing pole, automotive ought to be lighter and lighter, ought to devour less fuel and in the meantime they ought to give solace and well being to travelers, that sadly prompts increment in weight of the vehicle. This inclination in vehicle development drove the creation and execution of very new materials which are light and meet plan prerequisites. Lighter associating bars help to diminish lead caused by powers of dormancy in motor as it doesn't require huge adjusting weight on crankshaft. Use of metal lattice composite empowers security increment and advances that prompts viable utilization of fuel and to acquire high motor power. It interconnects the cylinder and the wrench shaft and transmits the gas powers from the cylinder to the crankshaft. It’s essential capacity is to transmit the push and draw from the cylinder stick to the wrench stick and therefore change over the responding movement of the cylinder into rotary motion of the crank the usual form of the connecting rod in internal combustion engines. The upper end of the connecting rod is associated with the piston by the piston pin. In the event that the piston is secured in the piston pins supervisors or on the off chance that it drifts in the cylinder and the interfacing pole, the upper gap of the Connecting pole will have a strong bearing (bushing) of bronze or a comparative material.

II. METHODOLOGY

The aim of this paper is to redesign the existing connecting rod to minimize the overall weight of the component and to save considerable amount of material. Connecting rod is subjected to different analysis using different materials and to manufacture the rod with best material which is lesser in weight and provide more strength.

To Study of the connecting rod and its design

- To do part modeling of connecting rod by using UNIGRAPHICS 7.5.
- To generate FEA model using ANSYS APDL
- To carry out static analysis of connecting rod.
- Next, modal is carried out on connecting rod to now the natural frequencies occurring for different materials which are used for connecting rod.
- Comparing the results of both designs.

III. 3D MODELING OF CONECTING ROD

The 3D model of the connecting rod was developed using CATIA software. CATIA stands for Computer Aided Three-dimensional Interactive Application.
The French Dassault Systems is the parent company and IBM participates in the software’s and marketing, and CATIA is invades broad industrial sectors, and has been explained in the

previous post position of CATIA between 3d modeling software programs.
CATIA classified under the following software packages:
CAD (Computer Aided Design)
CAM (Computer Aided Manufacturing)
CAE (Computer Aided Engineering)

For the fifth version, there are versions from 1 to 20, for example, CATIA V5 R17, it Means CATIA fifth edition version seventeenth, While years system was adoption in the sixth edition, for example, CATIA V6 2011 means CATIA sixth edition version of Year 2011. CATIA consists of modules each Module specialized in specific design field, and will review now the most famous of these modules:

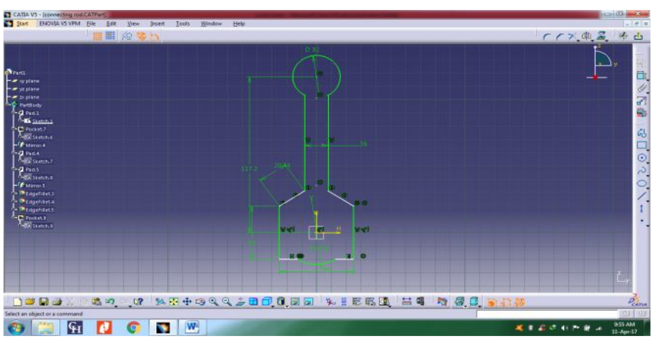


Figure.1. shows the 2D view of connecting rod.

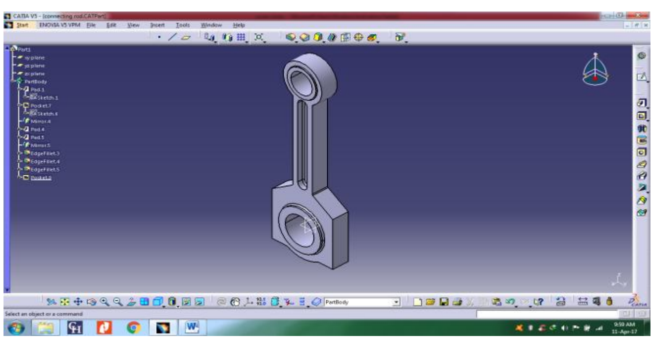


Figure.2. shows the isometric view of connecting rod

.

