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STRUCTURAL ANALYSIS OF CONNECTING ROD

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ABSTRACT

The objective of this work is to carry out the structural analysis of a connecting rod made from three differing types of alloys. Connecting Rods has a wide use in all sorts of automobile engines acting as a crucial middle point between the piston and therefore the crankshaft of an engine of an automobile. It's liable for transmission of the up and down movement of the piston to the crankshaft of the engine, by converting the reciprocating motion of the piston to the rotation of crankshaft. The performance of a rod in an engine depends on its design and weight. Hence, for the assembly of a long-lasting, economical and light-weight rod, analysis and optimization become necessary. The material "structural steel" of rod is replaced with Aluminium alloy, Magnesium alloy and Titanium alloy material for rod. The model of rod is made in catia v5 and imported in ANSYS 2021 R1 workbench for static analysis. After analysis, a comparison is formed between an existing steel rod and therefore the three composite rods in terms of Von Misses stress, equivalent strain and total deformation. All these parameters also are found analytically and compared with results of Finite Element Analysis. All those results are within the range and therefore the values of these materials are found as compared of steel. The general work is split into three phases. First, concept and a review of existing material. Second, we do modeling and static structural analysis. Third, is comparison of elastic strain, total deformation, and maximum Von misses stress value in alloy connecting rods.

Keywords: Connecting Rod, Piston, Crankshaft, Structural Analysis, FEA, Structural Steel.

I. INTRODUCTION

One resource of power in automobile sector is combustion engine. Combustion engine transforms energy within the sort of up and down motion of the piston right into energy. The various components of combustion engine are cylinder, piston, rod, crank and also crank shaft. Rod is simply one among the vital driving components of light engine; it creates a simple device that transforms direct movement right into rotating movement. Thus, a rod is employed to rework up and down movement of the piston right into rotating activity of the crankshaft. Hence, the rod has got to be sufficiently strong to face up to forces without damages thanks to the pressure created from the burning. A rod may be a framework that sustains the axial compressive tons that features a tendency to prevent working thanks to inelasticity. Devastating damages would definitely happen to the engine needing costly repair services if the rod was to prevent working. As the latest created combustion engine began to regulate, the importance of the rod alongside the crank shaft was necessary to the procedure of a dependable engine. Throughout the manufacturing of those combustion engines, the facility generated has actually continuously been growing, causing enhanced pressures being exhibited in current engines. Generally connecting rods are being made from chrome steel and aluminium alloy through the forging process, as this method provides high productivity which too with a lesser cost . Forces originated on the connecting rod are generally by its weight and combustion of fuel inside cylinder acting upon piston then on the rod, which ends up in both the bending and axial stresses.

Fig. 1.1 Connecting Rod

II. LITERATURE REVIEW

BOGA SUDHA, Dr. I SATYANARAYANA and C.SIVAKANDHAN- The connecting rod is that the intermediate between the piston and the crankshaft, which helps it to function properly. It transfers the rotation of crank to up and down movement of the piston in the cy1inder. In this project, the comparison is made for the simplest material between steel & Aluminum alloy. The replica of connecting rod is made in 3D modeling software knows as Solid works. Then these designs are carried for structural analysis. This structural analysis is completed in software called Ansys. By structural analysis we will get the warmth stress, strain & total deformation by which we will select the simplest material for rod.

A Muhammad, M A H Ali1 and I H Shanono- The performance of a connecting rod in an engine is impacted by its design and weight. Hence, for the production of a long-lasting, economical and light-weight rod, analysis and optimization become necessary. This text provides a assessment of some essential work done by various researchers in designing; analyzing and optimization of connecting rod of an engine with the help of FEA in ANSYS workbench. A far-reaching comparison table and graphs for the reviewed research articles are provided. The paper will function as a stepping stone for both old and new researchers within the field of automotive design.

Mr. Shubham Chougale - In this work, a connecting rod is designed for two wheeler by analytical method. With the help of that design a physical replica is created in CATIA V5. Structural system of connecting rod has been analyzed using finite element analysis. With the use of finite element analysis various stresses are calculated for a particular loading conditions using finite element analysis software ANSYS WORKBENCH 14.5. The same work is carried out using different material. A comparative analysis is made on the basis of various performances with considerable reduction in weight

III. OBJECTIVE

The objectives of this project are to:

1. Develop a geometrical replica of a connecting rod using CATIA V5 software.
2. Carry out the structural analysis in Ansys 2021 R1 software.
3. Compare the result.

