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COMPARATIVE STUDY OF MATERIALS FOR MANUFACTURING CONNECTING ROD

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Abstract

The connecting rod is the intermediary member between the piston and the crankshaft. Its main function is to transmit the pushing and pulling force of the piston pin to the crank pin thus converting the reciprocating motion of the piston into the rotary motion of the crank. The part which is highly stressed by the internal combustion engine is the connecting rod. A connecting rod act as a lever arm by transmitting motion from the piston to the crankshaft. In this paper, we will study various materials which have been experimented with and analysed for the manufacturing of connecting rods.

Keywords: *Connecting Rod, Manufacturing, Engineering Materials.*

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1. INTRODUCTION

The connecting rod has a colossal field of research. In addition to this, vehicle construction led to the invention and implementation of quite new materials which are light and meet design requirements. And the optimization of connecting rods had already been started in the early year 1983 by Webster and his team. There are many materials that can be used in connecting rods for optimization. The connecting rod in modern automobile internal combustion engines is usually made of steel but aluminum (for light weight and high impact absorption at the expense of durability) or titanium (for high performance) or cast iron for applications such as motorized scooters can be selected [1]. In this study materials compared are Carbon Steel, Forged Steel, Aluminium 360, AlFASiC, Magnesium Alloy, and Beryllium Alloy.

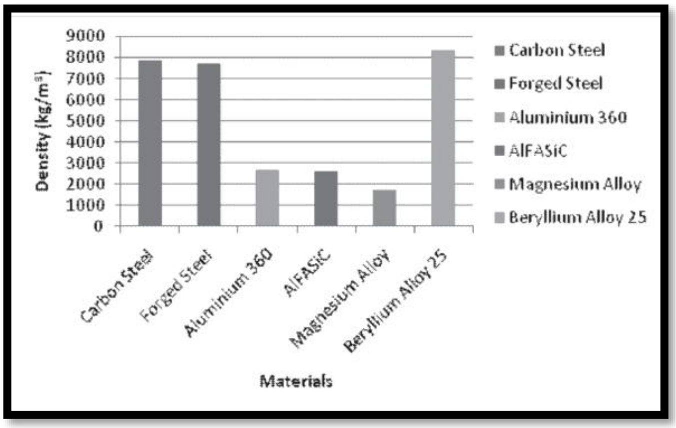

Figure 1. Graph of Materials vs Density

K. Sudershankumar [2] et al, (2012) described the modelling and analysis of Connecting rods. In his project carbon steel connecting rod is replaced by an aluminium boron carbide connecting rod. Aluminium boron carbide is found to have a working factory of safety nearer to the theoretical factory of safety, increasing the stiffness by 48.55% and reducing stress by 10.35%.

Leela Krishna Vegi, Venu Gopal Vegi [3], (2013), demonstrated that the factor of safety (from Soderberg's), stiffness of forged steel is more than the existing carbon steel found and the weight of the forged steel material is less than the existing carbon steel and reported that by using fatigue analysis lifetime of the connecting rod can be determined.

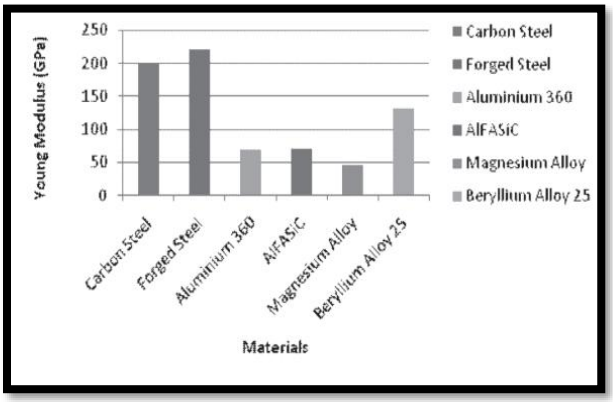

Figure 2. Graph of Materials vs Young Modulus

Kuldeep B. et al [4], (2013) described in the study that Weight can be reduced by changing the material of the current Al360 connecting rod to a hybrid AlFASiC Composite. He described that the aluminium composite connecting rod is 43.48% lighter than the Al360 connecting rod and much stiffer. A. Gupta et. al. [5], (2014) compared three materials used for manufacturing connecting rods these are Al360, magnesium alloy, and beryllium alloy using. The modelling and analysis of connecting rod were done. The FEM analysis was performed considering three materials: AL360 beryllium and magnesium alloy. In his study he found out that out of above three material beryllium alloys is the best suitable material for connecting rod of two wheelers. Comparing the various results obtained through the analysis it can be concluded that the stress induced by the beryllium alloy is lower than that of the aluminium and magnesium alloy.

