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DESIGN AND ANALYSIS OF CONNECTING ROD: A REVIEW

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Abstract: The connecting rod is the intermediate member between power transmitting and power receiving element. Its primary function is to transmit the push and pull from the piston pin to the crank pin, thus converting the reciprocating motion of the piston into rotary motion of the crank. Also in some special cases like ginning and pressing machine connecting rod is used to convert the rotary motion into oscillating one. In such cases connecting rod should be well designed. Its proper analysis should be done so as to ensure the its proper operation under given condition. Designing the connecting can be done for various materials followed by analysis using FEA software. Weight reduction and cost reduction are some important aspect in this design. This paper basically deals with the some research work related with this design and analysis of the connecting rod.

Keywords: Connecting rod, design, analysis, ANSYS.

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INTRODUCTION

The connecting rod is used in a machine to convert the rotary motion into reciprocating or vice versa. While performing this operation some stresses are develop in connecting rod. The major stresses induced in the connecting rod are a combination of axial and bending stresses in operation. The axial stresses are produced due to cylinder gas pressure (compressive only) and the inertia force arising in account of reciprocating action (both tensile as well as compressive), where as bending stresses are caused due to the centrifugal effects. Connecting rod consists of a long shank, a small end and a big end. The cross-section of the shank may be rectangular, circular, tubular, I-section or H-section. Generally circular section is used for low speed engines while I-section is preferred for high speed engines. The most common type of manufacturing processes is casting, forging, and powdered metallurgy. Connecting rod is subjected to a complex state of loading. It undergoes 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 critical importance. Due to these factors, the connecting rod has been the topic of research for different aspects such as production technology, materials, performance, simulation, fatigue etc. In the cotton mill industry the ginning machine is a heart of all the industry. These machines have various mechanisms and there is versatile problem of failure of connecting rod between motor shaft and ginning shaft. The small end of connecting rod have wrist pin, it is also called as a piston pin, the motor have rpm about 1440 rpm and its reduces to 1050 rpm which gives reciprocating motion to the ginning blade. The ginning blade has large vibrations so as to a whole machine. As wrist pin connects the connecting rod to ginning shaft it also serves all vibrations, and it fails several times that reduces the productivity. To increase the shock absorbing capacity of pin and connecting rod it should be designed proper material followed by the analysis. To design connecting rod some research work has been observed which explain further.

Some research work related to design and analysis of connecting rod are as follows:

1. Yogesh Kumar Bharti et al.(2013), work on the stress analysis of connecting rod. Connecting rod was design & modelled by using Pro/E 4.0 v. It was then imported to ANSYS for analysis.

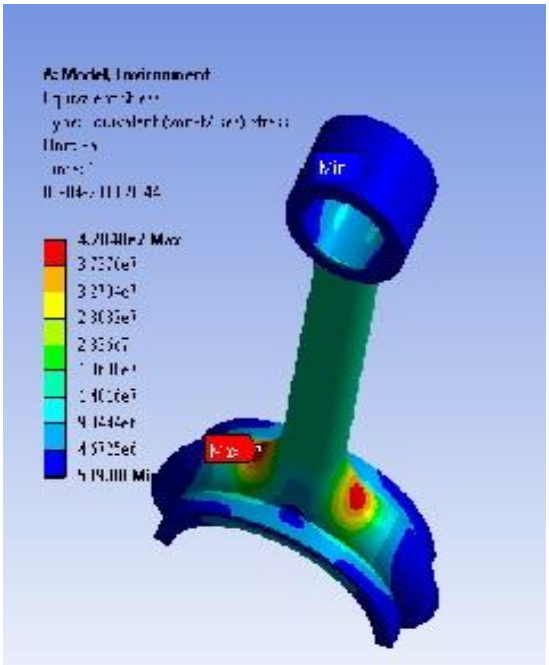

Fig. 1: Equivalent (Von-Mises) stress Fig.2 : Shape Optimization

The main objective of this work is to determine shear stresses and optimization in the existing connecting rod, which are in different cross-section as plus (+) section, I-section and ellipsoidal section. The failures of existing design suggest the minimum design changes in the existing connecting rod.

2. **Suraj Pal, Sunil kumar,** analysed the connecting rod of a Hero Honda Splendor has been done using FEA tool ANSYS Workbench. So firstly a proper Finite Element Model is developed using Cad software Catia, Pro/E Wildfire 4.0. The main aim of the project is to determine the Von Misses stresses, Shear stresses, and Equivalent Alternating stress, Total Deformation, Fatigue Analysis and Optimization in the existing Connecting rod. Then static analysis is done to determine the von Misses stress, shear stress, elastic strain, total deformation in the present design connecting rod for the given loading conditions using Finite Element Analysis Software ANSYS v 12.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. The results were also used to determine of various stress and the fatigue model to be used for analyzing the fatigue strength. Outputs of the fatigue analysis of include fatigue life, damage, factor of safety, stress biaxiality indication. Then results of present model in ANSYS are compared with the results of existing design in the reference paper.