IV. METHODOLOGY

Step.1: Modelling of connecting rod as per the dimensions in Catia v5.

Step.2: The 3-D model was imported in ANSYS 2021 R1 workbench.

Step.3: The materials were assigned to the connecting rod in the mechanical interface.

Step.4: Mesh was generated for connecting rod with high refinement.

Step.5: Inner section of piston end was decided for fixed end.

Step.6: In the static structural analysis, the pressure is applied at an inner section of the piston end and force of 100N is applied.

Step.7: Analysis solution was performed and stresses values were checked for the connecting rod. Total deformation, von-misses stresses and von-misses strain were used to compare the results.

Step.8: The existing material is replaced by alloys of Aluminium, Magnesium and Titanium and all the steps from step.1 to step.8 were performed again to get the results. For the revised geometry, the results of existing connecting rod and with modified geometry were compared.

V. MATERIALS

5.1 Structural Steel:

The connecting rods are most usually made of structural steel or aluminium alloy for production engines. These materials have different properties and suitable for different engines.

Table 5.1.1 Represents the structural steel properties

Density	7850 kg m^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1

Specific Heat	434 J kg^-1 C^-1
Thermal Conductivity	60.5 W m^-1 C^-1
Resistivity	1.7e-007 ohm m

5.2 Aluminium Alloy:

Aluminium rods are admired among high rpm race engines. They are very light and strong, but they a short fatigue lift. In a restricted use circumstances, they can last for a long period of time and usually those types of engines see repeated tear downs anyway. High rpm is where aluminium rods offers a trump card, so it can be favoured by most of the company's. The aluminium alloys are less in weight and are economical as compared to other materials.

Table 5.2.1 Represents the aluminium alloy properties

Density	2770 kg m^-3
Coefficient of Thermal Expansion	2.3e-005 C^-1
Specific Heat	875 kg^-1 C^-1

5.3 Magnesium Alloy:

Magnesium alloys are mixtures of magnesium with other metals; it is the lightest structural metal. Magnesium alloys have a hexagonal lattice structure, which affects the basic properties of these alloys. Cast magnesium alloys are used for many components of modern automobiles and have been used in some high-performance vehicles.

Table 5.3.1 Represents the magnesium alloy properties

Density	1800 kg m^-3
Coefficient of Thermal Expansion	2.6e-005 C^-1
Specific Heat	1024 J kg^-1 C^-1
Thermal Conductivity	156 W m^-1 C^-1
Resistivity	7.7e-007 ohm m

5.4 Titanium Alloy:

Titanium alloys are metals which contain a mixture of titanium and other chemical elements. Such alloys have very high durability and toughness. They are light in weight, have remarkable corrosion resistance and it can also withstand extreme temperatures. However, the high cost of both raw materials and processing limit their use to military applications, aircraft, spacecraft, medical devices, connecting rods.

Table 5.4.1 Represents the titanium alloy properties

Density	4620 kg m^-3
Isotropic Secant Coefficient of Thermal Expansion	9.4e-006 C^-1
Specific Heat Constant Pressure	522 J kg^-1 C^-1
Isotropic Thermal Conductivity	21.9 W m^-1 C^-1
Isotropic Resistivity	1.7e-006 ohm m

VI. DIAGRAM OF PROJECT

The project is designed in CATIA V5 and later imported to ANSYS software.

