Modelling and Analysis of Aluminium Alloy Composite Connecting Rod

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***Abstract*--The Connecting rod is a high volume production from automobile and a major link inside of a internal combustion engine. It connects the piston to the crankshaft and is responsible for transferring power from the piston to the crankshaft. The connecting rod is subjected to more stresses than other engine components. Failure and damage are also increased in the connecting rod thus stress analysis study in connecting rods is very important. There are different types of materials and production methods used in the creation of connecting rods. The most common types of materials used for connecting rods are steel and aluminium. Aluminium alloy can be preferred for manufacturing of connecting rods. This paper describes modelling and analysis of connecting rods made of Aluminium alloy reinforced with SiC particles fabricated by ultrasonic stir assisted casting process for 4-stroke petrol engine of a specified model and compared with steel connecting rods. We used PRO-E (creo-parametric) software for modelling of a connecting rod and ANSYS 14.5 workbench for static analysis. We found out the stresses developed in the connecting rod under static loading with different loading conditions of compression and tension at the crank end and pin end of the connecting rod.**

Keywords – Connecting rod, PRO-E (creo-parametric), ANSYS14.5 Workbench, Aluminium and SiC alloy, Finite Element analysis.

I. INTRODUCTION

Every vehicle that uses an internal combustion engine requires at least one connecting rod depending upon the number of cylinders in the engine. The automobile engine connecting rod is a high volume production, critical component. It is the intermediate component between crank and piston. The objective of the connecting rod is to transmit push & pull from the piston pin to the crank pin and then converts reciprocating motion of the piston into the rotary motion of crank. The main components of a connecting rod are big shank, a small end and a big end. There are different types of materials and production methods used in the creation of connecting rods. The most common types of material for connecting rods are steel and aluminium. The most common types of manufacturing processes are casting, forging and powdered metallurgy.

Due to its large volume of production, it is only logical that optimization of the connecting rod for its weight or volume will result in large-scale savings. It can also achieve the objective of reducing the weight of the engine component, thus reducing inertia loads, reducing
engine weight and improving engine performance and fuel economy.

In this study we used aluminium alloy reinforced with SiC particles fabricated by Ultrasonic assisted stir casting process to reduce the weight of the connecting rod and reduce the effect of stresses generated during operation.

The connecting rod undergoes a complex motion, which is characterized by inertia loads that induce bending stresses which is a complex state of loading. It undergoes high cyclic loads of the order of 10^8 to 10^9 cycles, which range from high compressive loads due to combustion, to high tensile loads due to inertia. Therefore, durability of this component is of critical importance. Due to these factors, the connecting rod has been the topic of research for different aspects such as production technology, materials, performance simulation, fatigue etc.

II. SPECIFICATION OF THE PROBLEM

The objective of the present work is the analyses of a connecting rod made of Aluminium Alloy (Al 5083) Reinforced with Silicon carbide (SiC) which was fabricated by ultrasonic assisted stir casting process. Nowadays Steel and aluminium materials are most commonly used to design the connecting rod. In this paper the material (structural steel) of connecting rod replaced with developed Aluminium alloy. The model of connecting rod was created in Pro-E (Creo-parametric) and imported in ANSYS 14.5 workbench for static analysis. After analysis a comparison is made between an existing steel connecting rod and an aluminium alloy connecting rod viz., Aluminium Alloy (Al 5083) Reinforced with Silicon carbide (SiC) in terms of Von misses stress, equivalent strain and total deformation.

III. MODELING OF CONNECTING ROD

Optimized Connecting rod has been modelled with the help of PRO/E (Creo-Parametric) software.

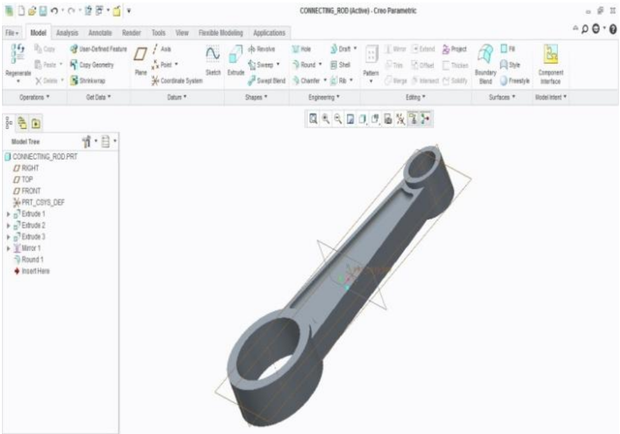

Fig.1 Model of connecting rod in PRO-E (Creo-parametric)

The developed solid model of a connecting rod shown in figure 1.

