MODELING AND FE-ANALYSIS OF CONNECTING ROD FOR COST AND MATERIAL OPTIMIZATION

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ABSTRACT

The main objective in the "Design analysis and optimization of connecting rod by Ansys for weight and cost reduction" is to modified and prepared suitable design of connecting rod. The main aim in this project is to modified existing connecting rod design by changing some design parameters to improve weight and cost factor for large production rate. It is concern with structural analysis of connecting rod and crosscheck failure by FEM. This is complete by two steps; first one is structural analysis of connecting rod and second is optimization of material without effect on stress distribution. So first a proper Model is prepared using Pro/E Wildfire 4.0 software. Then static analysis is done to determine the von Misses stress, elastic strain, total deformation in the present design of 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 on basis of Factor of Safety. Based on the observations of the load analysis and its results, optimization tool was selected and applied to the current design. Then results of modified or optimized model in ANSYS are crosscheck by stress analysis and F.O.S.

Keywords: - Ansys Workbench, Connecting Road, FEA, Optimization, Pro-E,

I INTRODUCTION

Connecting rods for automotive applications are typically manufactured by forging from either wrought steel or powdered metal. They could also be cast. However, castings could have blow-holes which are detrimental from durability and fatigue points of view. The fact that forgings produce blow-hole-free and better rods gives them an advantage over cast rods. Between the forging processes, powder forged or drop forged, each process has its own pros and cons. Powder metal manufactured blanks have the advantage of being near net shape, reducing material waste. However, the cost of the blank is high due to the high material cost and sophisticated manufacturing techniques.

With steel forging, the material is inexpensive and the rough part manufacturing process is cost effective. Bringing the part to final dimensions under tight tolerance results in high expenditure for machining as the blank usually contains more excess material. For purpose of modeling and analysis, a design, equations and for basic fundamental detail I use Machine Design Book and design data book. [7]

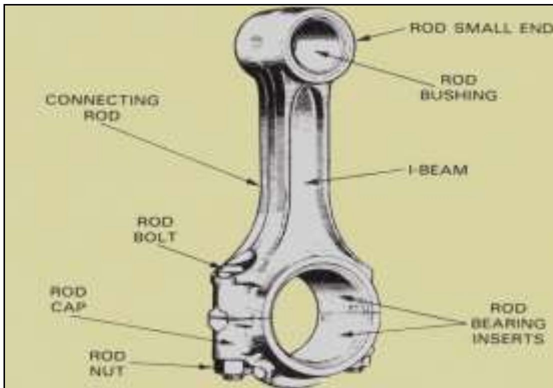

Fig -1: A**utomobile Connecting rod**

Marthanapalli et al (2013) [1] optimized and materialized a four stroke single cylinder 150cc engine connecting rod. For that modeling they are used Pro-E software and followed by Ansys for stress analysis. in their experiment they reduce weight (10 gm) by change in cross section of shank part from I-section to H-section. Furthermore to reduce production cost they suggest Aluminum alloy A360 instead of carbon steel. They concluded from their study that by using of Aluminum alloy weight can be reducing by 4 times compare to existing carbon steel. Asadi, et al (2010) [2] concluded that from their study as follows the maximum pressure stress was obtained between pin end and rod linkage and the maximum tensile stress was obtained in lower half of pin end. Least fatigue cycle was obtained equal 10 cycles. Results of FEM method and results of experimental equations were similar (Maximum difference was only 13%) this shows accuracy of our modeling, meshing and loading.Anil kumar et al (2012) [3] carried out Optimization of Connecting Rod Parameters using CAE Tools. They found that the design parameter of connecting rod with modification gives sufficient improvement in the existing results. The stress was found maximum at the piston end. This can be reduced by increasing the material near the piston end. The weight of the connecting rod was also reduced by 0.004 kg which was not significant but reduces the inertia forces.