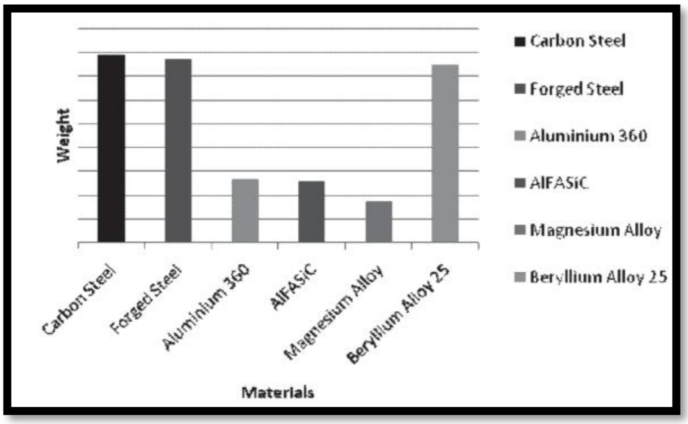

Figure 2.3. Graph of Materials vs Weight

Mr. H. B. Ramani, et. al. (2012) [6] investigates the stress developed at different parts of connecting rod using CAE software. It is evident from the result shown by the authors that the maximum stress developed was between the pin end and rod linkages and between the bearing cup and connecting rod linkage. The maximum tensile stress developed in the lower half of the pin end and between the pin end and rod linkage. It is suggested that the results obtained can be useful to bring about modification in the design of connecting rod. The properties of different materials are shown in the below-mentioned chart through which the analysis of the material was done. He took different types of connecting rods made of cast steel, forged steel, aluminium-360, AlFASiC (Aluminium based composite material reinforced with silicon carbide), magnesium alloy, and Beryllium alloy, and compared their density, young modulus, stiffness, and, weight. Know the review is focused on three materials that are light in weight & having stiffness. Stress, strain, and displacement comparison for Al360, beryllium alloy, and magnesium alloy is taken into consideration.