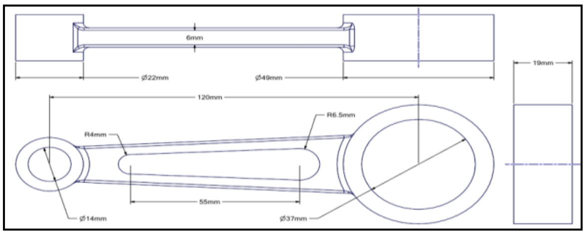


Fig. 6.1 Represents the taken dimensions

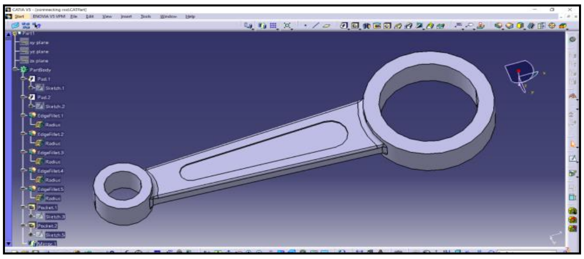
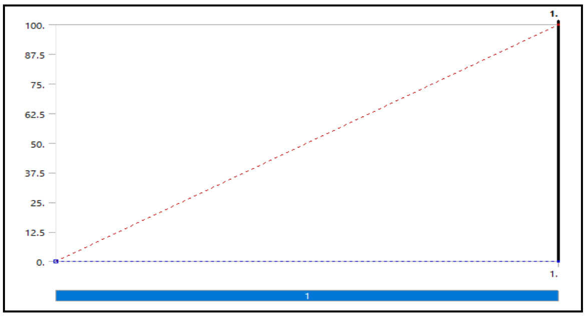


Fig. 6.2 Represents the geometry model in CATIA V5

VII. CALCULATION

7.1 LOAD APPLICATION

Establishing boundary condition is an important factor to consider in FEA. The first key action required prior to the start of an analysis is the setting of boundary conditions. Constraints that include fixed support, forces, and pressure applied to the model after meshing process are embedded in a way that adapt to the practical real life situation, which is an important and main action needed in analysis. The deformation, stress and strain values of the connecting rod are based on an acceptable design constraint using static structural analysis. The static and dynamic analysis using ANSYS software of connecting rod using various materials (aluminium alloy, magnesium alloy and titanium alloy) is done. The deformation, stress, and strain values under a compression load of 100 N were determined for the static structural analysis. The boundary conditions on the connecting rod include supports and loads; the smaller end is subjected to the loading while the big end is fixed of the connecting rod.



Graph 7.1.1 Represents load application

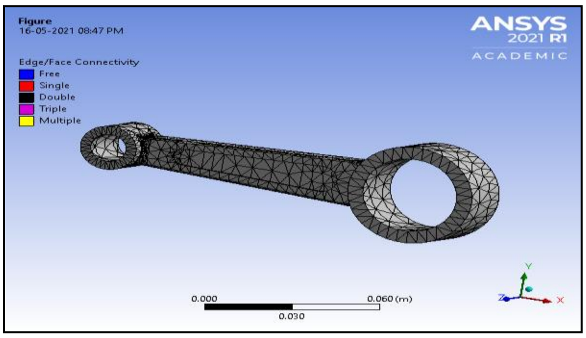


Fig 7.1.1 Represents meshed geometry

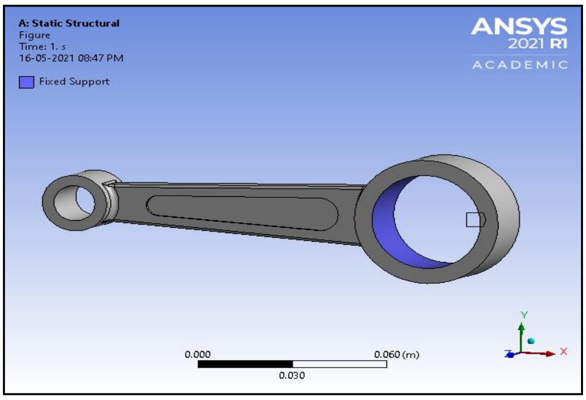


Fig 7.1.2 Represents the fixed support at bigger end

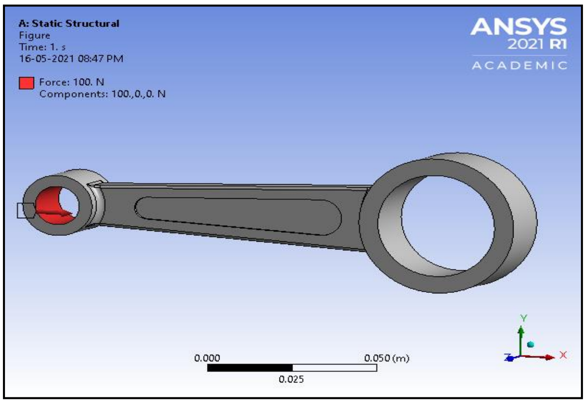


Fig 7.1.3 Represents the load application at smaller end

Table 7.1.1 Boundary conditions applied

Object Name	*Fixed Support*	*Force*
Scope		
Scoping Method	Geometry Selection	
Geometry	1 Face	
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Components
Applied By		Surface Effect
Coordinate System		Global Coordinate System
X Component		100. N (ramped)
Y Component		0. N (ramped)
Z Component		0. N (ramped)

