



Review on Design and Analysis of Connecting Rod Using Different Material

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Abstract:

Connecting Rods are used practically generally used in all varieties of automobile engines acting as an intermediate link between the piston and the crankshaft of an engine of an automobile. It is responsible for transmission the up and down motion of the piston to the crankshaft of the engine, by converting the reciprocating motion of the piston to the rotary motion of crankshaft. While the one end, small end the connecting rod is connecting to the piston of the engine by the means of piston pin, the other end, the bigger end being connected to the crankshaft with lower end big end bearing by generally two bolts. Generally connecting rods are being made up of stainless steel and aluminium alloy through the forging process, as this method provides high productivity and that too with a lower production cost. Forces generated on the connected rod are generally by weight and combustion of fuel inside cylinder acts upon piston and then on the connecting rod, which results in both the bending and axial stresses. The present paper attempts to design and analyze the connecting rod used in a diesel engine in context of the lateral bending forces acting along its length during cycle of it The lateral bending stress are commonly called as whipping stress and this whipping stress forms the base of evaluation of performance of various materials that can be used for manufacturing of connecting rod. The conventional material used is steel which is designe using CAD tool which is CATIA V5 and subsequently analysed for bending stress acting on it in the arena of finite element analysis using ANSYS workbench 14.5 and this procedure is followed for different material which are aluminium 7075 , aluminium 6061 and High Strength Carbon.

Keywords: Connecting Rod, Analysis, FEA

I. INTRODUCTION

The conversion of heat energy into mechanical energy is achieved by device called as internal combustion engine and connecting rod forms an integral part of this engine. The function of connecting rod is to transmit the gas pressure available at piston end to crank end for efficient conversion of heat energy into mechanical energy. During this process of nergy conversion various forces and corresponding stresses are generated on the body of connecting rod and it forms the most stressed part of I. C engines. The two forces acting on connecting rod can be classified as buckling load due to gas pressure and lateral bending due to inertia forces.

The inertia forces cause bending of connecting rod which causes whipping stress acting on it. In this project the conventional material used for manufacturing of connecting that is steel is replaced by aluminium alloys such as 7075 and 6061 and High Strength carbon fiber. The lateral bending of connecting rod occurring on each materials are evaluated analytically and using FEA approach. Computers employing microelectronics technology are called for aiding the geometric modeling of connecting rod which would provide the model for subjecting it to various materials.

The calculation of whipping stress due to inertia is first calculated for each material using analytical approiach. Geometricallymodeled connecting rod in CATIA V5 is subjected to diffrent materials and the equivalent stress results are calculated by FEA software named as ANSYS which are compared with the equivalent stress acting on the conventional connecting rod material that is steel to provide a platform for evaluation and validation of design.

II. MATERIAL FOR CONNECTING ROD

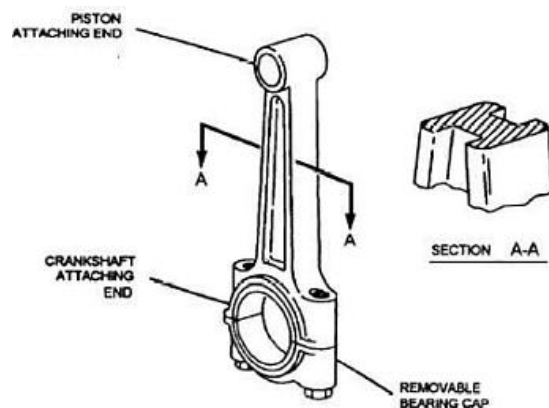


Figure.1. Connecting rod assembly.