The following are the sequence of steps which have been followed for modelling of connecting rod.

a. Selection of the reference plane.
b. Setting of the dimensions in mm.
c. Going to the sketcher and sketch circular entities.
d. Extrusion of these entities for making both ends of the connecting rod.
e. Reselection of reference plane for shank of connecting rod.
f. Entities made to be tangential to both ends.
g. Extrusion of the entities symmetrically.
h. Selection of plane for making entities of groove.
i. Making of groove on the shank and mirroring for creation of groove on both sides.

IV. STRUCTURAL ANALYSIS OF CONNECTING ROD

A 3D model of a connecting is used for analysis in ANSYS 14.5 workbench. The loading conditions are assumed to be static. Analysis is done with pressure loads applied at the piston end and at the fixed crank end. The element selected is 45 tetrahedral. Finite element analysis is carried out on carbon steel connecting rod as well as on aluminium alloy reinforced with SiC particles. The material properties for Al alloy composite were taken from the reference papers. From the analysis the equivalent stress (Von-mises stress), equivalent strain Max Shear stress and total deformation were determined.

Fig. 2 shows the connecting rod with fixed big end and fig. 3 shows the connecting rod with pressure at small end.

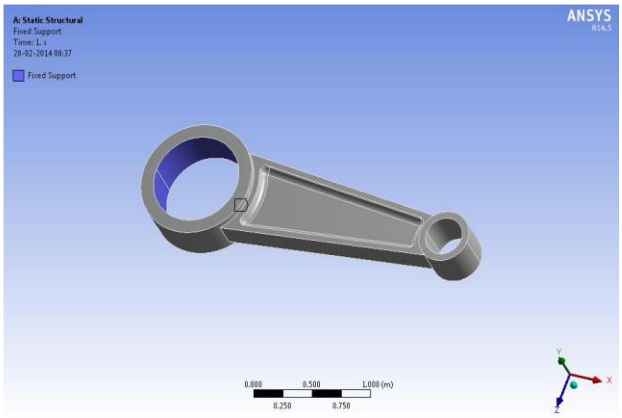

Fig.2 Connecting rod with fixed big end

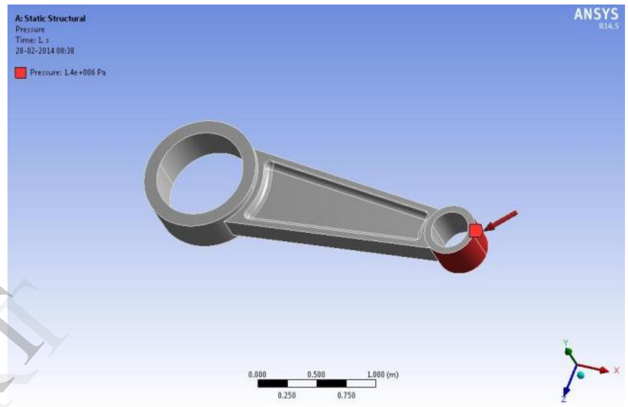

Fig.3 Connecting rod with pressure at small end

V. RESULTS OF FINITE ELEMENT ANALYSIS AND COMPARISON WITH EXISTING RESULTS

A. At 1.4 MPa pressure

a) Equivalent Stress

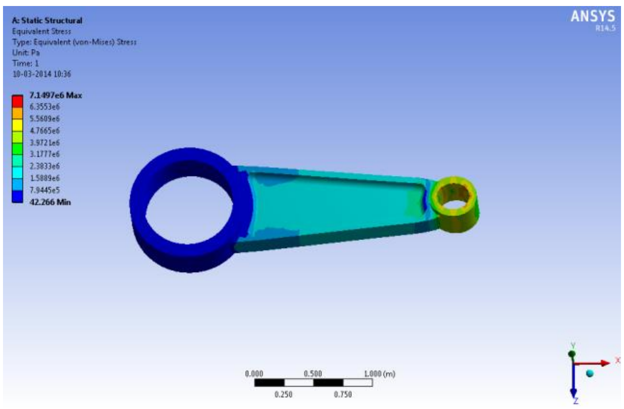

Fig. 4 Equivalent Stress of Structural steel connecting rod

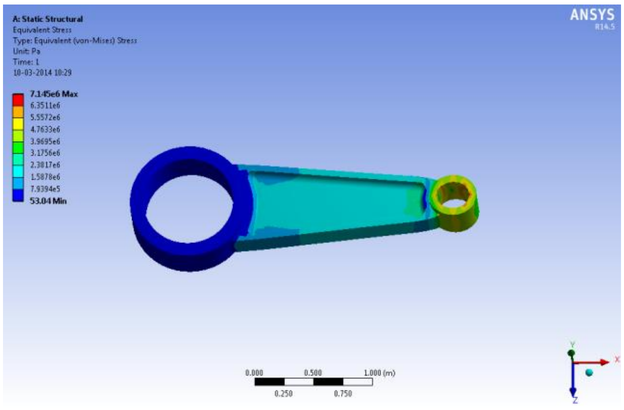

Fig. 5 Equivalent Stress of Al 5083 alloy Composite Connecting rod

Fig. 4 and Fig. 5 shows Min Equivalent stress as 42.266 Pa and 53.04 Pa and max equivalent stress as 7.1497 X 10^6 Pa and 7.145 X 10^6 Pa for a connecting rod made of Structural steel and Al alloy composite respectively.

b) Max Shear stress

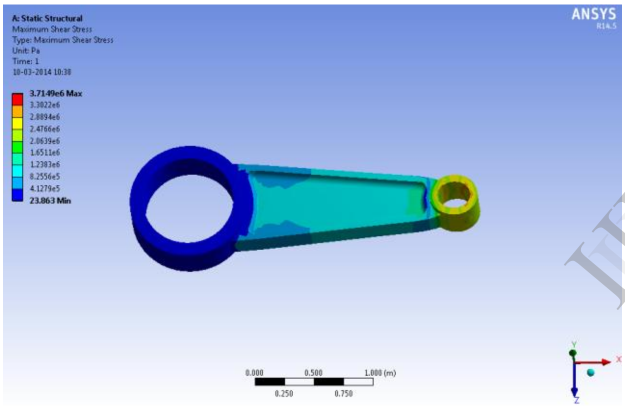

Fig. 6 Maximum Shear Stress of Structure steel Connecting rod

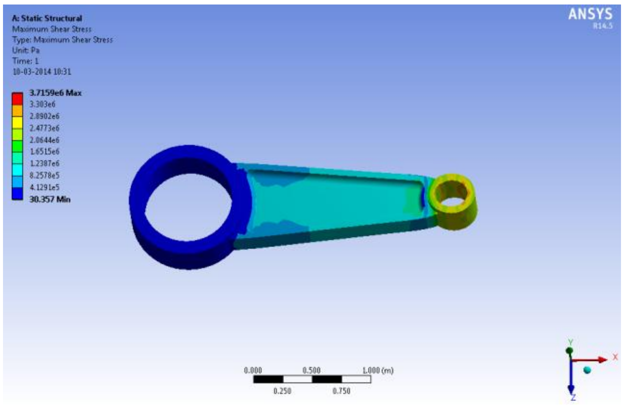

Fig. 7 Maximum Shear Stress of Al 5083 alloy Composite Connecting rod

Fig. 6 and Fig. 7 shows Min Shear stress as 23.863 Pa and 30.357 Pa and max Shear stress as 3.7149X 10^6 Pa and 3.7159 X 10^6 Pa for a connecting rod made of Structural steel and Al alloy composite respectively.

