JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Analysis of Connecting Rod Using CATIA

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Abstract: As you know that, connecting rod is an important part of internal combustion engine, it is the link between the piston and the crankshaft. The main work of connecting rod is to convert the linear motion of the piston (thrust force) into rotary motion of the crankshaft. In this study, we have tried to analyze and understand the design of a connecting rod structure using Finite Element Analysis method. An invariable model of connecting rod is modeled using CATIA V5R21 and static structural analysis is also carried out by using the same software simulation tool. Further analysis was carried out by considering different designs to understand the variations of equivalent von-misses stress, strain.

***Index Terms* - Connecting rod, Finite element analysis, CATIA V5R21, Static structural analysis.**

I. INTRODUCTION

Connecting rod is a link between the piston and the crankshaft, which converts the linear motion of piston into rotary motion of crankshaft. Connecting rod consists of two ends, one is the smaller end which is connected to piston by using piston pins or gudgeon pin whereas the bigger end is connected to the crankshaft by using bearing. During this process, the thrust force is exerted on the piston by the combustion of the fuel and this force is to be transmitted to the crankshaft by using connecting rod, due to which the connecting rod undergoes through tremendous amount of stress acting on it, which can later on result to, it's failure. Therefore we carried out finite element analysis of the four-stroke petrol engine connecting rod with different designs using CATIA V5R21 in order to increase the life of the connecting rod. Since, to get the specified results, we have created three models of the connecting rod. One is the existing model of the connecting rod and the other two are the modified versions of it, which is created or generated using CATIA V5R21, which is a 3D designing and simulation software. This is performed to understand the various designs of the connecting rod and analyze them to get an optimal design. The selected design had better results in various parameters and was under safe stress.

II. AIM AND OBJECTIVE

- The main aim and objective of this research paper is to perform analysis of traditional or existing connecting rod and perform some optimization in its design, to get a better version of it.
- And geometrically modeling of the connecting rod is done, as per the dimensions generated from the process of design procedure followed.
- To analyze the stresses using FEA approach on each model of connecting rod designed for study.
- The designing and analysis is performed on a software name CATIA V5R21.

III. LITERATURE REVIEW

This section includes the literature survey of earlier research work made by various researchers on connecting rod. Various researchers presented the different techniques in the development of connecting rod and their optimization. This section presents the summary of these research works.

- Kuldeep B "Analysis and optimization of connecting rod using ALFASiC composites".

Generally connecting rods are manufactured using carbon steel and in recent days Aluminium alloys are finding its application in connecting rod. In this work connecting rod is replaced by Aluminium based composite material reinforced with silicon carbide and fly ash. And it also describes the modelling and analysis of connecting rod. FEA analysis was carried out by considering two materials. The parameter like von misses stress, von misses strain and displacements were obtained from ANSYS software.

- Sujata demonstrated the analysis is performed on the connecting rod using various composite materials. They mainly focused on the material used for the connecting rod and structural analysis in static loading. The model is prepared by using SOLIDWORKS workbench and CATIA and analysis are done by using FEA software which shows the weight reduction, increase in von-misses stress, decrease in von- misses strain and reduction on deformation.

- Nikhil, in their study the material of connecting rod is replaced by aluminum-based composite material reinforced with silicon carbide and fly ash and they also describe the model and analysis of connecting rod. FEA analysis was performed by considering two different materials of connecting rod for the 180cc engine. They consider the parameters like von misses stress and displacement result were obtained from ANSYS software. Compared to the existing material and the replaced material found to have less weight and better stiffness. It results in the reduction of 39.48% of weight, with 64.23% reduction in displacement.

- Amit Kumar describes the model of connecting rod, which is designed using CATIA software and then analyzed on Ansys 14.0. The weight of connecting rod in Bajaj Pulsar 150cc is reduced. The parameters included are von misses stress, strain, and deformation under loading conditions of compression at the crank end and pin of the connecting rod.

- Prof. N.p.doshi “analysis of connecting rod using analytical and finite element method”. The most common types of materials used for connectinrods are steel and aluminium. Connecting rods are widely used in variety of engines such as, in-line engines, v-engines, opposed cylinder engines, radial engines and oppose-piston engines. For the project work we have selected connecting rod used in light commercial vehicle of tata motors had recently been launched in the market. We found out the stresses developed in connecting rod under static loading with different loading conditions of compression and tension at crank end and pin end of connecting rod.