FINITE ELEMENT ANALYSIS OF CONNECTING ROD

The objective of this analysis is to perform structural static analysis of the connecting rod by applying the operating pressure as per calculations done in the previous chapter. The 3D model of the connecting rod was modeled using CATIA software. The model is then converted into parasolid format and imported into Ansys classic to do the analysis. The analysis was performed for 3 different materials (Forged steel, 6110A (AlMg0.9Si0.9MnCu) Aluminum and 7075-T6 Aluminum). From the analysis deflections and stresses were plotted and compared. From the analysis results the factor of safety, Weight and Stiffness calculations were carried out and compared.

STRUCTURAL ANALYSIS OF CONNECTING ROD

Finite Element Modeling (FEM) and Finite Element Analysis (FEA) are two most well known mechanical designing programming applications offered by the current CAE frameworks. The fact that knows is that the FEM is the most popular numerical technique for solving engineering problems. The method is general enough to handle any complex shape of geometry (problem domain), any material properties, any boundary conditions and any loading conditions. The generality of the FEM fits the analysis requirements of today's complex engineering systems and designs where closed form solutions are governing equilibrium equations are not available. In addition it is an efficient design tool by which designers can perform parametric design studying various cases (different shapes, material loads etc.) analyzing them and choosing the optimum design.

FINITE ELEMENT MODELING (Meshing)

3D model of the connecting was developed in CATIA. The model was then converted into a parasolid to import into ANSYS. A Finite Element model was developed with solid 187 elements to idealize all components of the connecting rod. The elements that are used for idealizing the connecting rod are described below. Structural static analysis was carried out to find the deflections and stresses. The geometric model of the connecting rod used for analysis is shown in the below Figures.

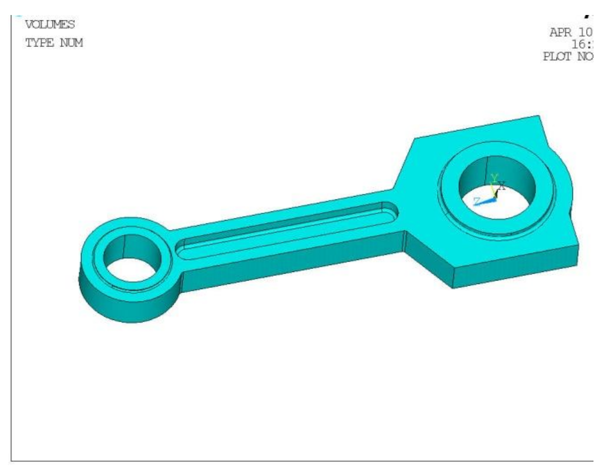


Figure.3.shows the 3D model of connecting rod used for analysis.

The connecting structure is meshed with solid elements and a total of 55285 elements and 61284 nodes are created.

The finite element model of the connecting rod is shown below

Figure.4. shows the Mesh model of connecting rod used for analysis.

MATERIAL PROPERTIES

The analysis was performed for 3 different materials (Forged steel, 6110A (AlMg0.9Si0.9MnCu) Aluminum and 7075-T6 Aluminum)Aluminum alloy 2014-T6

The Mechanical Properties of forged steel are given below:

Density	=	7.7 g/cm^3 (170 lb/ft^3)
Elastic Modulus (Young's)	=	221 GPa (10 x 10^6 psi)
Poisson's Ratio	=	0.33
Average hardness	=	101 HRB
Tensile Strength	=	Ultimate(UTS)625 MPa
Tensile Strength	=	Yield (Proof) 625 MPa

BOUNDARY CONDITIONS

The following boundary conditions and loading is applied for static analysis of connecting rod

1. Small end of the connecting rod is constrained in all dof as shown in the Figure.
2. Pressure of 15.5 Mpa applied on the big end as shown in the Figure.

