Analysis of Connecting rod using Composite Material: A Review

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***Abstract*— The connecting rod is a component which connects the reciprocating piston to the linear crankshaft, transmitting the piston motion to crankshaft. In automobile engineering field, every vehicle runs on I.C. engine and uses at least one connecting rod. Due to the fuel consumption more number of compressive and tensile forces acting on the connecting rod. Due to the magnitude of such forces, failure can be occur. To avoid this, the existing connecting rod is replaced by composite materials. Because the composite material have good characteristics such as wear resistance, hardness, and high tensile strength. The modelling is done by using solid work workbench and CATIA, and analysis is done by using FEA software. The present paper is a review of the analysis performed on connecting rod using various composite materials.**

***Index Terms*— ANSYS, CATIA, Connecting rod, Deformation, Stress**

- **Introduction**

The connecting rod is an intermediate part between the piston and crankshaft. Small end of connecting rod is connected to the piston by using gudgeon pin and big end of connecting rod is connected to the crankshaft.

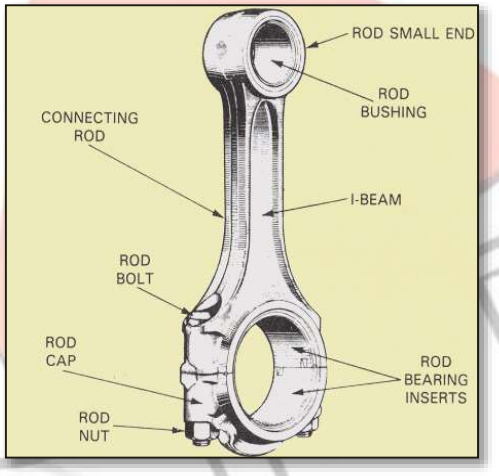

Fig 1: connecting rod

Due to the combustion of fuel various stresses are acting on the connecting rod, these forces are as follows:

1. Forces on the piston due to gas pressure and inertia of the reciprocating parts
2. Force due to inertia of the connecting rod
3. Force due to friction of the piston rings and of the piston
4. Force due to friction of the piston pin bearing and crank pin bearing

To avoid this forces the existing connecting rod is replaced by composite material and analysis is done by using FEA software and find out the results and this results are compared with existing material which is used for connecting rod.

- **Review work carried out:**

The Leela Krishna Vegi et al. [1] have made their paper on structural analysis of connecting made up of composite material. In this paper they replaced currently existing carbon steel material with forged steel. They have designed the connecting rod of Suzuki having engine capacity of 150 cc. for modelling of connecting rod they used CATIA and analysis is carried out using ANSYS software. Static structural analysis is carried out using ANSYS 13.0 in which they found out various parameters like equivalent stresses, normal stresses in X, Y, and Z direction and also deformation in X, Y, Z direction. Calculation for factor of safety, weight, stiffness and fatigue life were made. While analysis they found following results:

Table 1 Stresses and Deformation of Forged Steel

Sr. no.	Types	Max(MPa)	Min(MPa)
1.	Equivalent stress	38.298	4.0317e-9
2.	Normal stress(X-axis)	25.283	-15.692
3.	Normal stress(Y-axis)	28.08	-15.485

4.	Normal stress(Z-axis)	1.1978	-0.85736
5.	Shear stress(xy plane)	20.166	-20.183
6.	Shear stress(yz plane)	0.9152	-0.96534
7.	Shear stress(zx plane)	0.7183	-0.72013
8.	Total deformation	0.002593	0
9.	Directional deformation (x-axis)	0.0005354	-0.0025925
10.	Directional deformation (y-axis)	0.0016764	-0.007687
11.	Directional deformation (z-axis)	0.00013292	-0.0001347

The comparison was carried in between steel connecting rod and composite connecting rod and concluded the following:

1. For both materials equivalent stress was same.
2. Factor of safety and stiffness of forges steel material was increased than that of carbon steel.
3. Weight of forged steel was less than carbon steel.
4. No. of cycles for forged steel were (8500*10^3) which is more than carbon steel (6255*10^3).
5. Cost of forged steel material is less than carbon steel.

The Mr. F. A. Pathan et al [2] had done static analysis of connecting rod for weight optimization. They designed the connecting rod of hero splendor vehicle having 100 cc engine capacity. They developed the designed model of connecting rod using modelling software. In this work the traditional material i.e. Al360 of connecting rod was replaced with aluminium fly ash silicon composite. Analysis of connecting rod was carried out using ANYSY 14.0. In static structural analysis they performed analysis of von misses stresses, deformation and equivalent strain in connecting rod. 15.48 MPa pressure was applied for FEA analysis. From the analysis they found following results:

Table 2 Comparison of the results

	Al fly ash silicon composite	**Al360**
Von mises stresses	92.305MPa	92.305MPa
Deformation	0.038435	0.04484
Equivalent strain	0.0013414	0.001565

From the above results conclusion is made that, aluminium fly ash silicon has higher stiffness to weight ratio and higher strength than AL360.

