Original Research Paper

Volume -10 | Issue - 5 | May - 2020 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Engineering

MODELING AND ANALYSIS OF CONNECTING ROD FOR MULTI-CYLINDER ENGINE BY FEA APPROACH

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ABSTRACT The project report presents a procedure for weight optimization process through Ansys software using finite element analysis. The automobile engine connecting rod is a high volume production component. It undergoes high cyclic loads such as high compressive loads due to combustion, to high tensile loads due to inertia. It connects reciprocating piston to rotating crankshaft, transmitting the thrust of the piston to the crankshaft. Every vehicle that uses an internal combustion engine requires at least one connecting rod depending upon the number of cylinders. In this project, finite element analysis for connecting rod is taken as a case study. So firstly a proper Finite Element Model is developed using CATIA V5R20 .Then the Finite element analysis is done to determine the Von Mises stresses in the existing connecting rod for the given loading conditions using Finite Element Analysis software ANSYS WORKBENCH 9.0. 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. Based on the observations of the static FEA and the load analysis results, the load for the optimization study was selected. It achieve saving in material, weight and cost for manufacturing of connecting rod.

KEYWORDS : Von misses stresses, deformation, Catia, Ansys, finite element analysis, Modeling, Weight optimization.

1. INTRODUCTION

Connecting rod is one of the most critical components internal combustion engines bearing the statically and dynamically fluctuating loads. A Connecting rod is the link between the reciprocating piston and rotating crank shaft. The aim of the connecting rod is to convert the reciprocating motion of the piston into the rotary motion of the crankshaft. It has mainly three parts namely- a pin end, a shank region and a crank end. Pin end is connected to the piston assembly and crank end is connected to crankshaft.

The objective of the present work is to design and analyses of connecting rod made of Aluminum. Model is imported in ANSYS 12.0 for analysis. After analysis a comparison is made between existing aluminum connecting rod with AISI 4340 and Titanium alloy in terms of weight, stresses, deformation. The optimization of connecting rod had already started as early years. However, everyday consumers are looking for the best from the best. That's why the optimization is really important for automotive industry especially. Optimization of the component is to make the less time to produce the product that is stronger, lighter and less total cost productions. The design and weight of the connecting rod influence on car performance. Hence, it effects on the car manufacture credibility. The structural factors considered for weight reduction during the optimization include the buckling load factor, stresses under the loads, bending stiffness, and axial stiffness.

Thus, the component can give the higher strength, efficient design and lighter that would create a major success in the automotive and manufacturing industry. The benefits of connecting rod optimization are eventually gone back to consumer itself. Among the main objectives are to improves the engine performance and also to strengthen the product that is ensure the safety of human being. Connecting rod failed due to insufficient strength to hold the load. By maximize the strength, automatically it will longer the life cycles of the connecting rod. In modern automotive internal combustion engine, the connecting rods are most usually made of steel for production engine. But can be made of aluminum or titanium for high performance of engines. [1, 2]

Function: The connecting rod connects the crankshaft directly to the piston or, as in some other designs, to the crosshead. It is a running component connecting the crankshaft to the piston (in trunk piston engines) or to the crosshead (in crosshead engines). It has both linear (reciprocating, up-and-down) & rotational (rotary) motion.

Lubrication: Lubrication is carried out through the shank bore (drilling) in running throughout the shank length. It conducts oil from the big end to the small end for lubrication and to the inside of piston for its cooling.