7.2 STRUCTURAL ANALYSIS

7.2.1 Connecting rod analysis using structural steel

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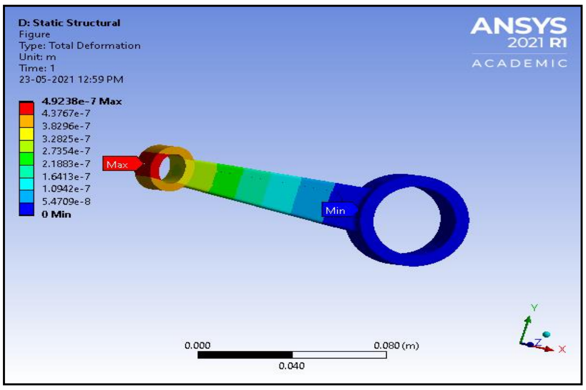

Fig 7.2.1.1 Represents total deformation

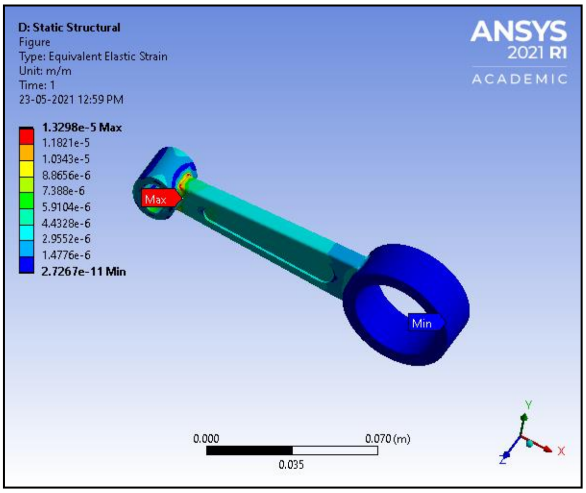

Fig 7.2.1.2 Represents equivalent elastic strain

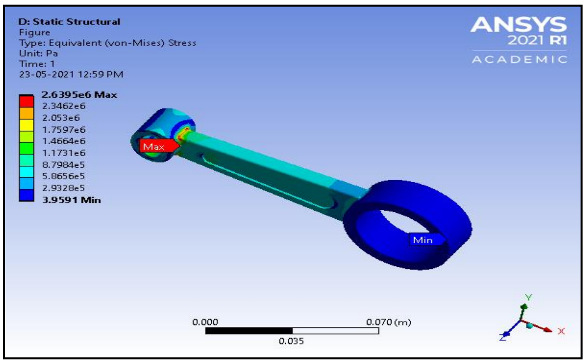

Fig 7.2.1.3 Represents equivalent (von-Mises) stress

Table 7.2.1.1 Represents total deformation

	Total Deformation
Minimum	0. m
Maximum	4.9238e-007 m
Average	1.3192e-007 m

Table 7.2.1.2 Represents equivalent elastic strain

	Equivalent Elastic Strain
Minimum	2.7267e-011 m/m
Maximum	1.3298e-005 m/m
Average	2.2575e-006 m/m

Table 7.2.1.3 Represents equivalent (von-Mises) stress

	Equivalent Elastic Stress
Minimum	3.9591 Pa
Maximum	2.6395e+006 Pa
Average	4.4485e+005 Pa

