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ANALYTIC DESIGN ANALYSIS AND OPTIMIZATION OF CONNECTING ROD AND DETERMINATION OF ITS STRESSES USING CAE TOOLS

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Introduction

The function of connecting rod is to transmit the thrust of the piston to the crank shaft.Role of connecting rod in the conversion of reciprocating motion into rotary motion.A four-stroke engine is the most common type.The four strokes are intake,compression, power ,and exhaust. Each stroke requires approximately 180degrees of crank shaft rotation,so the complete cycle would take720degrees.Each stroke plays a very important role in the combustion process.In the intake cycle,while the piston moves downward,one ofthe valves open.This creates a vacuum,and an air-fuel mixture is sucked into the chamber. During the second stroke compression occurs.In compression both valves are closed,and the piston moves upward and thus creates a pressure on the piston.Then extstroke is power.During this process the compressed air-fuel mixture is ignited with a spark,causing a tremendous pressure as the fuel burns.The forces exerted by piston transmitted through the connecting rod moves the crank shaft.Finally, the exhaust stroke occurs.In this stroke,the exhaust valve opens,as the piston moves backupwards,it forces all the air out ofthe chamber and thus which completes the cycle of crankshaft rotation.

I. Problem Statement

The automobile engine connecting rod is a high volume production, critical component. 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 the engine.

Connecting rods are widely used in variety of car engines. The function of connecting rod is to transmit the thrust of the piston to the crankshaft, and as the result the reciprocating motion of the piston is translated into rotational motion of the crankshaft. It consists of a pin-end, a shank section, and a crank end. Pin-end and crank-end pin holes are machined to permit accurate fitting of bearings. One end of the connecting rod is connected to the piston by the piston pin. The other end revolves with the crankshaft and is split to permit it to be clamped around the crankshaft. The two parts are then attached by two bolts. Connecting rods are subjected to forces generated by mass and fuel combustion. These two forces results in axial and bending stresses. Bending stresses appear due to eccentricities, crankshaft, case wall deformation, and rotational mass force. Therefore, a connecting rod must be capable of transmitting axial tension, axial compression, and bending stresses caused by the thrust and pull on the piston and by centrifugal force (Afzal and Fatemi, 2003).

The connecting rod of the tractors is mostly made of cast iron through the forging or powder metallurgy. The main reason for applying these methods is to produce the components integrally and to reach high productivity with the lowest cost (Whittaker, 2001; Repgen, 2005). Nevertheless, connecting rod design is complicated because the engine is to work in variably complicated conditions and the load on the rod mechanism is produced not only by pressure but also inertia (Augugliaro and Biancolini, 2000). When the repetitive stresses occur in connecting rod it leads to fatigue phenomenon which can cause so dangerous ruptures and damages. An example of the fatigue analysis and design was presented in 2003 by some researchers (Biancolini et al., 2003). A rupture due to the fatigue and the method of correcting the connecting rod design was also

reported (Rabb, 1996). Beretta et al. (1997) presented a strengthening method for the connecting rod design. Finite element (FEM) method is a modern way for fatigue analysis and estimation of the component longevity which has the following advantages compared to the other methods. This achievement seems so useful particularly when the component doesn't have a geometrical shape or the loading conditions are sophisticated. The influential component factors are able to change such as material, cross section conditions etc. Component optimization against the fatigue is performed easily and quickly. Analysis is performed in a virtual environment without any necessity for prototype construction (Lo and Bevan, 2002). Totally these qualities, lead to savings in time and cost.

Since 1986, more than 500 million powder forged (PF) connecting rods have been manufactured and installed in automobiles worldwide. The application of forging a preformed near-net shape consolidated from metal powder has been widely accepted since the early eighties and today is the preferred manufacturing technique for 60% of the connecting rods manufactured in North America. The remaining portion of the connecting rod market segment is produced by use of either conventional steel forging, or to a lesser extent, casting manufacturing processes.