The A. Prem Kumar et al [3] had done structural analysis of connecting rod. In which they analyse the stress, strain and deformation of connecting rod with using different materials with same geometry. He had done the analysis by changing the material of connecting rod. Generally used carbon steel material which was replaced by aluminium based composite material with boron carbide. He chooses two alloy of Al for his analysis that is AL6061 and Al6061+B4C. 3D modelling of connecting rod was carried out with the help of Pro-e software. Analysis was the carried out with the help of ANSYS software which is FEA based software from analysis he found out the stresses induced in connecting rod under tensile and compressive loading at crank end and piston end from the result he concluded three results:

1. Deformation of AL6063 +B4C (0.02356mm) is less as compared to Al 6061(0.056350mm), this results in increase the life time of the connecting rod.
2. Al6061+B4C connecting rod has high von misses stresses (0.011035) than Al 6063(0.010421 MPa), which results in high strength of connecting rod.
3. Al6061 +B4C have low von misses strain as compared to A6061.

The B Sunil Kumar et al [4] had designed the connecting rod. Modelling of designed connecting rod was carried out in solid works 2016 design software and the static structural analysis is carried out in ANSYS work bench 14.5 software. In this paper two type of composite material were used, as aluminium alloy 42CrMo4 and aluminium based composite material reinforced with boron carbide (Al6061 +B4C). Boundary conditions were applied on the connecting rod and unknown variables such as stresses, deformations, strain and maximum shear stresses were found out using the FEA software. And it was observed that 42Cr Mo4, Al6061+B4C metals have a greater strength and low wear tear. The main objective of this paper was to study the stress, strain and deformation induced in the CR.

From their research they concluded that a Al6061 +B4C show less stress and low deformation values compared to the 42Cr Mo4 and these less stress values are more suitable for fabrication of CR.

The Prateek Joshi et al [5] made their research on analysis of connecting rod by using different materials. The main objectives of these paper was to carry out the load strain and stress analysis of connecting rod of different materials and compare the high strength carbon fiber connecting rod with connecting rod made up of stainless steel and aluminum alloy. These results could be used for weight reducing and for designing modification of the connecting rod. In this paper modeling had done using Pro-E software and analysis is carried out using ANSYS software. Generally, they analyze forces acting on the connecting rod such as bending and axial due to reduction of weight and combustions of fuel. In that paper he found out the von misses stresses, strain intensity output and which new materials are more suitable for connecting. The comparison is made between the new material and existing material used for the connecting rod. Static analysis had done on the connecting rod for different materials and the fatigue location was found out. They conclude following results:

1. The strain intensity acting on the connecting rod which is made up of carbon fiber was greater as compared with the connecting rod made up of stainless steel.
2. Connecting rod made up of aluminum alloy has higher intensity of stress, strain acted as compared to CR made up of carbon fiber that is carbon fiber should be better replacement of aluminum alloy.

The Vinay Patil et al [6] had done the comparative study of AISI 4340 and Al 7068 and Al 7078 connecting rods. ANSYS software was used for the analysis of connecting rod. They replace steel (AISI 4340) with aluminium 7078 and apply various load condition on the connecting rod such as compressive load, tensile load and buckling load and then analysis the connecting rod. The main objective of this analysis was to reduce the weight and improve the strength of connecting. They apply various boundary conditions for AISI 4340 and factor of safety was considered as 2.5, tensile yield strength= 284 MPa and the allowable compressive strength= 445.4 MPa. Same boundary conditions were applied on the Al7068 material. By comparing both materials they got following results:

Table 3 Properties of connecting rod using different material

Item	**AISI4340**		**Al7068**	
	Tetra	Hex	Tetra	Hex
Compressive strength	50000	49600	39700	39300
Tensile strength	13500	13500	12000	12100
Buckling load	37220	37190	12957	12944

The Abhinav Gautam et al [7] made paper the static analysis of connecting rod by using Finite element analysis approach. Modelling was carried out with the help of CATIA and analysis is carried out using FEA software. Static analysis of connecting rod was done using ANSYS. The main purpose of this paper is to minimize the failure of smaller end due to gudgeon pin assembly which is under high crushing load. During analysis they fixed the small end and apply load on the big end. . Type of meshing is the finite element mesh, generated using parabolic tetrahedral element. Three loads that is 15.39 KN, 14.32 KN, and 13.26 KN were applied one by one at 180 degree of surface and stresses were obtained. From the analysis they conclude that, the area close to root of the smaller end is very prone to failure, may be due to higher crushing load due to gudgeon pin assembly. As the stress value is maximum in this area and stresses were repetitive in nature, there were chances of fatigue failure were always higher at this region.

- **Conclusion**

This literature study is mainly focused on the material used for the connecting rod and structural analysis in static loading. In the literature, the analysis performed on the connecting rod has been reported. The suggested work on the analysis of connecting rod has done successful in weight reduction, increase in von misses stresses, decrease in von misses strain, reduction in deformation etc. This study will help for enhancement and development of connecting rod. The properties of connecting rod can be improved by using modal analysis, static and thermal analysis and by validation of results.

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