c) Equivalent elastic strain

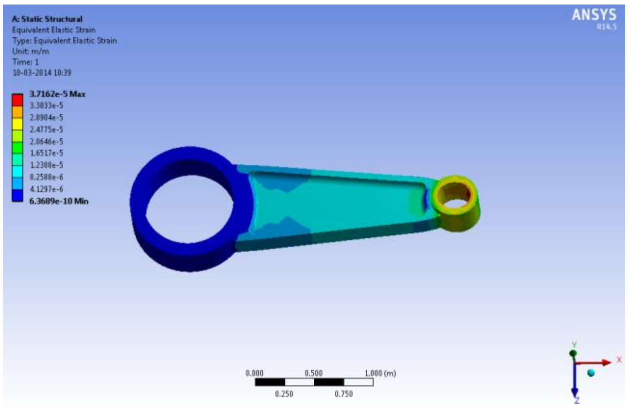

Fig. 8 Equivalent elastic strain of Structural steel connecting rod

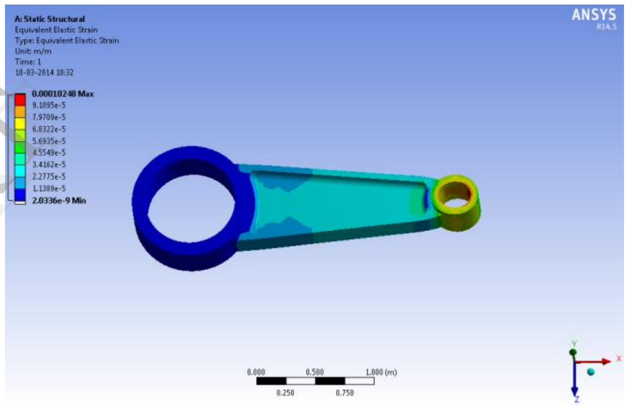

Fig. 9 Equivalent elastic strain of Al 5083 alloy Composite Connecting rod

Fig. 8 and Fig. 9 shows Min Equivalent elastic strain as 6.3689 X 10^{-10} m/m and 2.0336 X 10^{-9} m/m and max Equivalent elastic strain as 3.7162 X 10^{-5} m/m and 1.0248 X 10^{-4} m/m for a connecting rod made of Structural steel and Al alloy composite respectively.

d) Total deformation

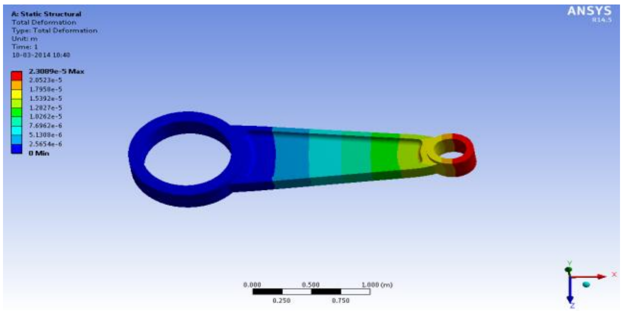

Fig. 10 Total Deformation of Al 5083 alloy Composite Connecting rod

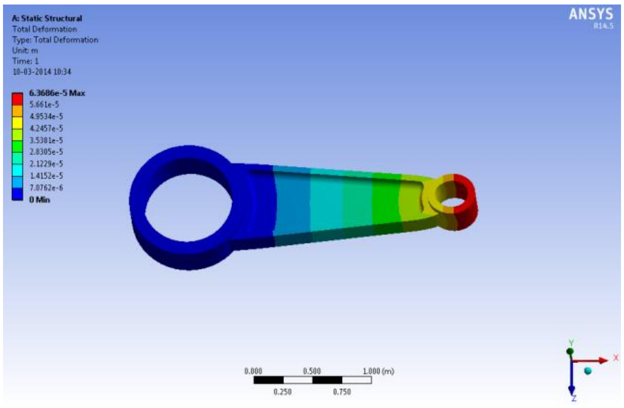

Fig. 11 Total Deformation of Al 5083 Composite Connecting rod

Fig. 10 and Fig. 11 shows Min Total deformation as 0 for both and max Total deformation as 2.3089 X 10^{-5} m and 6.3686 X 10^{-5} m for a connecting rod made of Structural steel and Al alloy composite respectively.