According to above reasons, 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.

The connecting rod is subjected to a complex state of loading. It undergoes high cyclic loads of the order of 108 to 109 cycles, which range from high compressive loads due to combustion, to high tensile loads due to inertia. Therefore, durability of this component is of 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.

Figure 1 : Failure of a connecting rod

II. Methodology

The geometric model of the connecting rod is developed using modeling package CREO 2.0 software. OptiStruct was used to perform the process. All of the optimization processes use some application software that included in the HyperWorks (HW). Using HyperMesh, finite element model was established from importing model until applying loads and boundary conditions. The model can be either solid model (e.g. IGES, Catia, ProE, STEP, etc) or other Finite element software (e.g. Radioss, Nastran, Nastran, NASTRAN, etc). The model is linear finite element model or bulk data. Preliminary analysis was conducted to the initial model using NASTRAN to get initial required information (stress distribution, displacement, maximum stress, etc). That information would be used as reference for optimization process setting and compared to the optimized model for assessing optimization process performance. There are some iterations and evaluations during the optimization process to achieve an optimized model. Validation process is important step in this design optimization. The optimized model's performance is compared with initial models. If the result is not satisfactory, redefinition is required to explore others possible design space. Furthermore, Hyperview, Hypergraph and NASTRAN were used to display and plot the data for results interpretation.

III. Modelling

The connecting rod on which the present investigation is done is taken from the research paper ofPal S, Kumar S(2012), "Design Evaluation and optimization of connecting rod parameters using FEM" IJEMR, Vol. 2, issue 6.

Serial No.	Parameters	Values
1.	Length of connecting rod	95 mm
2.	Outer diameter of big end	40 mm
3.	Inner diameter of big end	30 mm
4.	Outer diameter of small end	18.5 mm
5.	Inner diameter of small end	12.7 mm

Table No.1 Dimension of connecting rod

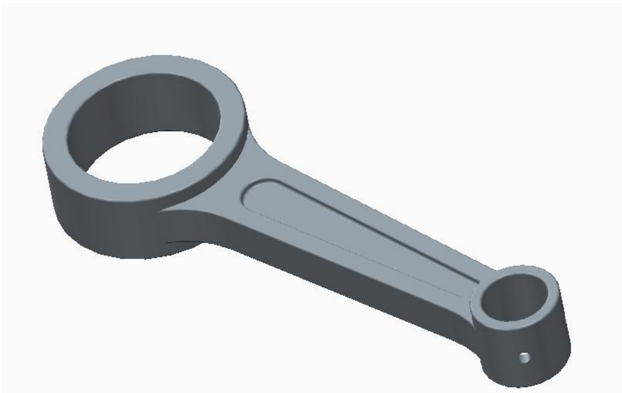
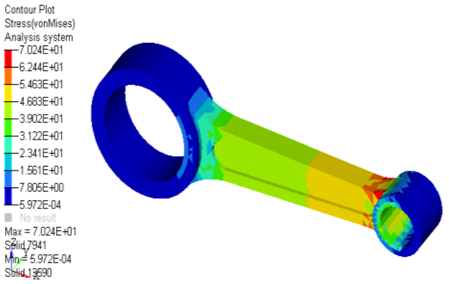


Fig.No.2 Connecting Rod

IV. Finite Element Method

The basic idea of FEA is to make calculations at only limited (Finite) number of points and then interpolate the results for the entire domain (surface or volume). Any continuous object has infinite degrees of freedom and it's not just possible to solve the problem in this format. Finite element method reduces the degrees of freedom from infinite to finite with the help of descritization or meshing (nodes and elements).The Objective of FEA was to investigate stresses and problem area experienced by the connecting rod. FromStress contours, the state of stress as well as stress concentration factors can be obtained and consequently usedfor optimization.