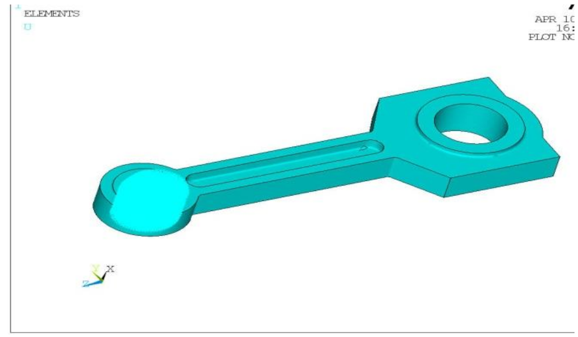


Figure.8. shows small end of connecting rod fixed in all Dof.

RESULTS

Results of static analysis of connecting rod for forged steel material:

Deflections: From the static analysis deflections are plotted and total deflection of 0.0027 mm is observed on the connecting rod with forged steel material as shown in the below Figures

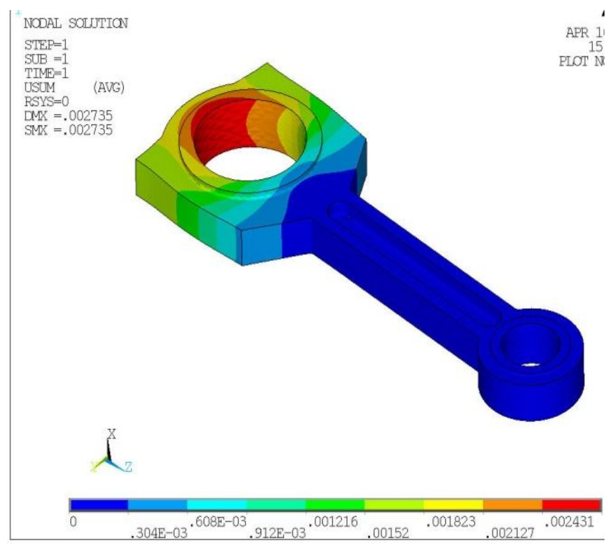


Figure.5. shows the Total deflection of connecting rod for forged steel material.

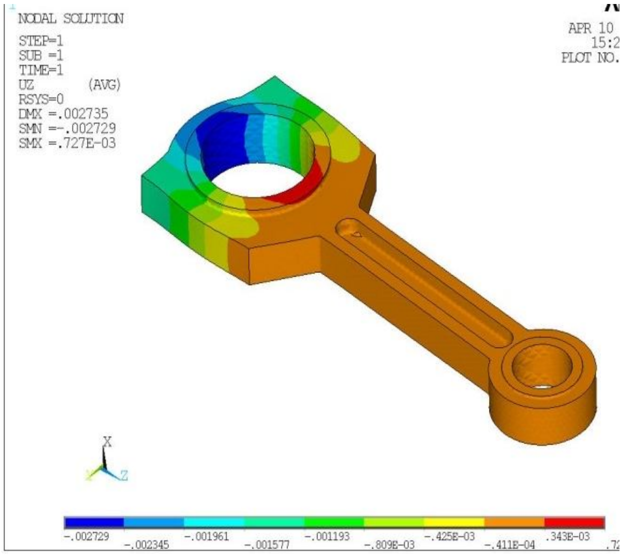


Figure.6. shows the Deflection in Z-Direction of connecting rod for forged steel material.