The most common type of production methods is casting, forging, and powdered metallurgy. Connecting rod must withstand a complex state of loading. It need to undergo 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 vital. Due to these factors, automotive connecting rods have been the topic of research for different aspects such as production technology materials, performance, simulation, fatigue, etc. In modern automotive cylinder engines, the connecting rods are most usually made of forged steel for production engines. Connecting rods for automotive applications are typically manufactured by forging from either forged. They could also be cast. Between the forging processes, powder forged or drop forged, each process has its own advantages and disadvantages. Powder metal

manufactured blanks have the advantage of near net shape and saving materials. However, the cost of the blank is high due to the high material cost and sophisticated manufacturing techniques. With steel forging, the material is cheap and the drop forging manufacturing process is cost effective. Due to its large volume 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

III. RESEARCH PROBLEM DEFINITION

The present work provides an insight of bending stress acting along the body of connecting rod due to inertia forces acting on the connecting rod which are known by name of whipping stress. The bending moment is dependent on material selected for connecting rod and is used to evaluate the bending stress acting on steel, Al7075, Al6061 and high strength carbon fiber. The comparative study of bending stress parameter provides the best material to be selected for connecting rod of diesel engine

IV. METHODOLOGY

[4.1] To design the connecting rod for a diesel engine so as to determine the section thickness of connecting rod.

[4.2] to geometrically model the connecting rod as per the dimensions generated from the process of design procedure followed.

[4.3] To analyse the whipping load which is bending stress due to inertia forces acting on each material of connecting rod

[4.4] To analyse the bending stress using FEA approach on each material selected for study.

[4.5] To plot the results for bending stress acting on Al7075, Al6061 and high strength carbon fiber and comparing this with bending stress acting on conventional material.

V. LITERATURE SURVEY

The following research papers are consulted for obtaining an in-depth understanding of various aspects of the project:-

Suraj Pal et al. [1] “Design Evaluation and Optimization of Connecting Rod Parameters Using FEM” In this paper Finite element analysis of single cylinder four stroke petrol engines is taken for the study; Structural systems of Connecting rod can be easily analyzed using Finite Element techniques. So firstly a proper Finite Element Model is developed using Cad software Pro/E Wildfire 4.0. Then static analysis is done to determine the von Mises stress, shear stress, elastic strain, total deformation in the present design connecting rod for the given loading conditions using Finite Element Analysis Software ANSYS. In the first part of the study, the static loads acting on the connecting rod, After that the work is carried out for safe design.

G. Naga MalleshwaraRao et al. [2] “Design Optimization and Analysis of a Connecting Rod using ANSYS” The main Objective of this work is to explore weight reduction opportunities in the connecting rod of an I.C. engine by examining various materials such as Genetic Steel, Aluminium, Titanium and Cast Iron. This was entailed by performing a detailed load analysis.

K. Sudershan Kumar et al. [3] “Modelling and Analysis of Two Wheeler Connecting Rod” This paper describes modelling and analysis of connecting rod. In this project connecting rod is replaced by Aluminium reinforced with Boron carbide for SuzukiGS150R motorbike. A 2D drawing is drafted from the calculations. A parametric model of connecting rod is modelled using PRO-E 4.0 software. Analysis is carried out by using ANSYS software.

B. Anusha, C.VijayaBhaskar Reddy et al. [4] “Modelling and Analysis of Two-wheeler Connecting Rod by Using Ansys” In this paper a static analysis is conducted on a connecting rod of a single cylinder 4-stroke petrol engine. The model is developed using Solid modelling software i.e. PRO/E (creo-parametric). Further finite element analysis is done to determine the von-mises stresses shear stress and strains for the given loading conditions.

B. Anusha, Dr. C. VijayaBhaskar Reddy et al. [5] “Comparison Of Materials For Two- Wheeler Connecting Rod Using Ansys” The modelled connecting rod imported to the analysis software i.e. ANSYS. Static analysis is done to determine von-mises stresses, strain, shear stress and total deformation for the given loading conditions using analysis software i.e. ANSYS. In this analysis two materials are selected and analyzed. The software results of two materials are compared and utilized for designing the connecting rod.

Mr. H. B. Ramani et al. [6] “Analysis of Connecting Rod under Different Loading Condition Using Ansys Software” In this study, detailed load analysis was performed on connecting rod, followed by finite element method in Ansys-13 medium. In this regard, In order to calculate stress in Different part of connecting rod, the total forces exerted connecting rod were calculated and then it was modelled, meshed and loaded in Ansys software. The maximum stresses in different parts of connecting rod were determined by Analysis. The maximum pressure stress was between pin end and rod linkages and between bearing cup and connecting rod linkage. The maximum tensile stress was obtained in lower half of pin end and between pin end and rod linkage. It is suggested that the results obtained can be useful to bring about modification in Design of connecting rod.