IV. MODELING OF CONNECTING ROD

In an internal combustion engine, most stressed part is connecting rod. There are different types of stresses induced in connecting rod. One of them is force of gas pressure which is induced by combustion of fuel in the cylinder so that a high compressive force is acted on the piston pin. And the other one is inertial force which is caused by reciprocating of piston. Connecting rod can be made of different type of materials. In modern era it is generally made of steel.

A. EXISITING MODEL

All the three geometrical model of connecting rod was constructed using CATIA V5R21 modeling tool. The dimensions of the Existing Model of the Connecting Rod is shown in Fig. 1

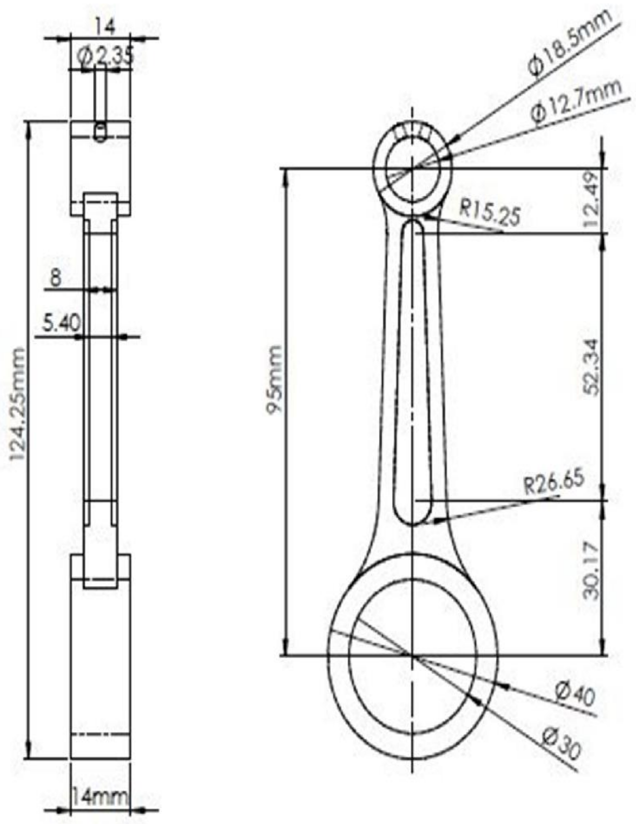

Fig. 1 Existing Design of Connecting Rod

And in Fig. 2 we can see the 3D model of the Existing Connecting Rod.

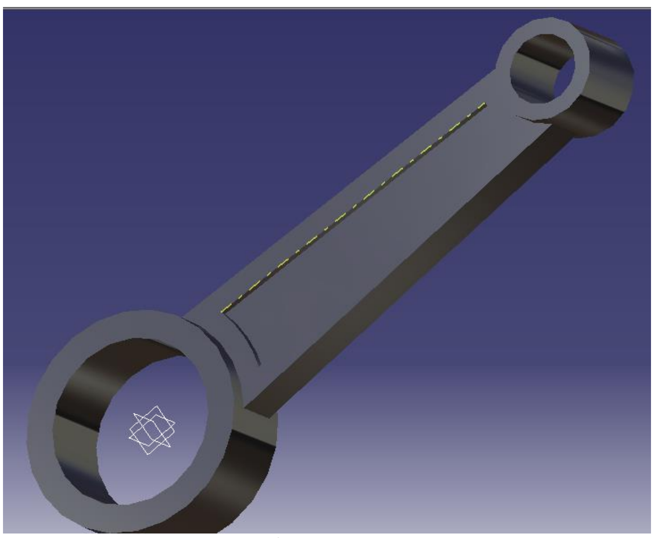

Fig. 2 3D model of the Existing Connecting Rod

B. MODIFIED MODELS

In Fig. 3 and 4 you can see the modified model of the existing model of the connecting rod. Some changes have been made in the existing model of the connecting rod as you can see.

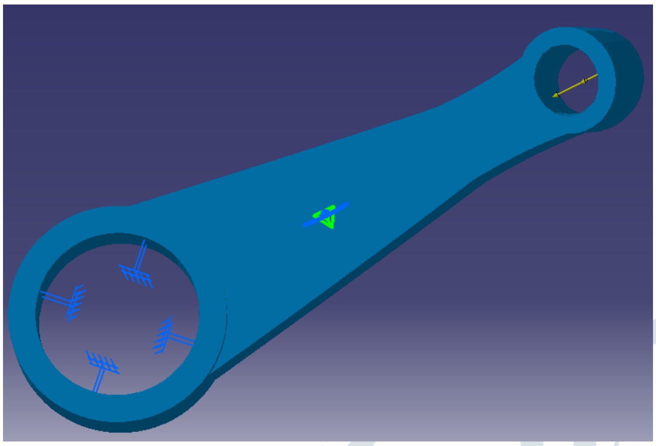

Fig.3 Modified Model 1

Fig.4 Modified Model 2

V. SELECTION OF MATERIAL

Structural Steel is used as the specimen material for the simulations so that the FEA results can be compared with the previously published results. The material properties of the structural steel are listed in Table. 1 and the stress-strain curve for the same are plotted in Fig. 5.