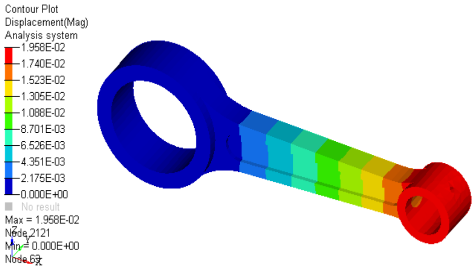


Fig No.3 : Von mises stress in existing modelFig No. 4 : Displacement in existing model

V. Structural Optimization

The optimization opted here is shape optimization. Shape optimization is a mechanized approach to change the structure shape in light of predefined shape variables to locate the ideal shape. DVs are utilized to change the geometry shape of the component, on HyperMesh it is used HyperMorph to define this parameter. In the optimization process step by step iterations are taken to minimize the weight with Von Mises stress as constraints.

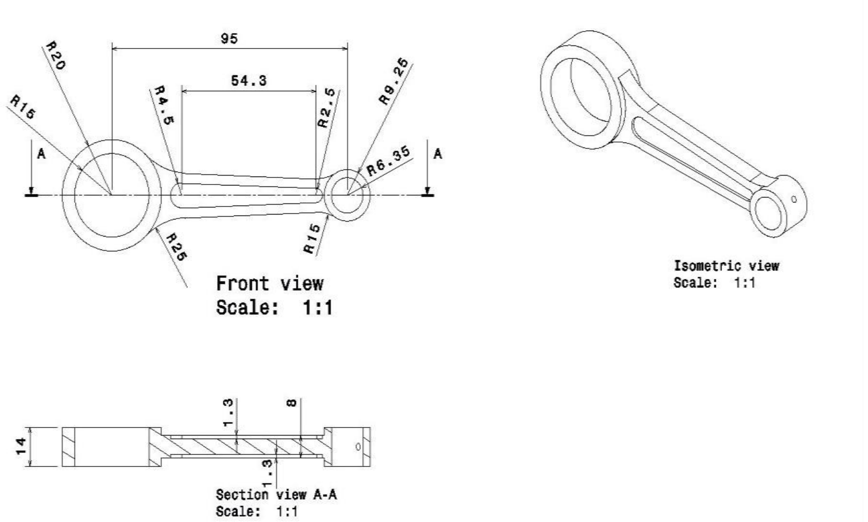


Fig No.5Model from reference paper

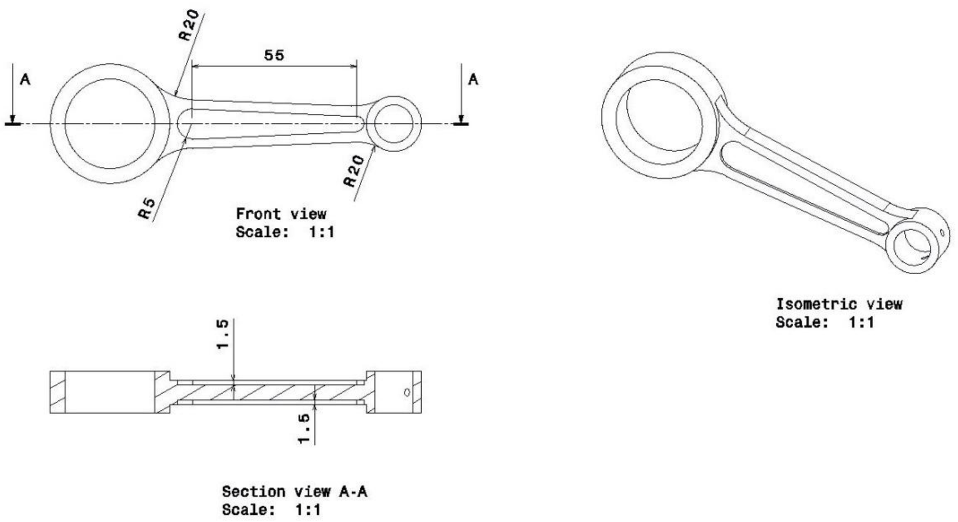
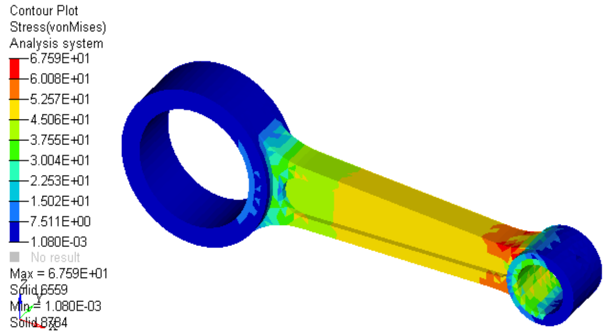