VI. GEOMETRIC MODELLING IN CATIA V5

[6.1] The various components for the assembly of connecting rod are designed as per the rating of a diesel engine used in TATA Sumo four wheeler. The dimensions are determined from above process and various components are modeled and subsequently assembled as final product that can be illustrated here.

[6.2] The first component to be modeled is the connecting rod with a section thickness of 7.3 mm and height of 36.5mm which can be shown below

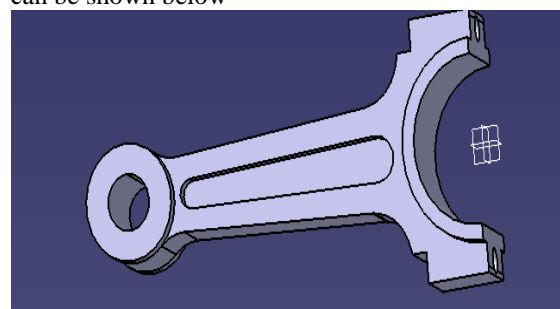


Figure.2. Geometric Modeling of connecting rod

[6.3] The next part modeling deals with geometrically designing the upper cap of connecting rod which is used for fixing the crank end of connecting rod .the dimensions of this components are same as upper section of connecting rod and can be depicted as follows

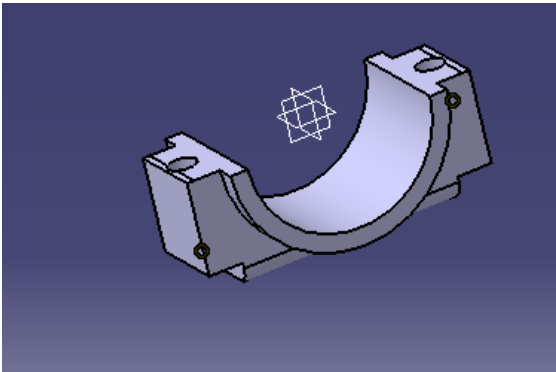


Figure.3. Geometric modeling of Upper cap of crank end

[6.4] The last component is a bolt of 12 mm which is metric in standard and is used for clamping of crank end to assemble the complete connecting rod

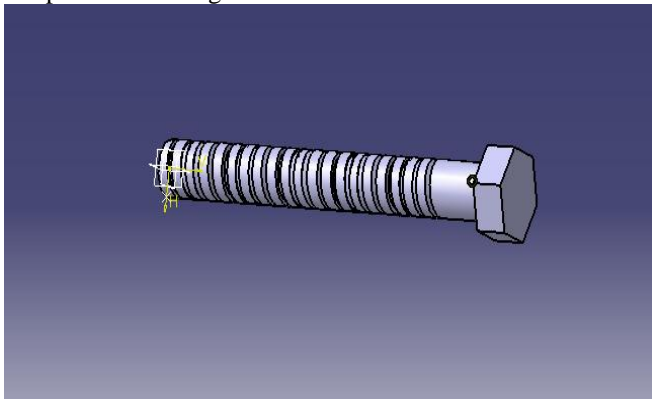


Figure.4. Geometric modeling of Upper cap of crank end

[6.5] All the components modeled previously are assembled as single product to provide the design of connecting rod. The constraint provided are geometrical constraint which are used to define the relation of various components with each other as shown below

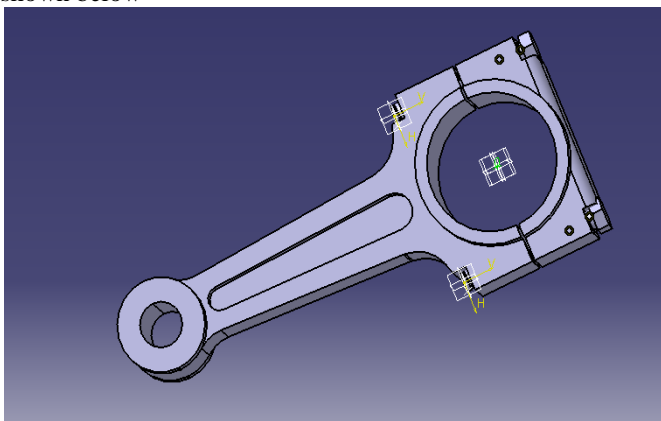


Figure.5. Assembly of connecting rod

VII. ANALYSIS OF SYSTEM

[7.1]The term internal combustion engine refers to the engine in which working fluid is inside the work producing chamber and in most of IC engines this mixture in terms of air and fuae is inducted during suction stroke. Further explosion of the mixture leads to generation of various gases and consequent pushing of piston in downward direction. This downward