Properties	Structural Steel
Coefficient of thermal expansion (K1)	1.2x10-5
Young's Modulus (MPa)	2x105
Poisson's ratio	0.30
Bulk Modulus (GPa)	166.67
Shear Modulus (GPa)	76.92
Tensile yield strength (MPa)	250
Tensile ultimate strength (MPa)	460

Table 1

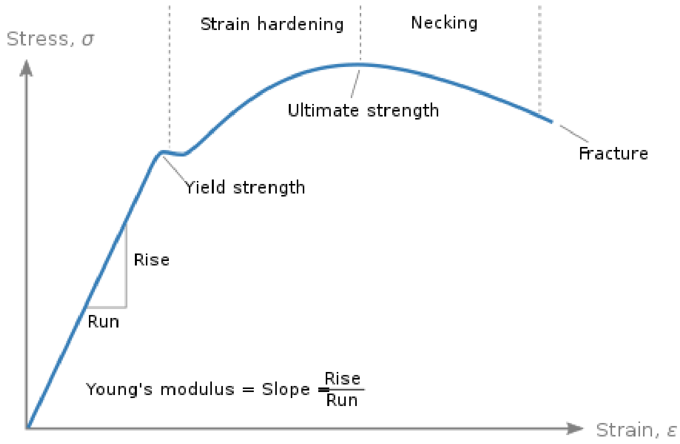

Fig. 5 Stress- strain curve for structural steel

VI. STATIC ANALYSIS

Static analysis deals with the conditions of equilibrium of the bodies acted upon by forces. This analysis can be either linear or non-linear. All types of non-linearity's are allowed such as large deformations, plasticity, creep, stress stiffening, contact elements etc. this chapter focuses on static analysis. A static analysis is used to determine the displacements, stresses, strains and forces in structures or components caused by loads that do not induce significant inertia and damping effects. The kinds of loading that can be applied in static analysis includes,

- Externally applied forces, moments and pressures
- Steady state inertial forces such as gravity and spinning
- Imposed non-zero displacements

VII. THEORY OF FAILURE

Theories of failure are those theories which help us to determine the safe dimensions of a machine component when it is subjected to combined stresses due to various loads acting on it during its functionality. These are employed in the design of a machine component due to the unavailability of failure stresses under combined loading conditions.
The various types of theories of failure are given below:-

- Maximum Principal Stress theory (RANKINE'S THEORY)
- Maximum Shear Stress theory (GUEST AND TRESCA'S THEORY)
- Maximum Principal Strain theory (St. VENANT'S THEORY)
- Total Strain Energy theory (HAIGH'S THEORY)
- Maximum Distortion Energy theory (VON MISES AND HENCKY'S THEORY)

VIII. VON MISES STRESS

- The Von-Mises Stress is often used in determining whether a ductile metal will yield when subjected to a complex loading condition.
- This is accomplished by calculating the Von Mises stress and comparing it to the material's yield stress, which constitutes the Von Mises Yield Criterion.
- Von Mises stress is a value used to determine if a given material will yield or fracture.

- It is mostly used for ductile materials, such as metals.
- The von Mises yield criterion states that if the von Mises stress of a material under load is equal or greater than the yield limit of the same material under simple tension then the material will yield.

A. ON EXISTING MODEL

As you can see, the total Von-Mises Stress acting, on the existing model of the connecting rod, in the below figures.

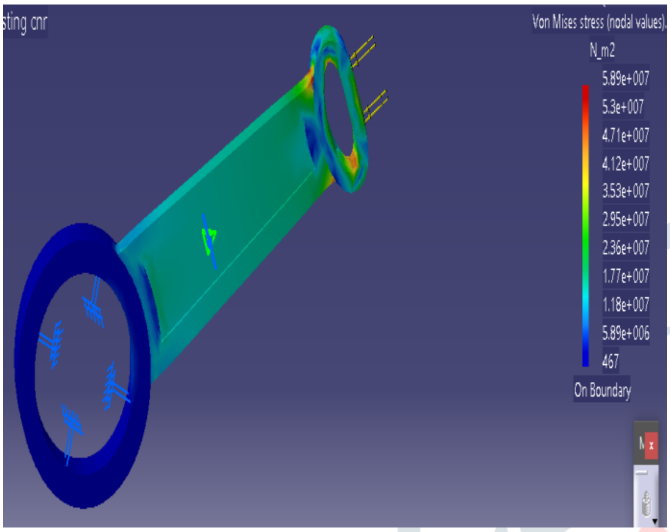

Fig.6 Existing Model

B. ON MODIFIED MODEL

Fig.7 and 8 shows the total Von-Mises stress acting on the modified models of the connecting rod.