7.2.2 Connecting rod analysis using aluminium alloy

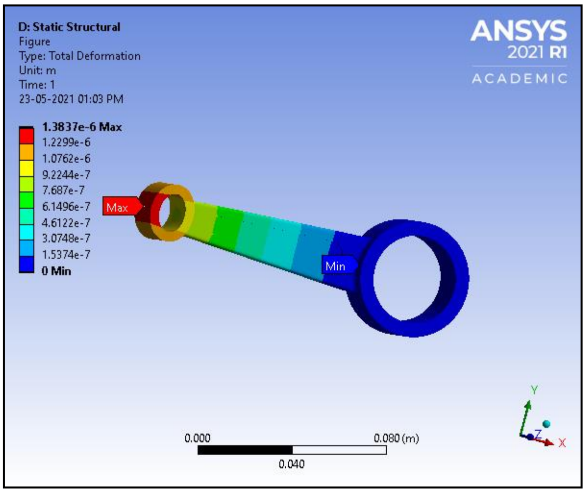

Fig 7.2.2.1 Represents total deformation

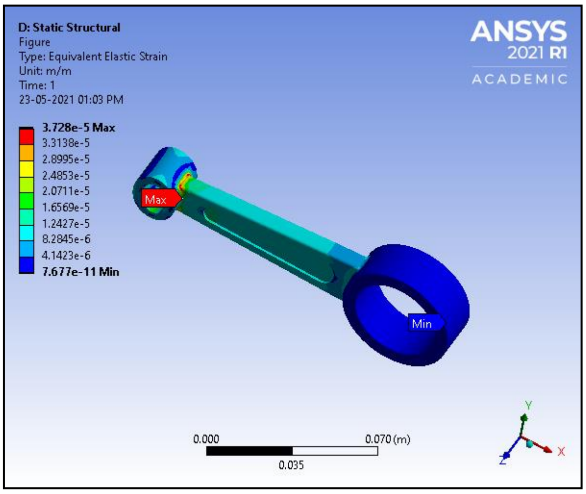

Fig 7.2.2.2 Represents equivalent elastic strain

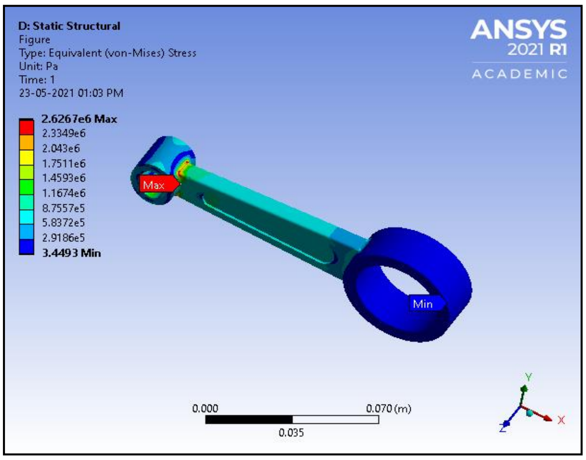

Fig 7.2.2.3 Represents equivalent (von-Mises) stress

Table 7.2.2.1 Represents total deformation

	Total Deformation
Minimum	0. m
Maximum	1.3837e-006 m
Average	3.7087e-007 m

Table 7.2.2.2 Represents equivalent elastic strain

	Equivalent Elastic Strain
Minimum	7.677e-011 m/m
Maximum	3.728e-005 m/m
Average	6.3537e-006 m/m

Table 7.2.2.3 Represents equivalent (von-Mises) stress

	Equivalent Elastic Stress
Minimum	3.4493 Pa
Maximum	2.6267e+006 Pa
Average	4.4448e+005 Pa