From the static analysis stresses are plotted and maximum Von-Mises stress of 41.56 Mpa is observed on the connecting rod for forged steel material as shown in the below Figures:

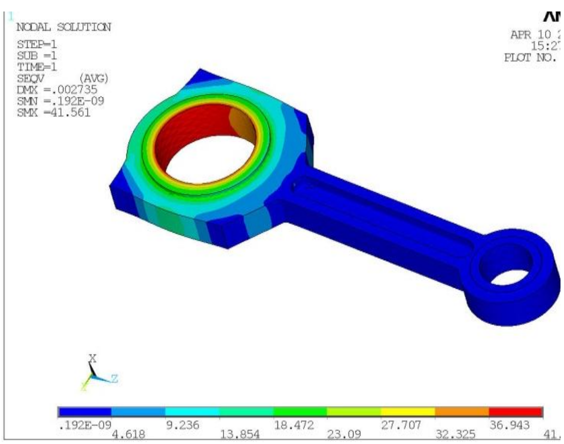


Figure.7. shows the Von-Mises stress on connecting rod for forged steel material**.**

ANALYSIS RESULTS FOR 6110A (AlMg0.9Si0.9MnCu) ALUMINUM MATERIAL

6110A aluminum is an alloy of aluminum, further classified within the AA 6000 series (aluminum-magnesium-silicon wrought alloy). 6110A is the Aluminum Association (AA) designation for this material. In European standards, it will typically be given as EN AW-6110A. Additionally, the EN chemical designation is AlMg0, 9Si0, 9MnCu.It has three common variants, each represented as a separate material. The Material Properties section below shows ranges encompassing all variants.

The analysis is carried on the connecting rod with **6110A (AlMg0.9Si0.9MnCu) Aluminum** material. The material properties and the alloy composition is shown below.

MATERIAL PROPERTIES OF 6110A (ALMG0.9SI0.9MNCU) ALUMINUM

Density	=	2.8 g/cm^3 (170 lb/ft^3)
Elastic Modulus (Young's)	=	72 GPA (10 x 10^6 psi)
Poisson's Ratio	=	0.33
Specific Heat Capacity	=	890 J/kg-K
Strength to Weight Ratio	=	130 to 170 kN-m/kg
Tensile Strength	=	Ultimate (UTS) 370 to 470 MPa (54 to 68 x 10^3 psi)
Tensile Strength	=	Yield (Proof) 250 to 440 MPa (36 to 64 x 10^3 psi)
Thermal Expansion	=	22 µm/m-K

ALLOY COMPOSITION OF 6110A (ALMG0.9SI0.9MNCU) ALUMINUM

Aluminum (Al)	=	94.8 to 98 %
Magnesium (Mg)	=	0.7 to 1.1 %
Silicon (Si)	=	0.7 to 1.1 %
Manganese (Mn)	=	0.3 to 0.9 %
Copper (Cu)	=	0.3 to 0.8 %
Iron (Fe)	=	0 to 0.5 %
Chromium (Cr)	=	0.050 to 0.25 %
Titanium (Ti)	=	0 to 0.2 %
Zinc (Zn)	=	0 to 0.2 %
Zirconium (Zr)	=	0 to 0.2 %
Residuals	=	0 to 0.15

RESULTS OF STATIC ANALYSIS OF CONNECTING ROD FOR 6110A (ALMG0.9SI0.9MNCU) ALUMINUM MATERIAL

Deflections: From the static analysis deflections are plotted and total deflection of 0.0084 mm is observed on the connecting rod with 6110A (AlMg0.9Si0.9MnCu) Aluminum material as shown in the below Figures.