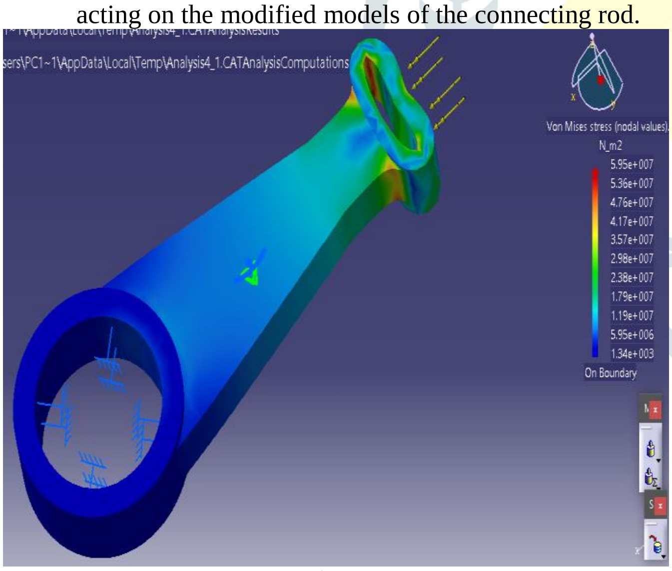

Fig.7 Modified Model 1

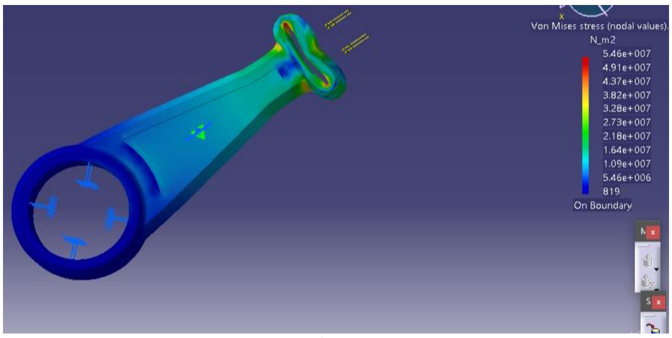

Fig.7 Modified Model 1

IX. Comparison of Results

Model	Von Mises Stress	
	Maximum (N_m2)	Minimum (N_m2)
Existing Model	5.89e+007	467
Modified Model 1	5.95e+007	1340
Modified Model 2	5.41e+007	283

Table 2

X. Conclusion

- Solid modelling of connecting rod was made in CATIA V5 R21, according to design procedure used and analysis under the effect of compressive loads in terms of pressure is also done in CATIA V5 R21.
- From the static analysis the stress is found maximum at the small end of the connecting rod.
- The analysis was completed and we got the strong and weak points of the design upon which improvements can be done.
- We can use other materials to compare with Al alloy and further optimization can be done.
- After observing all the three models, existing model, modified model 1 and model 2.
- Modified model 2 is better than existing model.

XI. Future Scope

The above work is presented on static analysis of connecting rod and has many aspects to research further as follows:-

- Torsional analysis can be done due to presence of small amount of torsional moment at the end points.
- Design modification can be done to minimize the weight of connecting rod and the inertia force.
- Work on the internal coating of hard material inside the both ends can be done to minimize the wear failure in connecting rod.
- Further changes in the design of connecting rod can be done.
- Selection of another material can also be done.
- Composition of different materials can be used to increase its strength.
- Dynamic analysis of connecting rod can be done and other factors of failure can be considered.
- Chamfering of sharp boundaries of connecting rod also helps in reducing the stress level and increases strength of the connecting rod.

ACKNOWLEDGMENT

I would like to thank Assistant Prof. Mr. Shyam Bihari Lal, Department of Mechanical Engineering, Buddha Institute Of Technology, GIDA, Gorakhpur, for a providing opportunity to learn through work, by the medium of project. I consider myself to be fortunate to get this opportunity to explore in the field of Design and Analysis of Connecting Rod using CATIA V5 R21 under his guidance.

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