Table 1: -Shows the comparison of Weight

Name	Original	Optimized	Weight reduction
Weight	131.5g	126.73kg	4.77g (3.62%)

3. **Pravardhan S. Shenoy and Ali Fatemi,** performed the study on a steel forged connecting rod with a consideration for improvement in weight and production cost. Since the weight of the connecting rod has little influence on its total production cost. Reduction in machining operations, achieved by change in material, was a significant factor in manufacturing cost reduction. The fatigue strength was the most significant factor in the design of the connecting rod. The study results in new designed connecting rod that is 10% lighter and 25% less expensive, as compared to the existing connecting rod. The objective of the optimization was to minimize the mass of the connecting rod under the effect of a load range comprising the peak compressive gas load and the peak *dynamic tensile load* at 5700 rev/min (at 360o

crank angle), such that the maximum, minimum, and the equivalent stress amplitude are within the limits of the allowable stresses. The production cost of the connecting rod was also to be minimized. Furthermore, the buckling load factor under the peak gas load has to

be permissible. As far as the optimized geometry, the connecting rod has to be interchangeable with the existing one in the current engine. Each of these requirements or constraints discussed areas APPLIED LOADS, ALLOWABLE,

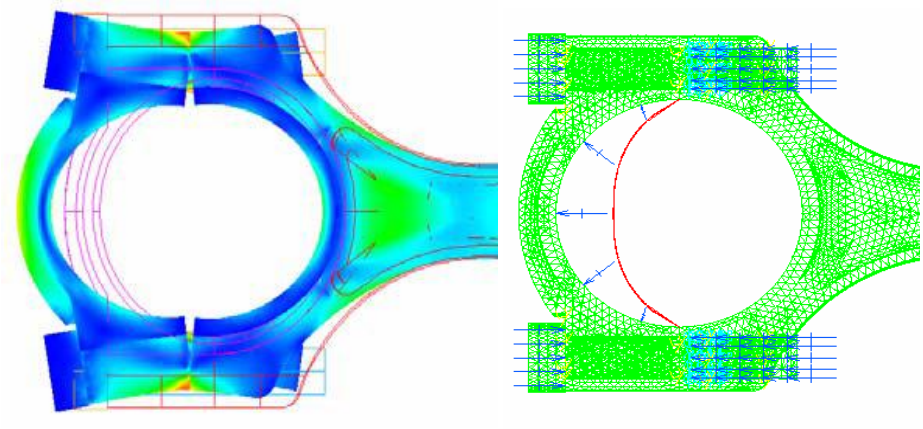

Fig.3: Von Mises stress variation and displacements (magnified 20 times) of the connecting rod and cap under tensile load. The FE model is shown on the right.

4.Pushpendra Kumar Sharma, Borse Rajendra R.(2012), The main aim of this research is to determine total Fatigue Analysis in the existing Connecting rod. If the existing design shows the failure, then suggest the minimum design changes in the existing Connecting rod. In this research only the static FEA of the connecting rod has been performed by the use of the software & the combination of finite element technique with the aspects of failure reduction is to be made to obtain the required design of connecting rod. A fatigue analysis can be separated into 3 areas: materials, analysis, and results evaluation. A large part of a fatigue analysis is getting an accurate description of the fatigue material properties. These properties are included as a guide only with intent for the user to provide his/her own fatigue data for more accurate analysis. Fatigue results can be added before or after a stress solution has been performed. To create fatigue results, a fatigue tool must first be inserted into the tree. This can be done through the solution toolbar or through context menus. The details view of the fatigue tool is used to define the various aspects of a fatigue analysis such as loading type, handling of mean stress effects and more. Several results for evaluating fatigue are available to the user. Outputs include fatigue life, damage, factor of safety, stress biaxiality, fatigue sensitivity.

5. Leela Krishna Vegi, Venu Gopal Vegi, This paper describes designing and Analysis of connecting rod. Currently existing connecting rod is manufactured by using Carbon steel. In this drawing is drafted from the calculations. A parametric model of Connecting rod is modelled using CATIA V5 R19 software and to that model, analysis is carried out by using ANSYS 13.0 Software. Finite element analysis of connecting rod is done by considering the materials, viz. Forged steel. The best combination of parameters like Von misses Stress and strain, Deformation, Factor of safety and weight reduction for two wheeler piston were done in ANSYS

software. Forged steel has more factor of safety, reduce the weight, increase the stiffness and reduce the stress and stiffer than other material like carbon steel. With Fatigue analysis it determines the lifetime of the connecting rod.