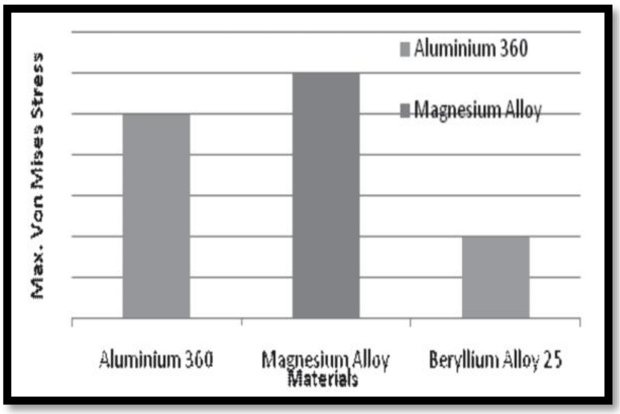

Figure 2.4. Graph of Materials vs Max. Von Mises Stress

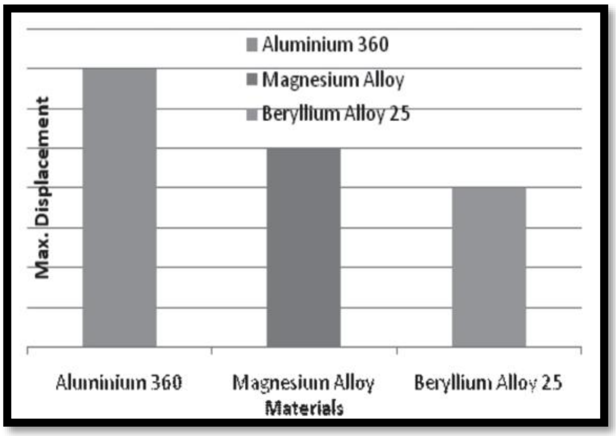

Figure 2.5. Graph of Materials vs Max. Displacement

Ankit Gupta and Mohd. Nawajish [7] describes the design and analysis of connecting rods for two-wheelers. In this study the connecting rod material was replaced by beryllium alloy and the analysis of magnesium alloy was carried out considering three materials magnesium alloy beryllium alloy AL360. PRO-E software was used to design the connecting rod in this study and analysis was done in ANSYS 10.0 software. The properties like maximum displacement, maximum von-mises stress and maximum von-mises strain appears to be minimum in beryllium alloy connecting rods as compared to other materials, and the resulting stress is lower in beryllium alloys. The author suggests that beryllium alloy can be used to make connecting rods for strength and durablility.

Prateek joshi et al. [8] compared connecting rod of Carbon Fiber material with Aluminium Alloy and Stainless-Steel connecting rod based on the load, strain and stress analysis of the connecting rod. For designing PRO-E and for analysis of connecting rod, Ansys software is used. Author concluded that Carbon Fiber is the best material that can be utilized for the manufacturing of Connecting Rod, for being lighter and equivalent strength with that of Stainless Steel and Aluminium Alloy.

D.Jeeva and Ashok Kumar.R.[9] aused finite element analysis to analyze connecting rod fracture. Ansys software is used to analyze the stress and temperature change in the connecting rod. For designing of connecting rod CATIA V5 software is used. The connecting rod is designed using CATIA V5 software. The authors found that the maximum displacement and maximum von Mises strain of the beryllium alloy connecting rod were lower. It was also concluded that aluminum alloy CR had higher weight and displacement than magnesium and beryllium alloy CRs. Hence aluminum alloy CRs show more quivery behavior. Marthanapalli Hari Priya and K. Manohar Reddy [10]demonstrated on forged steel connecting rods to reduce weight and production costs. The actual section of the connecting rod is changed from I to H and the weight of the connecting rod is reduced by 10 grams. The connecting rod material was changed to Al360 and the connecting rod weight was found to be four times less than carbon steel.

Vikash Singh and others [11] compared connecting rods using different materials according to the ANSYS parameters von mises strain, stress, and displacement. The connecting rod analysis was completed in the Ansys workbench16.2 software and the 3D model of the connecting rod was made in the Solidworks 2016 software. The strain, stress, and maximum von Miser displacement of the beryllium alloy connecting rod were smaller than those of the carbon steel, magnesium, and aluminum alloy connecting rod. The authors suggested that beryllium alloys could be used in the production of connecting rods to extend their service life. K U Arun Kumar and others [12] in their research work to analyze composite connecting rods of specific materials and composites using NX NASTRAN and ANSYS software found that the von-mises equivalent stress is almost the same for all materials but less AISI4140.

Akshay Nighot and others [13] optimized the design by calculating the weight and stiffness of different materials using CATIA for the design and ANSYS 16.2 for the research work and found that the forged steel connecting rod is heavier than the connecting rod made of magnesium, aluminum, and beryllium alloy. Among the alloys of aluminum magnesium and beryllium, the smallest compressive displacements and stresses were also found in beryllium. Lucjan Whitekett and others [14] used CATIA and ANSYS to create a geometric model for the purpose of studying the failure and stress analysis of turbocharged diesel engines and concluded that the origin of the crack is not due to corrosion or defect in material but due to maximum principal stress occurring at the hole of the bolt of the connecting rod. Vinayak Chamber and others [15] used NX 6.0 and ANSYS 14.5 software to investigate and analyze the structure of the connecting rod using FEA techniques the original weight of 129.9 g was reduced to 127.96 g by changes in the design. Puneet Aggarwal and others [16] developed a 3D model of a connecting rod to investigate the effect of different material components on the structural behaviour of the connecting rod and found that the von-misses stress and strain in the alloy of aluminum 7075 compared to forged steel, titanium alloy is less using SOLIDWORKS ver. 2013. It was due to the increase in the percentage of silicon in the Aluminium alloy. Kuldeep B and others [17] replaced the material Al360 with a hybrid Alfa Sic composite of connecting rod and described the design and analysis of connecting rod. Ansys parameters such as von-mises stress, von-mises strain, and displacement are obtained for both the materials and compared to find out that the weight of the hybrid Alfa Sic composite connecting rod was 43.48 percent less than the Al360 connecting rod.