motion is transmitted to the crank shaft by means of connecting rod and thus the transmitting member i.e connecting rod must be a rigid link ideally. As rigidity cannot be achieved in practice, the deformation produced on connecting rod must be very small which can be evaluated by studying the type of forces acting on connecting [7.2] Connecting rod is subjected to gas pressure and inertia forces of which inertia force contributes to bending of connecting rod. This lateral bending leads to generation of bending stress known by name of whipping stress acting on connecting rod during it’s cycle of operation. This bending stress is dependent on bending moment which acts on the length of connecting rod and is function of density of connecting rod used. Thus variation in material can produce certain results in terms of bending stress acting on the connecting rod and can help to optimize the material than can be used in application of connecting rods .From the domain of various materials that can be implied for construction of connecting rod following four materials are used for calculation of bending or whipping stress acting on them so as to choose the best material which would tend to reduce the whipping load and hence the vibrations of engine during its cycle of operation. The process of analytical analysis is initiated by calculating the maximum bending moment or which is termed as whipping load acting on connecting rod of each material and subsequently calculating the corresponding values of bending stress or whipping stress on connecting rod of each material. The mass of connecting rod per metre length is given by,

$$m_1 = \text{volume} \times \text{density}$$

$$= \text{area} \times \text{length} \times \text{density}$$

$$\text{Hence } m_1 = A \times l \times \rho$$

And $m_1 = A \times \rho$

Here $\rho =$ density of material of connecting rod

As form design consideration we know that $A = 11t^2$

Hence $m_1 = 11t^2 \times \rho$

The value of Maximum bending moment can be shown as

$$M_b = m \times \omega^2 \times r \times L / 9 \times 3^{0.5}$$

Here $m =$ mass of connecting rod

And $r =$ crank radius

$L =$ length of connecting rod

Substituting $m = m_1 \times L$ in above expression

$$M_b = m_1 \times \omega^2 \times r \times L^2 / 9 \times 3^{0.5}$$

$$I_{xx} = 34.91 \times t^4 \quad \text{and } y = 2.5t$$

Hence the bending stress

$$\sigma_b = (M_b \times y) / I$$

Thus above relation is used for calculating the bending stress or the value of whipping stress for different materials

Table.1. Bending moment acting on different materials

MATERIAL	Bending Moment N-m
Steel	5.716
Al7075	1.98
Al6061	1.914
High strength carbon fiber	1.17

[7.3] The connecting rod geometries of different materials are subjected above bending moment acting on the connecting rods and corresponding values of bending stress which are the von mises stresses calculated for each material and this can be shown as follows.