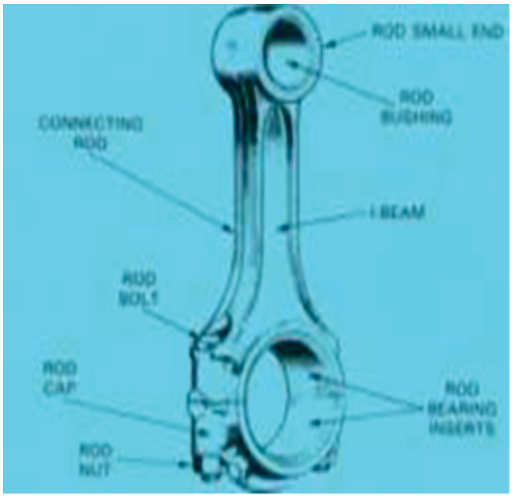

Figure.1: Connecting rod

2. LITERATURE REVIEW:

Kuldeep B [3] proposed that the material of connecting rod was replaced by aluminum based composite material reinforced with silicon carbide and fly ash and they also performed the modelling and analysis of connecting rod. FEA analysis was carried out by considering two materials. The parameters like von mises stress, von misses strain and displacements were obtained from FEA software. Compared to the former material the new material found to have less weight and better stiffness. It resulted in reduction of 43.48% of weight, with 75% reduction in dispacement. [3]

Mr. Pranav G Charkha [4] purpose that performed load analysis on connecting rod. Their study were deals with two subjects, first, static load stress analysis of the connecting rod, and second, optimization for weight. They performed finite element analysis on single cylinder four stroke petrol engines. Structural systems of connecting rod could be easily analyzed using Finite Element techniques. Optimization was performed to reduce weight. They found that weight can further more reduced by changing the material of the forged steel connecting rod to crack able forged steel (C-70). The optimized geometry was 20% lighter than the current connecting rod. Current connecting rods could be replaced by fracture split able steel forged connecting rods. These connecting rods were lighter in weight than existing connecting rod, with similar or better fatigue behavior. [4]

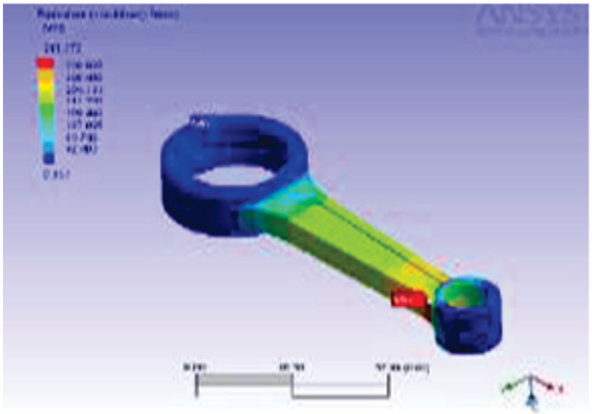

Fig.2: Equivalent Alternating Stress (21598 N)

Om Prakash [5] found the existing design performs by modelling and evaluates critical regions in the connecting rod under fatigue loading. The main objective of their work was to re-optimize the existing design of connecting rod of universal tractor (U650) by changing some of the design variables. Optimization of connecting rod was done under same boundary and loading conditions for variation in the few stress and fatigue parameters i.e. stresses, weight, life, damage and safety factor [5]. The allowable numbers of cycles under fully reversed fatigue loading were increased and assumed up to a maximum limit. Stress concentration coefficient was varied to obtain the maximum cycles condition. The critical regions under both static and fatigue analysis were identified and improved. The connecting rod was then modelled and optimized for the reduction in weight. [5]

Zhou Q [6] analyzed the various designs of connecting rod and finally he selects an optimal design for Finite Element Analysis. In this paper, use of ANSYS-12.0 Workbench and CATIA V5R19 and got various results and then he compared with the existing results.That result in good design which can be made feasible by a number of analysis using CAE tools and Software's, analyzed the Stress, Strain, and Deformation. [6]

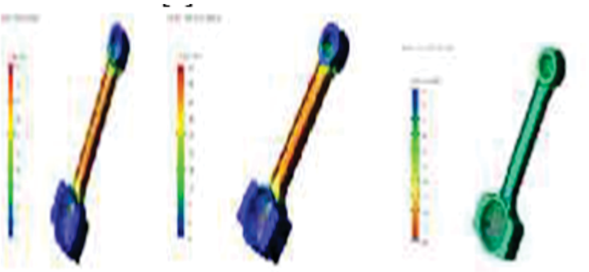

Fig.3: The drawing of the VON MISES stress, biggest main stress, smallest main stress of the crankshaft flexible-body

3. METHODOLOGY

A. Connecting Rod Design

Design is a very important stage for creating new products, because it can reduce costs as end product

Yielded depends on the quality of the design. Combustion pressure is the pressure of the gas produced by combustion in the combustion chamber.