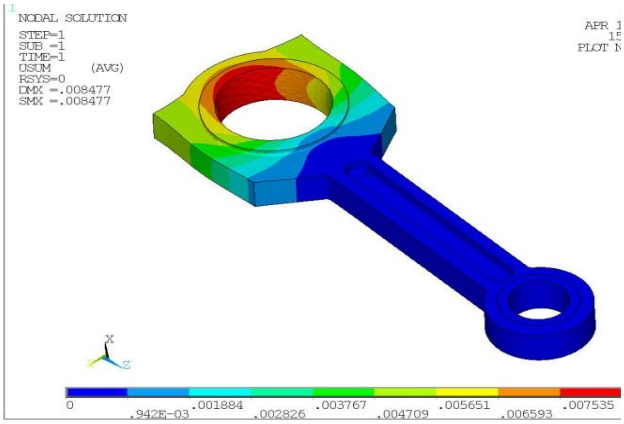


Figure.8. shows the Total deflection of connecting rod for 6110A Aluminum material.

From the static analysis stresses are plotted and maximum VonMises stress of 41.589 Mpa is observed on the connecting rod for forged steel material as shown in the below Figures.

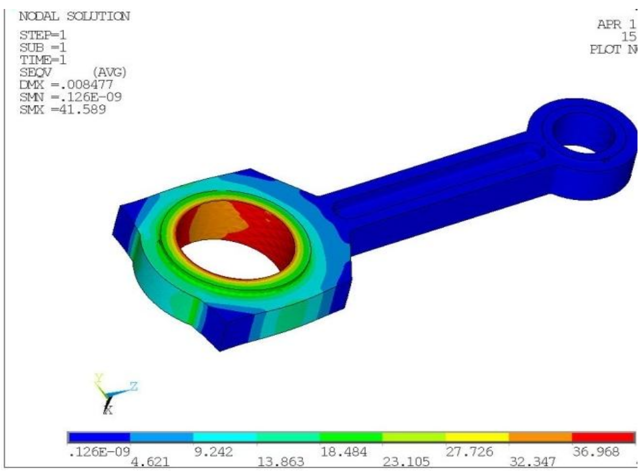


Figure.9. shows the Von-Mises stress on connecting rod for 6110A Aluminum material.

ANALYSIS RESULTS FOR 7075-T6 ALUMINUM MATERIAL

7075-T6 aluminum is a type of 7075 aluminum. It is furnished in the T6 temper. The analysis is carried on the connecting rod with **7075-T6 Aluminum** material. The material properties and the alloy composition is shown below.

RESULTS OF STATIC ANALYSIS OF CONNECTING ROD 7075-T6 ALUMINUM MATERIAL

Deflections: From the static analysis deflections are plotted and total deflection of 0.00845 mm is observed on the connecting rod with 7075-T6 Aluminum material as shown in the below Figures.

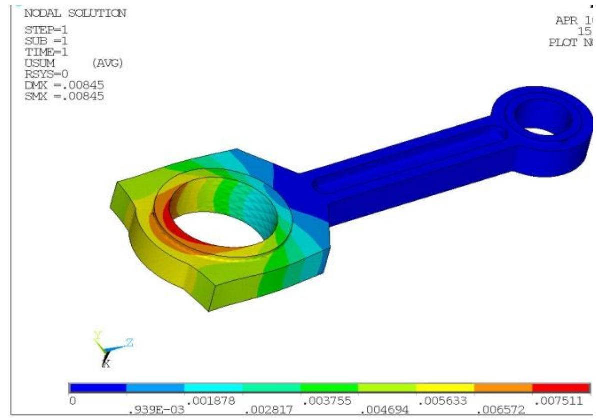


Figure.10. shows the Total deflection of connecting rod for 7075-T6 Aluminum material.