Table no.2: Stresses and Deformation of Forged Steel

Sr. no.	Types	Max (Mpa)	Min (Mpa)
1.	Equivalent stress	38.298	4.0317e-9
2.	Normal stress(x-axis)	25.283	-15.692
3.	Normal stress(y-axis)	28.088	-15.485
4.	Normal stress(z-axis)	1.1978	-0.85736
5.	Shear stress(xy plane)	20.166	-20.183
6.	Shear stress(yz plane)	0.91522	-0.96534
7.	Shear stress(zx plane)	0.7183	-0.72013
8.	Total deformation	0.0025932	0
9.	Directional deformation (x-axis)	0.0005354	-0.0025925
10.	Directional deformation (y-axis)	0.0016764	-0.007687
11.	Directional deformation (z-axis)	0.00013292	-0.0001347

When compared to both of the materials, forged steel is cheaper than the existing connecting rod material.

6. Prof. N. P. Doshi & Prof. N. K. Ingole, selected connecting rod used in light commercial vehicle of tata motors had recently been launched in the market. They used PRO-E wildfire 4.0 software for modelling of connecting rod and ANSYS 11 software for analysis. ANSYS Workbench module had been used for analysis of connecting rod. It is found out that 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. They also designed the connecting rod by machine design approach. Design of connecting rod which is designed by

machine design approach is compared with actual production drawing of connecting rod. Solid modeling of connecting rod was made in Pro-E according to production drawing specification and analysis under the effect of tensile and compressive loads in terms of pressure is done in ANSYS Workbench. In present work analytical result compare with numerical result among all load conditions the maximum value of equivalent stress was found to be 197.41 MPa when crank end of connecting rod is in tension. This stress is less than yield strength of material. It gives a factor of safety of 3.2.So the existing design is oversafe but It is consider for only static load condition. From analysis it is observed that the minimum stresses among all loading conditions, were found at crank end cap as well as at piston end. So the material can be reduced from those portions, thereby reducing material cost. For further optimization of material dynamic analysis of connecting rod is needed. After considering dynamic load conditions once again finite element analysis will have to be performed. It will give more accurate results than existing.

7. **Vivek. C. Pathade et. al.,** deals with the stress analysis of connecting rod by Finite Element Method using Pro/E Wildfire 4.0 and ANSYS WORKBENCH 11.0 Software. The automobile engine connecting rod is a high volume production critical component. Every vehicle that uses an internal combustion engine requires at least one connecting rod. From the viewpoint of functionality, connecting rods must have the highest possible rigidity at the lowest weight. The major stress induced in the connecting rod is a combination of axial and bending stresses in operation. The axial stresses are produced due to cylinder gas pressure (compressive only) and the inertia force arising in account of reciprocating action (both tensile as well as compressive), where as bending stresses are caused due to the centrifugal effects. The result of which is, the maximum stresses are developed at the fillet section of the big and the small end.

Materials and Methodology

The design of connecting rod is made with the different materials as per the different Researchers. The materials and their properties used for the design are as follows:

Table No.3: Material and their properties

Type of the material	Composition weight (carbon)	Density (Kg/m^3)	Hardness (BHN)	Breaking Strength (N/mm^2)
Mild Steel	0.2	7850	130	616
EN-8	0.4	7850	255	737
EN-9	0.55	7850	201-255	891
EN-31	1.5	7810	190	1102
SGI	0.03-0.04	7050	360	850

the experimental results it can be concluded that due to slight variation of alloying elements the physical properties of material like IS2602 may not change drastically but considerable change occurs in mechanical properties. When the materials with considerable difference in mechanical properties are joined by arc welding method then the mechanical properties of the weld bead depends a great extent on the type of filler material used, the heat input applied, the preheating and post heating conditions of the weld bead.

Study of above research work help in designing any connecting rod. Study of these research works is the first step and selection of material is very important step. Then following the design procedure and using FEA software analysis of connecting rod can be done.

CONCLUSION

Above all researchers gives the idea about designing of the connecting rod. It explains about the various stresses to be considered while designing the connecting rod. Also most of the researchers used the ANSYS software for analysis. These research papers can be used for designing the any connecting rod by following these standards. These standards can be used for designing the connecting rod of ginning and pressing machine also. Connecting rod can be designed for weight and cost reduction also to increase the life time of connecting rod.

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