The gas pressure will produce a force that pushes the piston and forward it to the connecting rod through the piston pin in the small hole.

B. Connecting Rod Modeling

Three-dimension model of the connecting rod and piston was drawn using CATIA V5R20 software Piston and connecting rod is connected using a piston pin with a diameter of 22 mm. The distance between center of the piston pin and crank pin is 155 mm. Crankshaft radius is 19 mm. The piston diameter is 86 mm. Three dimensional model of the connecting rod is a model that will be analyzed using Ansys software. In this analysis, the force of the set is the force Fc (compressive force). Analysis was performed using the axial press force with a value of 24752 Newton.

Table – 1 Material Properties Of Aluminium Alloy:

Density	2770 kg/m^3
Coefficient of Thermal Expansion	2.3E10-05
Young s Modulous	71000
Poisson's ratio	0.33
Shear Modulus	26692Mpa
Tensile Yield Strength	280 Mpa
Compressive Yield Strength	280 Mpa
Tensile Ultimate strength	310 Mpa

Connecting Rod Modeling for the following materials:

1] Aluminium alloy
2] AISI 4340 (American Iron and Steel Institute)-
3] Titanium alloy-

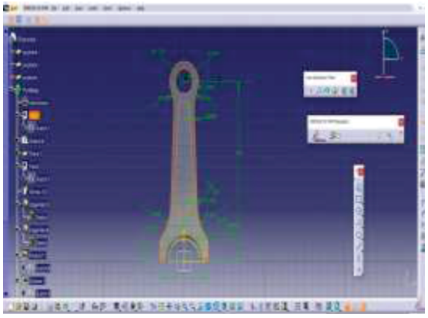

Fig.4: Model of connecting rod by CATIA without optimized.

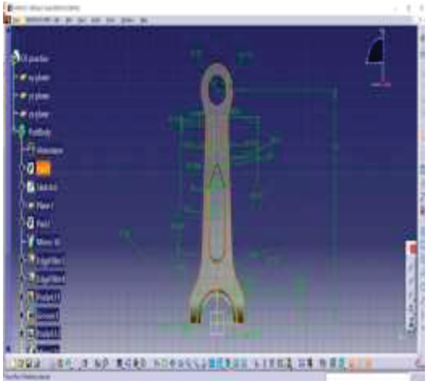

Fig.5: Aluminium alloy (Optimised/Implimented).

4. FLOWCHART

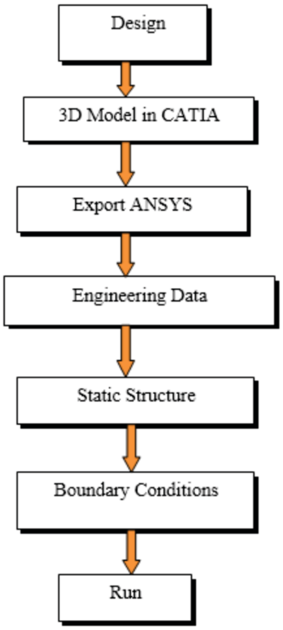

Fig.6: Folwchart design and analysis of connecting rod

5. RESULTS

Total Deformation for Aluminium alloy, AISI 4340 and Titanium alloy.

