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REVIEW ON OPTIMIZATION OF CONNECTING ROD BY USING COMPOSITE MATERIALS

Sujata D. Kadam[1], Rohini R. Date[2], Ashwini K. Kadam[3], Sujit S. Malgave[4]
[123] Students, Department of Mechanical Engineering, AITRC, Vita, India

[4]Assistant Professor, Department of Mechanical Engineering, AITRC, Vita, India

ABSTRACT

The connecting rod is a component which attaches 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.

KEY WORDS: *ANSYS, CATIA, IC engines, connecting rod, stresses, structural analysis*

I. 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.

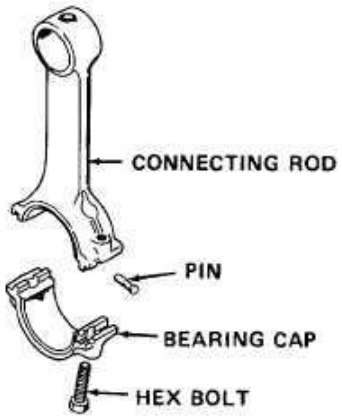

Fig 1: connecting rod

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.

II. LITERATURE REVIEW

The Arshad Mohamed et al [1] had done modelling and analysis of connecting rod. They had replaced the conventional material of connecting rod with aluminium reinforced with boron silicide composite, for Suzuki GSI 150R motor bike. The model of connecting rod is carried out in CATIA V5 software. The analysis is carried out using ANSYS software. In this paper good combination of parameters like von misses stress and strain, deformation, factor of safety and weight reduction of two wheeler piston were done in ANSYS software. Comparison was made between existing carbon steel connecting rod and aluminium connecting rod. They had applied 15.5MPa pressure at the small end of connecting rod and big end was fixed. Maximum and minimum von misses stress and strain, displacement, frequency were noted from the analysis.

Table 1. Deformation von misses stress and elastic strain for different materials

Sr. no.	Material	Deformation	Von misses		Elastic strain
			Max	Min	
1.	Carbon steel	0.01495	79.399	7.79e-5	3.97e-4
2.	Aluminum boron silicide	0.0155	61.383	3.9e-4	3.507e-4

When both the material were compared following conclusion were made:

1. stresses induced in connecting rod are almost same
2. factor of safety foe aluminium boron silicide metal matrix composite was high as compared to existing carbon steel
3. Reduction is weight was obtained after changing the material. Carbon steel(0.31kg) and for aluminium boron silicide (0.15kg)
4. Number of cycles of aluminium boron silicide (2095*10^4) was more than carbon steel (7046.36*10^3).

The Suraj pal and Sunil Kumar [2] described the design evaluation and optimization of connecting rod. Finite element analysis of connecting rod of Hero Honda splendor was taken for study using FEA tool ANSYS workbench. In this study, structural analysis of connecting rod was analyzed using finite element techniques. Hence, firstly proper model of connecting rod was developed using CAD software Pro/E wild fare 4.0. The static analysis was carried out by keeping the axial load 4319 N and buckling load 21598 N constant in both tension and compression using ANSYS software. The von misses stress, shear stress, elastic strain in present design of connecting rod were determined using FEA software ANSYS workbench V12. From the observation of static and load analysis, the load for optimization study was selected. These results were also used to determine various stress and fatigue life, damage, factor of safety, stress biaxiality. The result of existing model of connecting rod and modified model in ANSYS were compared. By changing the parameter of connecting rod they concluded the weight optimization of connecting rod. In existing model weight of connecting rod was 131.5g. and optimization of connecting rod was 126.73g the percentage weight reduction is 3.62% and fatigue results also good agreement with existing result.

The Kuldeep B et al [3] presented the analysis and optimization of connecting rod. For the finite element analysis of 150cc 4 stroke engine was taken for study using FEA tool ANSYS workbench. In this work structural analysis of connecting rod was analyzed using finite element techniques and total forces acting on connecting rod were calculated and then it was modeled in CAD. In this study, connecting rod was replaced by aluminum based composite material reinforced with silicon carbide and fly ash. For the finite element of analysis 16 MPa of pressure was used. For this study they were uses the Al6061-9%, SiC-15%Fly ash material. The pressure was applied at small end of connecting rod by keeping big end fixed. From the observation they found out the von misses stress, von misses strain and displacement were obtained from the ANSYS software. From this study they observed that weight was

reduced as compared with the connecting rod which is made up of Al360. The weight of Al360 was 268.11g and weight of AlFASiC was 151.55g. Hence there was net difference of 116.63 in new connecting rod. The connecting rod made up of ALFASiC was stiffer than Al360 connecting rod. Hence they were concluded that weight can be reduced by 43.48% with 75% reduction in displacement. As compare to former material new material found less weight and better stiffness.

The S. Ramsubramanian et al [4] presented the design manufacture and analysis of Al/SiC MMCs for connecting rod. For this study, the connecting rod was manufactured using the stir casting method. The connecting rod was designed and meshed using the solid works and hyper mesh. Then the analysis was done with the help of ANSYS workbench 14.0 software. In this study, the stress, strain, deformation and thermal analysis was carried out. The analysis was made using aluminum reinforced using SiC having ratios of Al60%/SiC40%, Al75%/SiC25%, Al70%/SiC30%. This property was done through the stir casting process. They had done proper estimation of properties with appropriate testing methods. Mechanical testing and required design analysis were discussed. Further, the Al60/SiC40 was subjected to stress, strain, deformation and thermal analysis and then compared with C70 steel. The following results were obtained:

- Al/SiC has less tensile strength than the C70 steel.
- Al/SiC has hardness nearer when compared with C70 steel.
- Al/SiC can withstand more temperature that C70 steel.