From the static analysis stresses are plotted and maximum VonMises stress of 41.58 Mpa is observed on the connecting rod for 7075-T6 Aluminum material as shown in the below Figures:

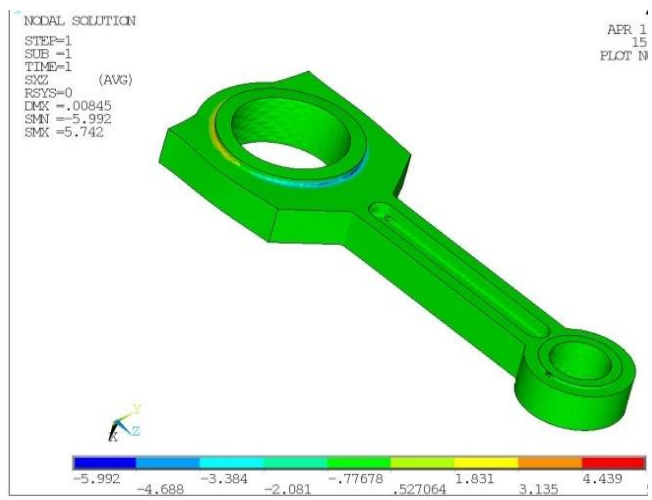


Figure.11. shows the Shear stress in XY,YZ and XZ-Dir on connecting rod for 7075-T6 Aluminum material.

CALCULATIONS FOR FACTOR OF SAFETY AND STIFFNESS FOR FORGED STEEL

Calculation for factor of safety of connecting rod:

f.s = factor of safety
σ_m = mean stress
σ_y = yield stress
σ_v = variable stress
σ_e = endurance stress
$(1/f.s) = (\sigma_m/\sigma_y) + (\sigma_v/\sigma_e)$
$\sigma_{max} = 41.561$ $\sigma_{min} = 0.126\times10\text{-}9$
$\sigma_m = (\sigma_{max} + \sigma_{min})/2 = 20.7805$
σ_y = 625Mpa
$\sigma_v = (\sigma_{max} - \sigma_{min})/2 = 20.7805$

$\sigma_e = 0.6 \times 625 = 375$
$(1/f.s) = 0.08862$
Factor of safety [F.S] = 11.28
Calculation for Weight and Stiffness:
Density of forged steel = 7.85×10−6 kg/mm3
Volume = 44549.3 mm3
Deformation = 0.0027 mm
Weight of forged steel = volume ×density
= 44549.3×7.85×10-6
= 0.35kg
= 0.31×9.81 = **3.43 N**
Stiffness = weight /deformation
= 3.43/0.0027
=1429.16 N/mm

RESONANCE

In physics, resonance is the tendency of a system to oscillate with greater amplitude at some frequencies than at others. Frequencies at which the response amplitude is a relative maximum are known as the system's resonant frequencies, or resonance frequencies.

MODAL ANALYSIS

Modal analysis was carried out on connecting rod with 3 different materials (Forged steel, 6110A (AlMg0.9Si0.9MnCu) Aluminum and 7075-T6 Aluminum) to determine the first 10 natural frequencies and fundamental mode shape of the structure.

This would enable us to understand the dynamic behavior of the structure. The more is the fundamental natural frequency the more will be the stiffness of the structure. The boundary conditions used for modal analysis is as below.

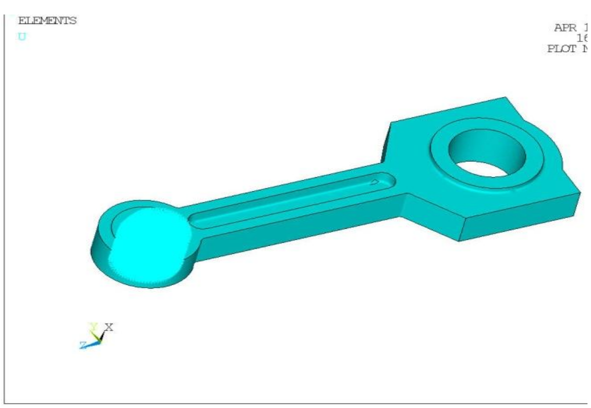


Figure.12. shows the Model Analysis of connecting rod for forged steel.

RESULTS OF MODAL ANALYSIS OF CONNECTING ROD FOR FORGED STEEL

The first 10 natural frequencies of connecting rod for forged steel and the corresponding mode numbers are tabulated in the below table and mode shape of the fundamental natural frequency is plotted in the below Figure.