I. Aluminium alloy:

Total Deformation-

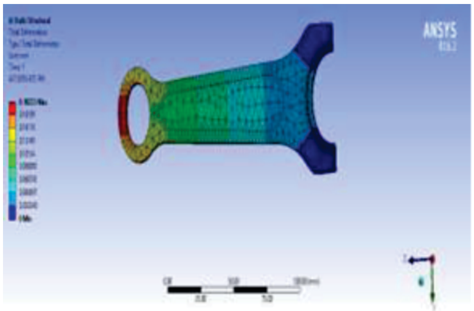

Fig.7: Total deformation of without optimized connecting rod.

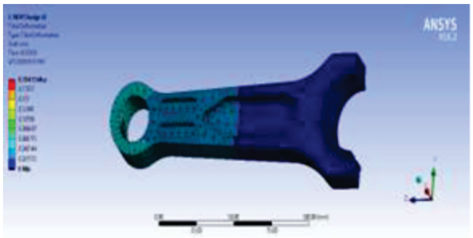

Fig.8: Total deformation of optimized connecting rod.

Maximum principal stress distribution within stressed body, there always exists three mutually perpendicular planes on each of which the resultant stress is normal stress.

Von misses stress:

Maximum distortion energy theory or Maximum shear strain energy theory or Von Misses theory states that, the failure occurs when Maximum shear strain energy when exceeds the shear strain energy in a simple tensile test, very good results for ductile materials and gives answers close to experimental values. In the static analysis, the value of force, location and intensity applied were fixed. The results of the analysis will be used as a material consideration for producing the connecting rod. The results of static analysis are deformation, Von Mises stress, maximum principal stress and minimum principal stress.

Table 2: Total Deformation

Models	Weight (kg)	Von-mise stress (Mpa)	Maximum principal stress (Mpa)	Total Deformation (mm)
Original model	0.243	249.49	282.48	0.182
New model	0.231	245	262.89	262.89
Total amount of change (%)	-4.93	-1.75	-6.93	6.59

This project discusses the modeling, stress, of deformation that occurred to the connecting rod in the Internal combustion engine using the CATIA software and ANSYS. Maximum Principal stress comes out to be 262.89MPa which is less than yield compressive strength that is 280 MPa and the maximum Von Mises stress occurred at the radius with the the value of 245Mpa.The static analysis results shows that the design carried out feasible to be continued, because the Von Mises stress and Maximum principal stress are still under the yield strength of the material(with a safaty factor of 15)hence the design is safe and Reduction in Weight is 4.93%.Also the Stresses are reduced upto 1.75% and 6.93% and the total deformation is more 6.59%.

II. AISI (American Iron and Steel Institute)-4340

Table 3: Material Properties Of Aisi 4340 Steel

Property	**Value**
Elastic Modulus	205000 Mpa
Poisson's ratio	0.32
Shear Modulus	80000 MPa
Density	7850kg/m^3
Tensile Yield Strength	1110Mpa
Compressive Yield Strength	710Mpa

Total Deformation (AISI-4340)-

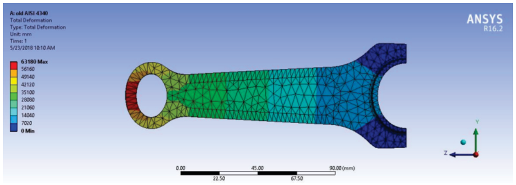

Fig.9: Total deformation without optimized of Connecting rod

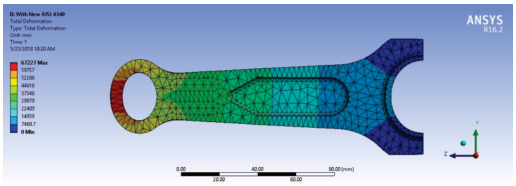

Fig.10: Total deformation Optimized of Connecting rod

Table 4: Total Deformation

Models	Weight (kg)	Von-mises stress (Mpa)	Maximum principal stress (Mpa)	Total deformation (mm)
Original model	0.689	247.21	278.73	63180
New model	0.657	267.46	288.1	67227
Total amount of change (%)	-4.64	8.19	3.36	6.40

In this AISI 4340 material, weight has been reduced 4.64% and Stresses are increased with 8.19%, 3.36% and total deformation is increased with 6.40%.