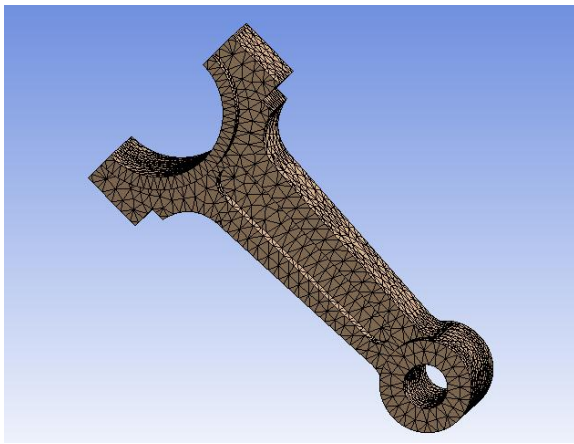


Figure.6. Meshing of Connecting Rod

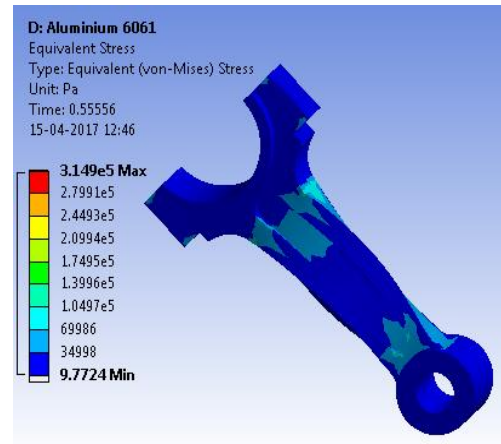


Figure.9. Bending stress on Al6061 connecting rod

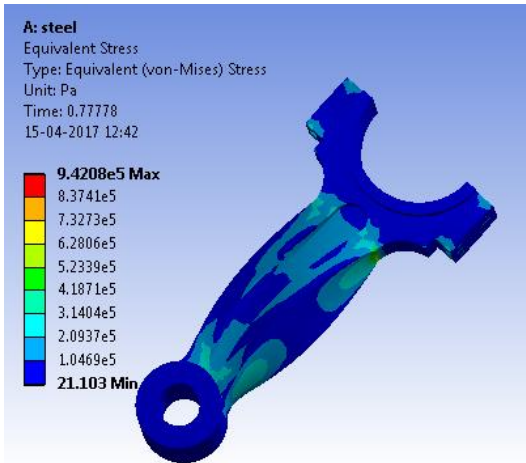


Figure.7. Bending stress on steel connecting rod

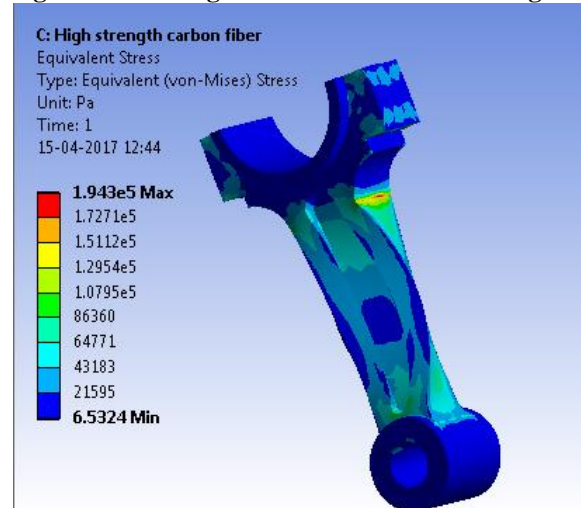


Figure.10. Bending stress on High strength carbon fiber connecting rod

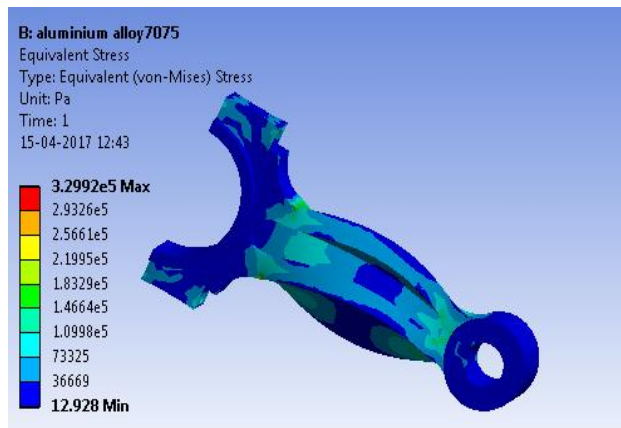


Figure.8. Bending stress on Al7075 connecting rod

VIII. RESULTS AND COMPARISON

[8.1]The process of designing and analyzing the system with relevant parameters of study is followed by inferences generated by evaluation process of the data obtained during the process of analysis. The connecting rod of various material other than conventional material is subjected to various moment ratings which were analytical values employed for analysis of connecting rod and were used to study the behavior of the connecting rod with materials under consideration. The results calculated can be drawn on the lines of effect of Maximum bending moment which is bending stress in this case. The various input values which are used for connecting rod are presented and the variation in the effect due to material variation in the system can be presented as follows