7.2.3 Connecting rod analysis using magnesium alloy

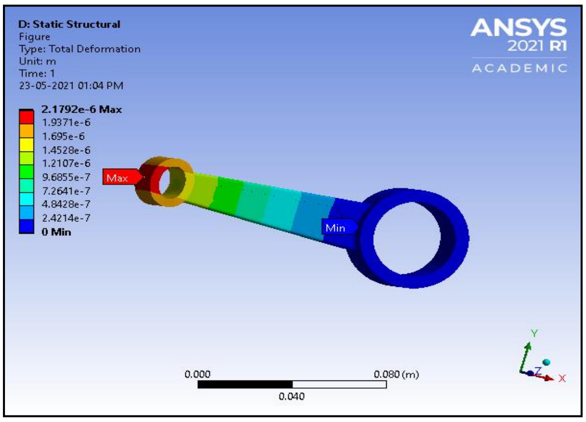

Fig 7.2.3.1 Represents total deformation

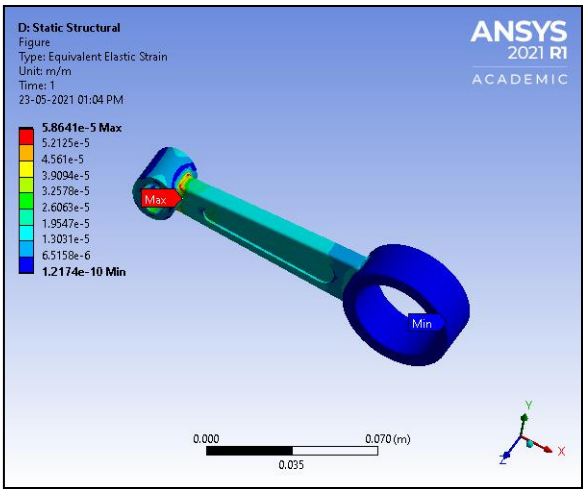

Fig 7.2.3.2 Represents equivalent elastic strain

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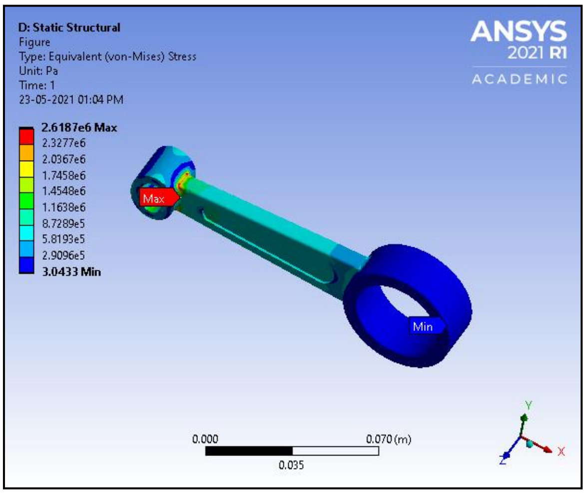

Fig 7.2.3.3 Represents equivalent (von-Mises) stress

Table 7.2.3.1 Represents total deformation

	Total Deformation
Minimum	0. m
Maximum	2.1792e-006 m
Average	5.843e-007 m

Table 7.2.3.2 Represents equivalent elastic strain

	Equivalent Elastic Strain
Minimum	1.2174e-010 m/m
Maximum	5.8641e-005 m/m
Average	1.0019e-005 m/m

Table 7.2.3.3 Represents equivalent (von-Mises) stress

	Equivalent Elastic Stress
Minimum	3.0433 Pa
Maximum	2.6187e+006 Pa
Average	4.4425e+005 Pa

7.2.4 Connecting rod analysis using titanium alloy

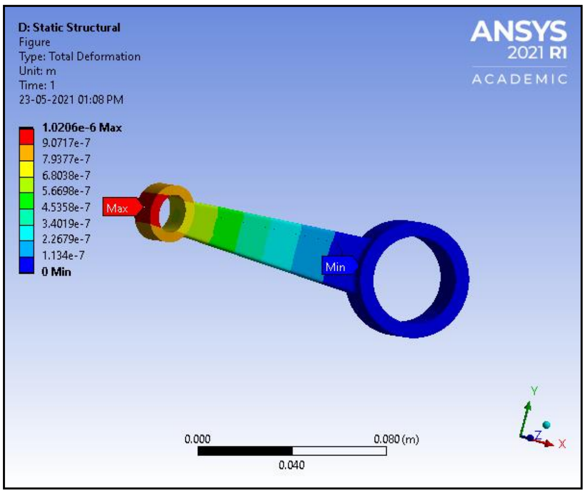

Fig 7.2.4.1 Represents total deformation

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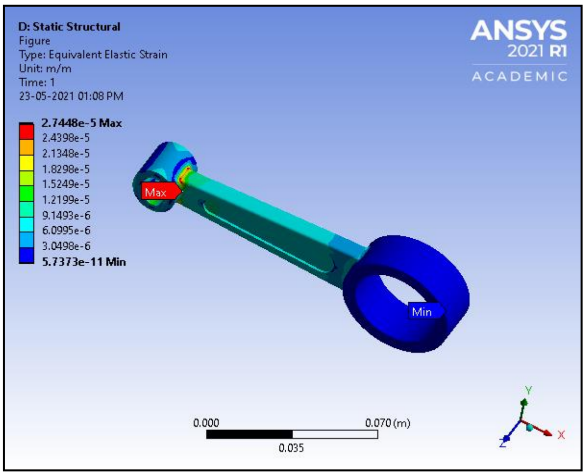