III. Titanium Alloy:

Table 5. Material Properties Of Titanium Alloy

Sr. No.	**Property**	**Value**
1.	Density	4620 Kg/m^3
2.	Coefficient of Thermal Expansion	9.4E-06 C^-1
3.	Young s Modulous	96000 Mpa
4.	Poisson Ratio	0.36
5.	Bulk Modulous	11400 Mpa
6.	Shear Modulous	35294 Mpa
7.	Tensile Yield Strength	930 Mpa
8.	Compressive Yield Strength	930 Mpa
9.	Tensile Ultimate Strength	1070 Mpa

Total Deformation (Titanium alloy)-

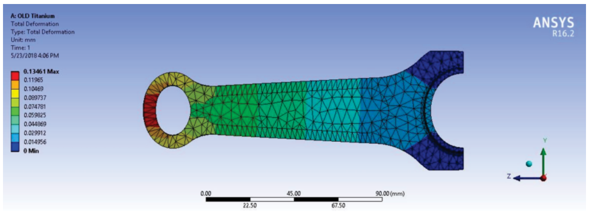

Fig.11: Total deformation without optimized of connecting rod

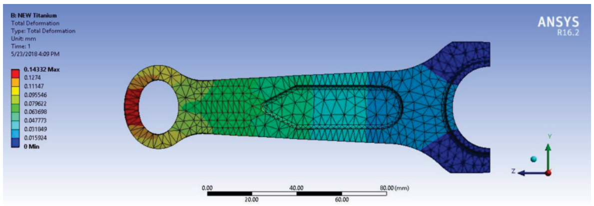

Fig.12: Total deformation Optimized of connecting rod.

Table 6: Total Deformation

Models	Weight (kg)	Von-mises stress (Mpa)	Maximum principal stress (Mpa)	Total deformation (mm)

Original model	0.405	252.1	289.99	0.134
New model	0.386	262.37	293.93	0.143
Total amount of change (%)	-4.69	4.07	1.36	6.71

In this Titanium alloy material, weight has been reduced 4.69% and Stresses are increased with 4.07%, 1.36% and total deformation is increased with 6.71%.

5. Comparison Of Three Materials

Table 7: Comparison Of Three Materials

Material	Weight Reduction (%)	Von-mises stress (%)	Maximum principal stress (%)
Al	-4.93	-1.75	-6.93
AISI 4340	-4.64	8.19	3.36
Ti	-4.69	4.07	1.36

In this Titanium alloy material, weight has been reduced 4.69% and Stresses are increased with 4.07%, 1.36% and total deformation is increased with 6.71%.

6. CONCLUSIONS

Maximum Principal stress for Aluminium alloy, American Iron and Steel Institute (AISI) -4340 and Titanium alloy which is less than yield compressive strength, hence the design is safe.

Connecting rod stress distribution was analyzed. Both compressive and tensile forces are acting on connecting rod but compressive forces are much greater than tensile forces, therefore we had designed according to compressive forces. Since, connecting rod is hinged at both ends by piston pin and crank pin.

The present work was aimed at evaluating alternate material for connecting rod with lesser stresses and lighter weight. This work found alternate material for minimizing stresses in connecting rod.

Optimization was performed to reduce weight. Weight can be further more reduced by changing the material of the current aluminium. From the static structural analysis it is observed that Von-Mises stresses, maximum principal stresses for AISI 4340 and Titanium was compared and it observed that stresses are less in aluminium.

The shank region of the connecting rod offered the greatest potential for weight reduction. Mass of the optimized connecting rod (AISI 4340) is 657 grams and optimized geometry is 4.64% lighter than the aluminium and titanium.

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