B. At 2.8 MPa pressure

a) Equivalent Stress

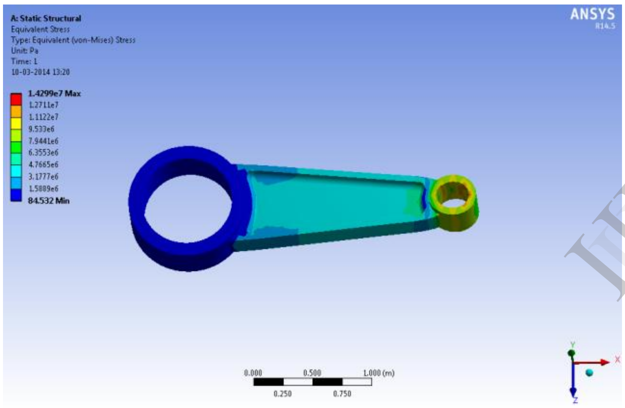

Fig. 12 Equivalent Stress of Structural steel connecting rod

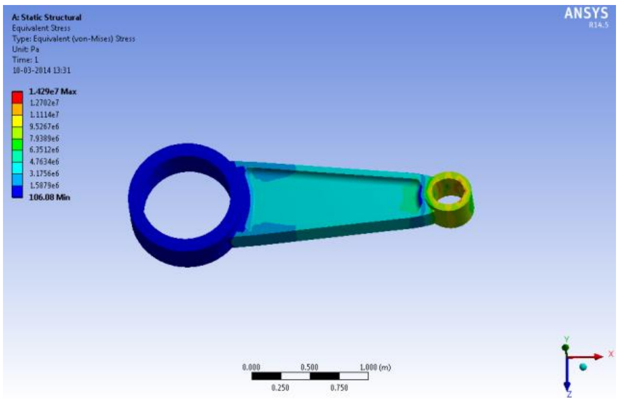

Fig. 13 Equivalent Stress of Al 5083 alloy Composite Connecting rod

Fig. 12 and Fig. 13 shows Min Equivalent stress as 84.532 Pa and 106.08 Pa and max equivalent stress as 1.4299 X 10^7 Pa and 1.4290 X 10^7 Pa for a connecting rod made of Structural steel and Al alloy composite respectively.

b) Maximum Shear stress

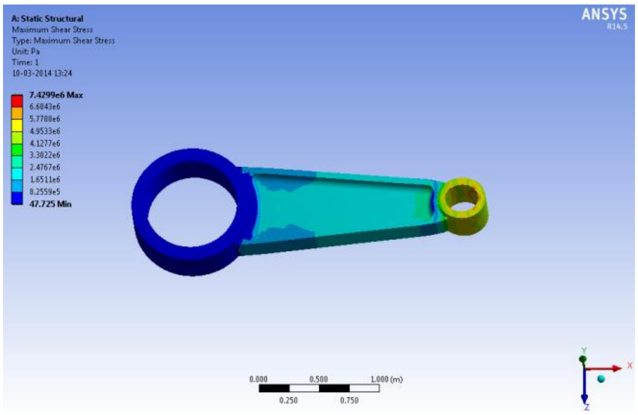

Fig. 14 Max Shear Stress of Structure steel connecting rod

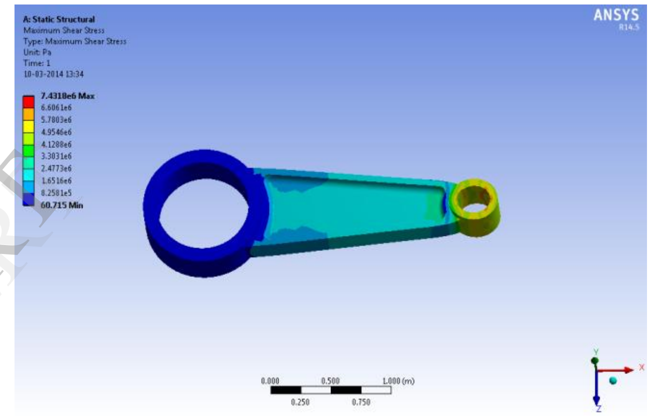

Fig. 15 Max Shear Stress of Al 5083 alloy Composite Connecting rod

Fig. 14 and Fig. 15 shows Min Shear stress as 47.725 Pa and 60.715 Pa and max Shear stress as 7.4299X 10^6 Pa and 7.4318 X 10^6 Pa for a connecting rod made of Structural steel and Al alloy composite respectively.