Fig 7.2.4.2 Represents equivalent elastic strain

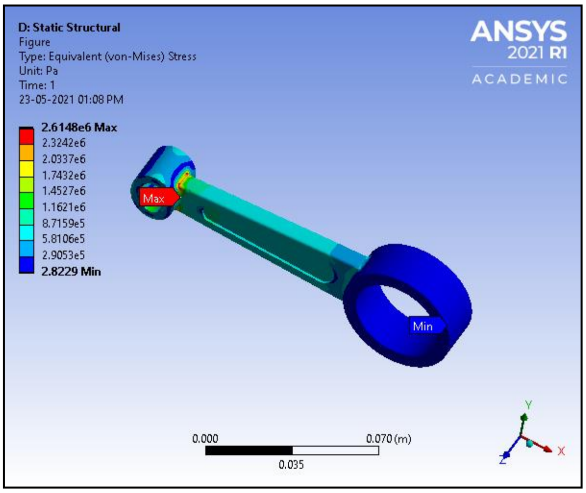


Fig 7.2.4.3 Represents equivalent (von-Mises) stress

Table 7.2.4.1 Represents total deformation

	Total Deformation
Minimum	0. m
Maximum	1.0206e-006 m
Average	2.7369e-007 m

Table 7.2.4.2 Represents equivalent elastic strain

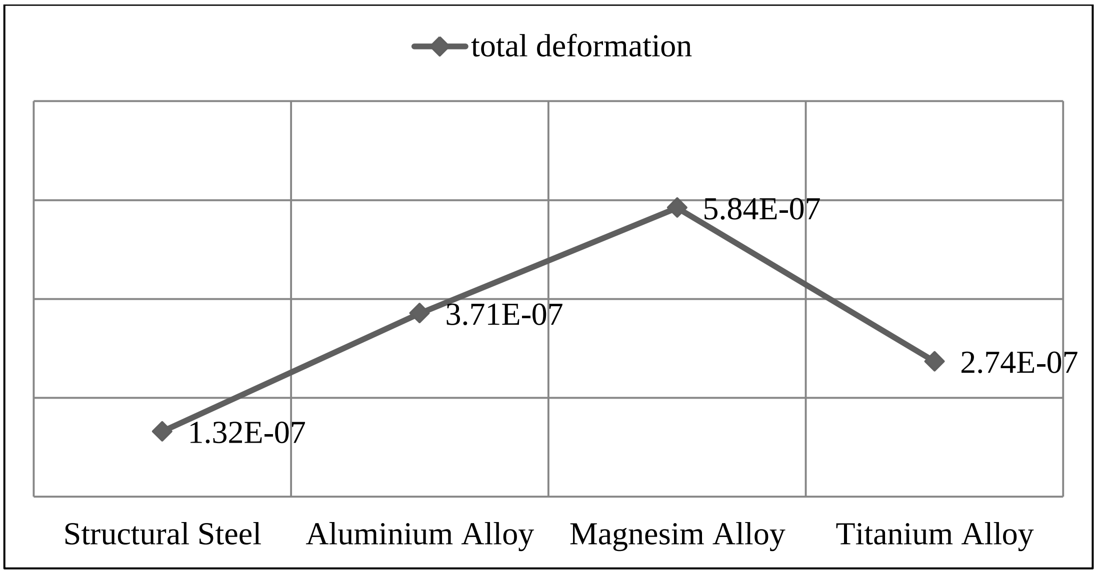
	Equivalent Elastic Strain
Minimum	5.7373e-011 m/m
Maximum	2.7448e-005 m/m
Average	4.6954e-006 m/m

Table 7.2.4.3 Represents equivalent (von-Mises) stress

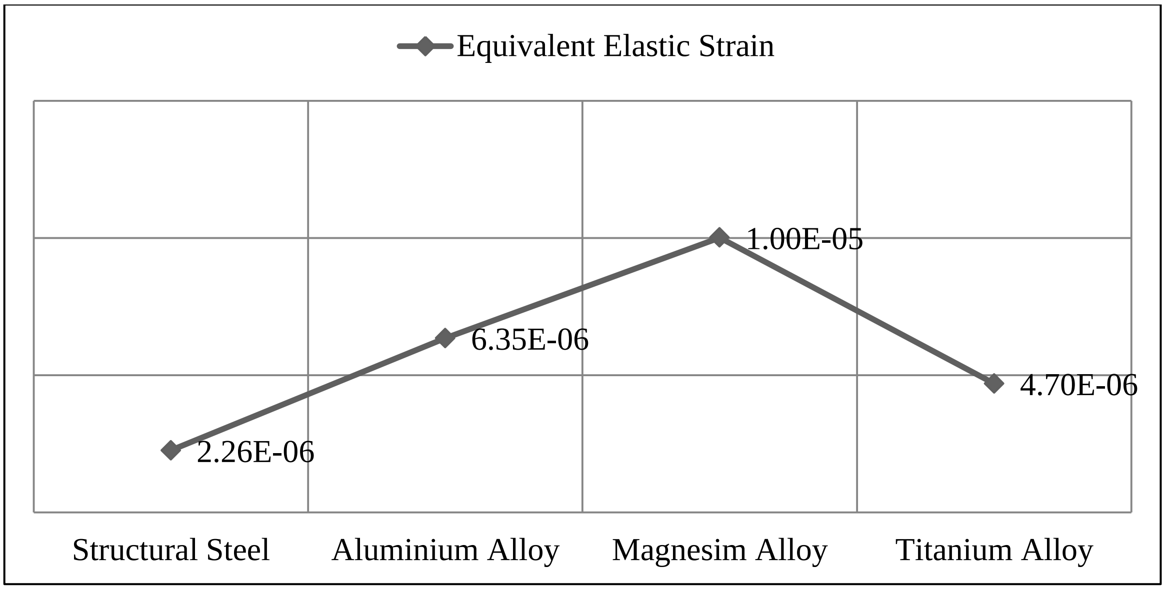
	Equivalent Elastic Stress
Minimum	2.8229 Pa
Maximum	2.6148e+006 Pa
Average	4.4413e+005 Pa