Fig No.6 Optimized Model



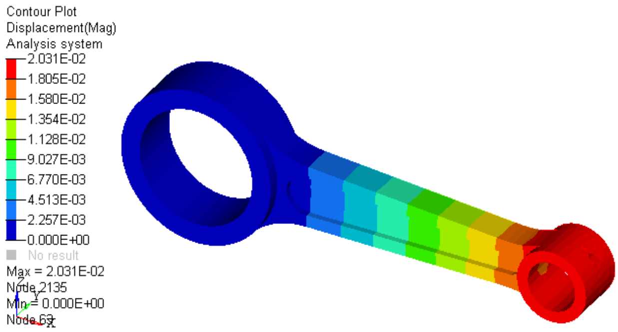
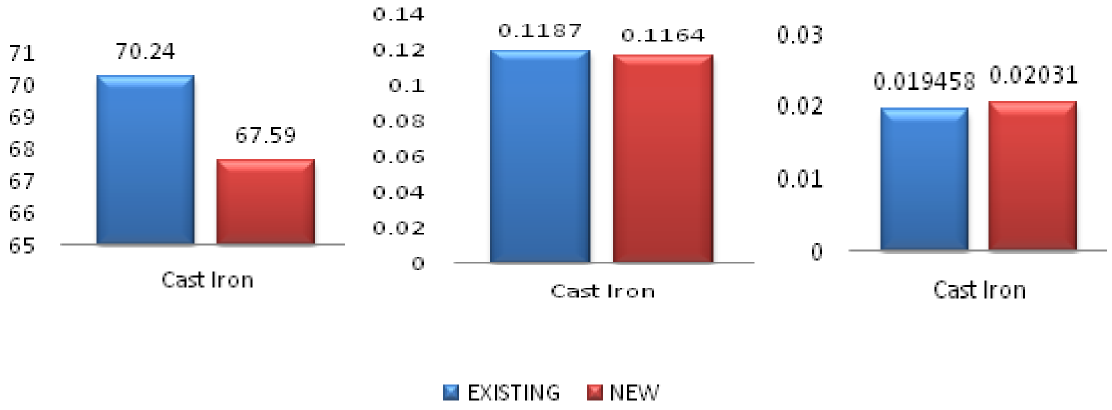


Fig No.7 : Von mises stress in optimized modelFig No. 8 : Displacement in optimized model

VI. Result and Discussion

This research project investigated weight and cost reduction opportunities that different material connecting rods offer.The connecting rod chosen for this project belonged to Hero Honda Splendor.

A comparative results is shown below of various parameters out of which, this study focuses on weight and von mises stress as one shows the opportunity of cost saving and other show the opportunity of long durable life and increased strength of the component.