Table.2. Analytical Values of Whipping stress

Property	Analytical Analysis			
Material of connecting rod	Structural Steel	Aluminium Alloy 7075	Aluminium Alloy 6061	High Strength Carbon Fiber
Bending Moment in N-m	5.716	1.98	1.914	1.17
Boundary condition	Fixed support on piston end and crank end	Fixed support on piston end and crank end	Fixed support on piston end and crank end	Fixed support on piston end and crank end
R.P.M	2200	2200	2200	2200
Bending Stress on connecting rod (in N/m ²)	8.636x 10 ⁵	2.993 x 10 ⁵	2.8916x 10 ⁵	1.767x 10 ⁵

Table.3. FEA values of Whipping stress

Property	Finite Element Analysis			
Material of connecting rod	Structural Steel	Al 7075	Al 6061	High Strength Carbon Fiber
Bending Moment in N-m	5.716	1.98	1.914	1.17
Boundary condition	Fixed support on piston end and crank end	Fixed support on piston end and crank end	Fixed support on piston end and crank end	Fixed support on piston end and crank end
R.P.M	2200	2200	2200	2200
Bending Stress on connecting rod (in N/m ²)	9.4208 x 10 ⁵	3.299 x 10 ⁵	3.149 x 10 ⁵	1.945 x 10 ⁵

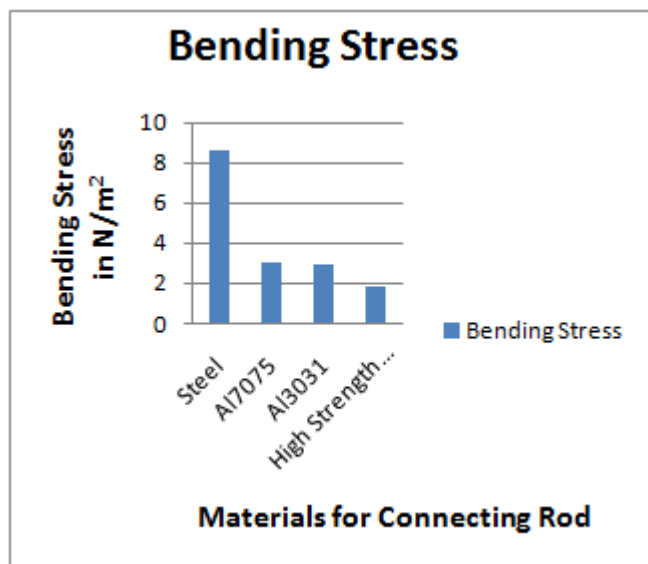


Figure.11. Comparison of analytical values of bending stress for materials under study

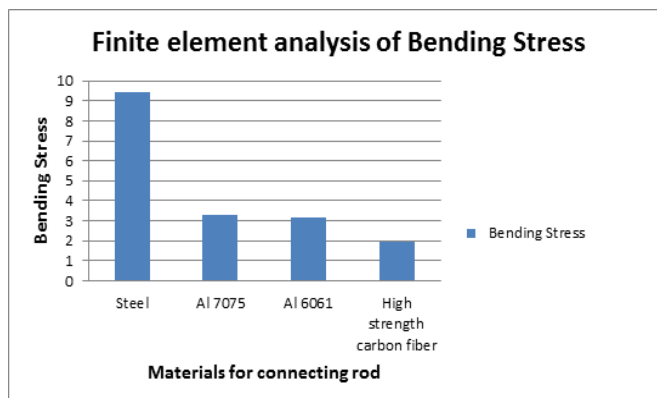


Figure.12. Comparison of FEA values of bending stress for materials under study

IX. CONCLUSION

[9.1] Thus it can be inferred that this paper projects a work to determine the best material that can be used for manufacturing of connecting rods. The geometric model generated with the aid of specification of design procedure is consequently analysed for bending stress which is caused by bending moment due to inertia of connecting rod. The FEA approach helps to evaluate the approximate values of bending stress acting on different material such as Al 7075, Al6061 and High strength carbon fiber which are used to compare with the conventional material employed which is steel. The connecting rod of high strength carbon fiber suffers lesser in context of bending due to inertia and thus can be best suited for connecting rod of diesel engine.

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