7.3 RESULT

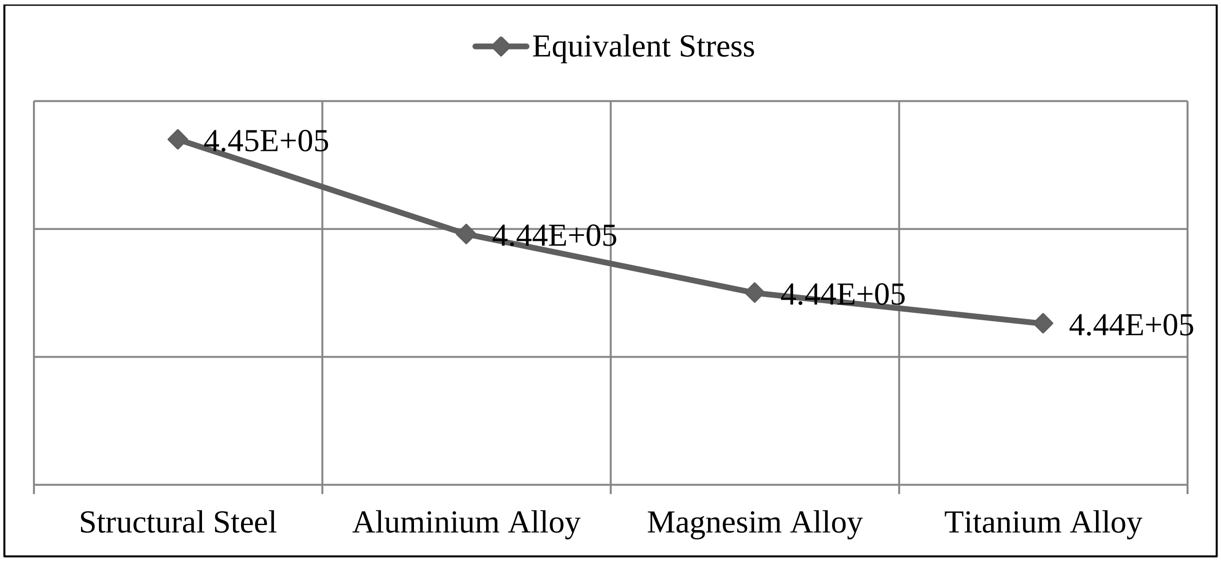
The following results comprise of all the factors of structural analysis [total deformation, equivalent elastic stress and equivalent (von-Mises) strain] done by finite element analysis on ANSYS on different materials.



Graph 7.3.1 Represents comparison of total deformation on applied materials



Graph 7.3.2 Represents comparison of equivalent elastic strain on applied materials



Graph 7.3.3 Represents comparison of equivalent (von-Mises) stress on applied materials

VIII. CONCLUSIONS

In this project, we are applying a specific load to the different materials to the connecting rod and carrying the analysis of connecting rod and comparing static structural analysis with 4 different materials.

By the above result, we can conclude that:

1. The aluminum alloy exhibits best properties in all the considered factors.
2. Higher life cycle of aluminium alloy when compared
3. The material to be used must have high strength and low weight
4. Material should be light weight without compromising in strength, can be attained by using the input of hybrid materials.

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