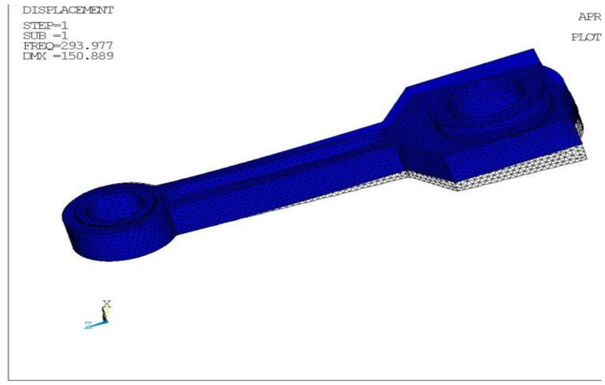
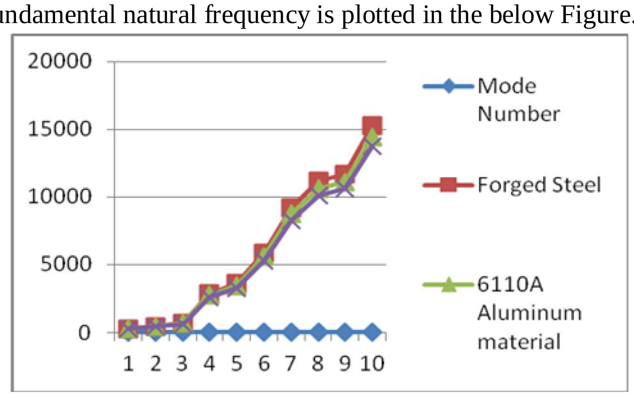


Figure.13. shows the 1st Mode shape @ 293.9 Hz of connecting rod with 6110 A materials.

Table.1. shows the Mode number and Frequency of Al.

Mode Number	Frequency (Hz) 7075-T6 Aluminum material
1	279
2	442.1
3	655.89
4	2610.7
5	3252.9
6	5316
7	8310.6
8	10098
9	10604
10	13787

mode numbers are tabulated and mode shape of the fundamental natural frequency is plotted in the below Figure.



Graph.1. shows the Comparison of natural frequencies of conecting rod for different materials.

IV. CONCLUSION

In this paper the structural static analysis is performed on the connecting rod by applying the operating pressure for 3 different materials (Forged steel, 6110A (AlMg0.9Si0.9MnCu) Aluminum and 7075-T6 Aluminum). The analysis is also extended to modal analysis to find the natural frequencies of the connecting rod for 3 different materials. From the static analysis results it is observed that the FOS for the forged steel, 6110 A and Aluminum 7075 material are 11.28, 6.32 and 8.33 respectively. From the modal analysis it is observed that the fundamental natural frequency for the forged steel, 6011 A and Aluminum 7075 material are 307 Hz, 294 Hz and 279 Hz respectively. From the results it is observed that forged steel have more FOS and more fundamental natural frequency then 6110A and Aluminum 7075 material.

REFERENCES

[1] Mohamed Abdusalam Hussin, Er. Prabhat Kumar Sinha and Dr. Arvind Saran Darbari, "DESIGN AND ANALYSIS OF CONNECTING ROD USING ALUMINIUM ALLOY 7068 T6, T6511**",** INTERATIONAL JOURNAL OF MECHANICAL ENGINEERING AND TECHNOLOGY (IJMET), Volume 5, Issue 10, October (2014).

[2] Leela Krishna Vegi and Venu Gopal Vegi**,** "Design And Analysis of Connecting Rod Using Forged steel", International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June-2013.

[3] S.Vijaya Kumar, S.K. Thenadayaal, V.P. Vasanth, and V. Vasantha kumar, "Design and Analysis of Two Wheeler Connecting Rod", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Special Issue 6, May 2015.