c) Equivalent elastic strain

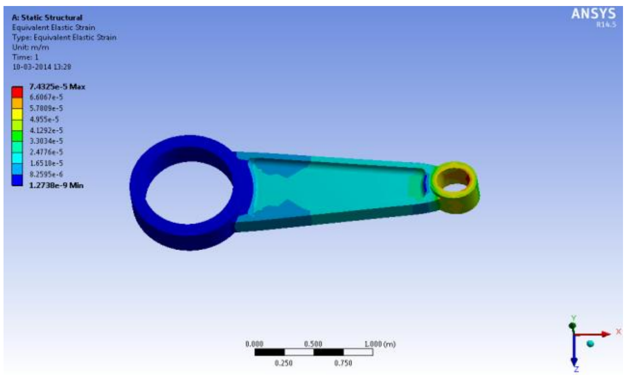

Fig. 16 Equivalent elastic strain of Structural steel connecting rod

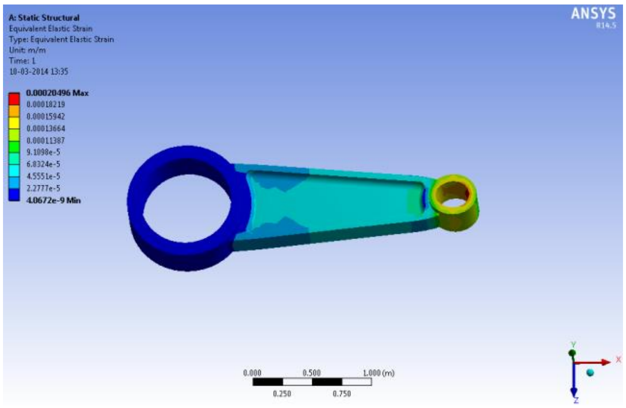

Fig. 17 Equivalent elastic strain of Al 5083 alloy Composite Connecting rod

Fig. 16 and Fig. 17 shows Min Equivalent elastic strain as 1.2738X 10^{-9} m/m and 4.0672 X 10^{-9} m/m and max Equivalent elastic strain as 7.4325 X 10^{-5} m/m and 2.0496 X 10^{-4} m/m for a connecting rod made of Structural steel and Al alloy composite respectively.

d) Maximum Deformation

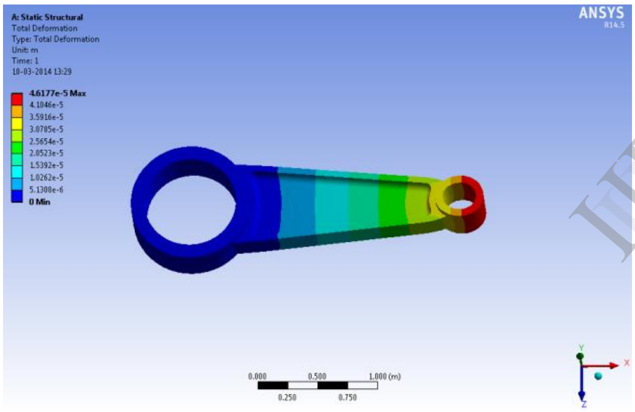

Fig. 18 Total Deformation of Structure steel Connecting rod

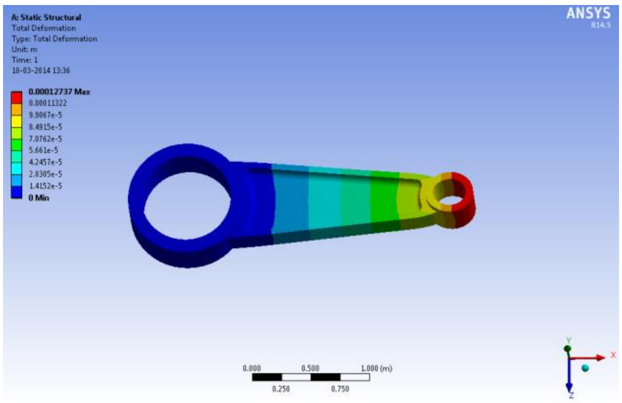

Fig. 19 Total Deformation of Al 5083 Composite Connecting rod

Fig. 18 and Fig. 19 shows Min Total deformation as 0 for both and max Total deformation as 4.6177 X 10^{-5} m and 1.2737 X 10^{-4} m for a connecting rod made of Structural steel and Al alloy composite respectively.

VI. Conclusion

- Automotive connecting rod made up of Aluminium based metal matrix composites have been successfully fabricated by ultrasonic stir casting technique with 10 wt. % SiC particles.
- The fabricated aluminium composite connecting rod has light weight about 1/3 of steel and good wear resistance.
- Equivalent elastic strain and total deformation in Al alloy composite connecting rod is slightly more than structural steel connecting rod but it comes under the permissible tolerance limit.
- The maximum von misses stress value is less in an aluminium alloy connecting rod as compared to the connecting rod made of steel. Thus a steel connecting rod can be replaced with a developed Al alloy connecting rod.

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