They were also carried out the mechanical test on C70steel vs. Al/SiC.

Table 2. Laboratory test report on C70 steel v/s Al/sic

Properties	C70 steel	Al/SiC
Tensile strength (MPa)	966	107.8
Hardness	156	125 HV
Temperature	632 c	858 c

The Harpreet singh et al [5] had studied the analysis of connecting rod. The modelling was carried out by using CATIYA V5 R17 software and analysis was done using ANSYS software. They analyze various parameters like equivalent stress, maximum shear stress, maximum and minimum principle stress and factor of safety. The connecting rod subjected to more compressive and tensile forces due to the fuel consumption. If the magnitude of this forces is more than many types of failure are occurs. In process of combustion the high load acting the connecting rod which leads to failure because of frequent loading. They had replaced the Al connecting rod with structural steel Al LM6 and Ti-6AL-4V. The two types of forces are considered i.e. compressive and tensile loads were applied on CR at the pin end and 34.23MPa on crank end. In this case of tension pressure was 70.88 MPa acting on end and 37.81 MPa on crank end.

According to their analysis they conclude following results:

1. equivalent stresses, maximum shear stresses maximum principle stresses and minimum principle stresses are nearly same for all three materials,
2. The factor of safety for Ti-6AL-4V is 3.9258 is more than other two materials,
3. Ti-6AL-4V materials was stronger than other two materials and the maximum stresses obtained in structural analysis were less than yield strength of material.

The G.M. Sayeed Ahmad et al [6] had studied design and fabrication of connecting rod using aluminium alloy and carbon fiber. The CATIA V5 R17 was used for modelling and analysis was done by using ANSYS software. In this study they had done structural analysis and harmonic analysis. If steel material was used for connecting rod, due to the high mass density of steel it exerts excessive stresses on the connecting rod of the engine, hence it requires heavier connecting rod for carrying the loads hence

maximum RPM is limited. In this study they replace the steel connecting rod with AL alloy and carbon fiber. The aluminum alloys are aluminum 6061, aluminum 7075, aluminum 2014 were used for analysis. According this analysis the results obtained were as follows:

Table 3. Results for stress and strain:

	Aluminum 6061	Al7075	Al2014	Carbon fiber
Displacement (mm)	0.821e-04	0.845e-04	0.008212	0.2701e^-0.3
Stress (N/mm^2)	71.5632	72.2133	71.5869	72.5887
Strain	0.43E-04	0.001129	0.001425	0.484E-04
Ultimate tensile strength	117	221	220	

Following results were concluded from this analysis:

1. The stresses acting on these four materials are nearly same
2. There are small change in ultimate tensile strength,
3. The weight of the connecting rod is less than steel,
4. The carbon fiber connecting rod has good strength.

The Mohamed Abdulsalam Husain et al [7] in this paper they studied the design and analysis of connecting rod. The modeling was done in solid work software and the analysis was carried out by using ANSYS software. They analyze the von misses stresses and strain, deformation, factor for safety and weight reduction of two wheeler piston rod by using by ANSYS software. In this thesis they had replaced forged steel rod connecting rod by aluminum alloy. They design the connecting rod by using following formulas:

1. For calculation of factor of safety:
   $(1/FOS)= \sigma m/\sigma y + \sigma v/\sigma e$
   Where,
   FOS= factor of safety,
   σm= mean stress,
   σy= yield stress,
   σv= variable stress,
   σe= endurance stress

2. For fatigue calculation:
   $N= 1000(Sf/0.9\ \sigma u)^{3/[\log(\sigma e/0.9\ \sigma u)]}$
   Where,
   N= no. of cycles,
   σu= ultimate tensile stress.

From there analysis they conclude that aluminium alloy has more factor of safety and more stiffer than other materials like forged steel and also they found the weight reduction and less stresses are induced in aluminium alloy than other materials.

The vikas singh et al[8] they studied about which forces acting on the connecting rod for different materials. In that paper they had done modeling in solid work 2016 and also analysis was carried out by using ANSYS 16.2 software. They were studied load strain deformation and analysis of factor of safety. They change the material of existing connecting rod by beryllium alloy and magnesium alloy. FEA analysis was carried out by considering five materials like Al 360, forged steel, Titanium alloy, Ti-13V-11Cr-3al, magnesium alloy, beryllium alloy. The main objective of this paper was to find which material is best for connecting rod by using ANSYS software. They found out which loads were acting

on connecting rod and concluded that the loads acting on connecting rod were compressive load which acts at piston pin and second is bending stresses and third is inertia forces. They also discuss about the material properties and composition of the materials and draw charts of density of material, weight of material and deformation of this various materials. By comparing the results they concluded that the forged steel was heavier than the aluminum, magnesium and beryllium alloy so the life of connecting rod using this alloy is maximum.

The Prateek Joshi et al [9] 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 result 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, 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 is 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.

III. 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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Authors Biography:

Kadam sujata dhananjay, Birth palace: shelakbav, Country: India Bachelor of engineering, Department of mechanical engineering Shivaji University, Kolhapur.

Date Rohini Rajendra, Birth palace: Kolewadi, Country: India Bachelor of engineering, Department of mechanical engineering Shivaji University, Kolhapur

Kadam Ashwini Kalidas, Birth palace: shelakbav, Country: India Bachelor of engineering, Department of mechanical engineering Shivaji Univercity, Kolhapur

Sujit S. Malgave, Country: India, Designation: Assistant Professor, Qualification: B.E. Mech. Engg, Area of Specialization: CAD/CAM/CAE Experience: 6 years