B Anusha et al [18] analyzed a static analysis performed on a connecting rod. The connecting rod is designed with PRO-E software FEA is performed in Ansys software to determine von Mises stress, von Mises strain, and total deformation. The authors concluded that the stresses induced in mild steel are lower than in cast iron in the present study. HD Nittukar et al [19] describe the design and analysis of connecting rods using different materials. Connecting rod design is done using NX10 software and connecting rod design is done by calculation. FEA is performed using Ansys software to determine the von Mises stress, von Mises strain, and total deflection of the connecting rod. ANSYS results show low analytical parameters for beryllium alloy connecting rods. H.D. Nitturkar et al [20] used NX10 and ANSYS software to analyze the stresses using the FEA approach for each material selected for the study, the minimum stresses at the crank end cap and piston end, and the static analysis. They concluded that the maximum tension was found at the small end. Ramesh B.T. and others [21] used ANSYS software to analyze and reduce the weight of connecting rods using different materials, Aluminum 7075 was found to be the best material for connecting rods in terms of toughness, manufacturing, and cost.

P Saikiran et al [22] used SOLIDWORKS software to design and analysis of the connecting rods was performed using ANSYS. They measured the transient temperature of the connecting rod at various points. They found that the maximum deformation occurs at the smaller end of the bearing at the Fiber's inner surface. Next, deformation is in the middle of the big end caused by buckling and significant shear failure under critical load and connecting rod bearings. Mohammed Abdusalam Husin and others [23] Using SOLIDWORKS & ANSYS 15.0 for connecting rod research and planning purposes. They found that the minimum stress on the crank end cap is also on the piston end under each stacking condition. Thus reducing the cost of materials.

Naman Gupta et al [24] used CREO 2.0 to design by simulation and over-machining of its connecting rod to optimize weight and lighten components within acceptable limits. Using AISI4340 has been found to reduce the weight of connecting rods by up to 74% more than the Vertical cut connecting rod made of Al7068. The acceptable limit is 15% of the community segment that is cut horizontally. Al7068 connecting rod can be restored instead of solid connecting rod Al 7068. Sebastian Anthony et al [25] used CATIA V5 for geometry modeling and for Analytical purposes ANSYS was used to perform FEM analysis and obtain stresses based on analysis of the load applied to the connecting rod and found this comparison for aluminum with steel and steel was a better choice due to its higher load strength than aluminum connecting rod.

ANSYS18.1 programming was used by Dr. BSN Murthy et al [26] to implement improved connecting rods under stacking pressure generation and recommended openings for weight reduction. They concluded that titanium has good mechanical properties and capacity and is also less malleable. They also recognized that there are tremendous edges of material ejection from the connecting rod's large end zone, small end zone, and areas associated with the small end. According to analytical calculations, the thickness of the I region may be reduced somewhat.

2. CONCLUSION

As the study shows various materials and their properties. The following materials are selected from the various materials based on their ease of availability, strength, cost, and properties required for connecting rod. The following table shows the materials along with their properties

S.N.	MATERIAL	DENSITY	YOUNGS MODULUS	POISSONS RATIO
1	BEI220H	1.844 g/cc	3.0375e11 Pa	0.070-0.18
2	Titanium alloy (Ti6al4V)	4429 kg/m3	1.04e11 N/mm2	0.31
3	Aluminum 6061 BORON Carbide	7.87 g/cc	200	0.29
4	Alloy Steel (8620).	7700 kg/m3	190-210	0.27-0.30

3. CONCLUSIONS AND RECOMMENDATIONS

The selected materials can be analyzed by using analysis software such as ANSYS and can be checked for weight reduction of the connecting rod.

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