Stress Weight
Displacement

Figure No.9 Graph between existing and new model optimization

Material	Von Mises stress (MPa)		Percentage Change
	Existing	Optimized	
Cast Iron	70.24	67.59	3.77

Table No.2 vonmises stresses optimization

Material	Displacement (mm)		Percentage Change
	Existing	Optimized	
Cast Iron	0.019458	0.02031	6.33

Table No.3 Displacement optimization

Material	Weight (Kg)		Percentage Change
	Existing	Optimized	
Cast Iron	0.1187	0.1164	1.97

Table No.4 weight optimization

VII. Summary And Conclusion

In this study, first a literature review on several aspects of connecting rods in the areas of load and stress analysis, durability, manufacturing, economic and cost analysis, andoptimization was carried out. Load analysis using the samecompressive loads and fixed support were applied onthe same portion of the connecting rod as in thereference paperwhich act as initial model for validation for the optimization process.

Based on the literature review conducted, results and observations from the initial mode andanalyses performed on the optimized connecting rod, the following conclusions can be drawn:

a) The existing and modified design is modeled usingmodeling software and various parameters are obtained and the results are taken and compared.

b) Modifying the design parameters can yield better results. Since modified model gavebest results. Therefore this design proved to be the best among others tested.

c) Reduction of weight was one of our primary aims. We found that weight can be reduced using structural optimization process. But the high density and low strengthCast Iron material has its limitation. So we suggested different materials, this gives significant weight reduction also the results for various stresses are better in case of other material. So changing the material and structural optimization is solution for weight reduction.

d) There is a reduction in stress by 3.77% and weight by 2% in new optimized model for the same material hence this can also be suggested without changing the material.

e) The maximum stresses occurred in static structural analysis are less than the yield strength of material. Hence the design is safe.

REFRENCES

1. Pravardhan S. Shenoy and Ali Fatemi, the University of Toledo, *"Connecting Rod Optimization for Weight and Cost Reduction"* (SAE International, 2005-01-0987).
2. Prof.N.P.Doshi, Prof.N.K.Ingole, DepartmentofMechanicalEngineering,BapuraoDeshmukhCollegeofEngg,Sewagram,India," *Analysis of Connecting Rod using Analytical and Finite Element Method"* (ISSN:2249-6645-International Journal ofModernEngineeringResearch).
3. Prof. Suraj Pal, Prof.Sunilkumar, Department of Mechanical Engineering, Y.C.O. Engg. Talwandisabo,India, *"Design Evaluation and Optimization of Connecting Rod Parameters*

Using FEM" (ISSN No.: 2250-0758 -International Journal of Engineering and Management Research)

4. Prof.B. Anusha, Dr.C.VijayaBhaskar Reddy, Department of Mechanical Engineering,Sri Kalahasteeswara Institute of Technology, Srikalahasti, India , *"Comparision Of Materials For Two-Wheeler Connecting Rod Using Ansys* ''(International Journal of Engineering Trends and Technology)
5. ShriprasadChorghe, SiddharthDholam, SwapnilKamthe, Sahili Salve &Prof. A. D. Dhale, Department of Mechanical Engineering,Shivajirao S. Jondhale college of engg, Mumbai, Pune, Maharashtra, India ,*"Design Optimisation And Analysis Of Connecting Rod Of Vehicle Engine Using Cae Tools''* (ISSN(P): 2319-2240; ISSN(E): 2319-2259-International Journal of Mechanical Engineering)
6. Swapnil B. Ikhar and Saifullah Khan, Dept. of Mechanical Engineering,St. VincenPallotti college of Engg, & Tech Nagpur, Maharashtra,*"Modelling and Analysis of Connecting Rod of Two Wheeler (Hero Honda Splendor)''*Discovery, Volume 24, Number 83, October 4, 2014
7. Guangchun WANG and Guoqun ZHAO, "*Mold and die engineering technology center,Shandonguniversity,"Powder forging of a Motorcycle connecting rod*".vol 18 No.6,2002.
8. Ganesha Ram, Dr. P. K. S. Nain and Mr. PramodKumar,Dept. of Automobile Engineering,Galgotias University, Greater Noida, India,*"Static Finite Element Analysis and Optimization of Two Wheeler Connecting Rod"*International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 6, June – 2014.