II. OBJETIVES

The objective of this work is too analyzed and optimizes the connecting rod for its cost and weight reduction and attractive option for auto manufacturers. For that I chose two cylinder engine's connecting rod. My main focus on static analysis of connecting rod under different load condition likes compressive and tensile load, and then after reduce cost and weight of connecting rod by giving optimization idea comparing under different load condition. To give the optimum design parameter a number of designs were generated by varying the values of the design variables within the specified limits till optimized design had been reached. The results were determined under the same weight and loading condition as for the existing connecting rod.

Table No.1 MATERIAL PROPERTIES OF CONNECTING ROAD

PROPERTY	VALUE
Density (kg/m3)	7850
Poission ratio	0.30
Young'S modulus (Mpa)	210000
Tensile yield Strength (Mpa)	550
Tensile Ultimate strength (Mpa)	550
Compressive Yield strength (Mpa)	900
Compressive Ultimate strength (Mpa)	600

III. 3-D MODEL OF CONNECTING ROD FOR ANALYSIS

The model of connecting rod generated in Pro-E 4.0 as shown in figure 2.

Fig.2 3D Model Prepared in Pro-E

IV. MESH MODEL(MESHING SIZE 1.0 mm)

Generate mesh in model of 1mm size for the analysis,

Type of Element : Tetrahedron ,Number of Nodes : 304977 ,Number of Elements : 179355

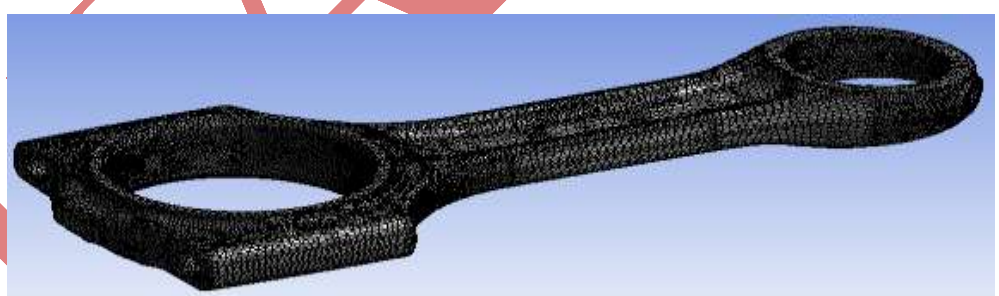

Fig.3 Meshing model in Ansys 12.0

V. ANALYSIS RESULT OF CONNECTING ROD.

To analyze connecting rod there is four possible load and boundary condition can applied small end compressive and tensile and big end compressive and tensile. Here we are discussing related to Small End compressive (86400N) and Big End Compressive with their producing stress, strain and F.O.S.

CASE I- SMALL END COMPRESSIVE LOADING

Fig 4. Force and Restraints Apply on Small End in Compressive loading (86400N)

Shows the Fig.4 Apply the Compressive force on Small end and its fixed support to the big end. And Fig. 5 &6 Shows Von Misses Stress and Strain Produce in case of Small End Compressive Loading.

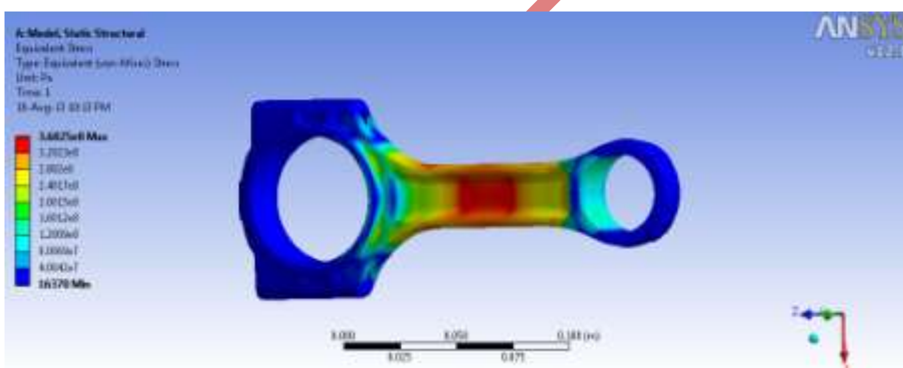

Fig. 5. Von Misses Stress in Small End Compressive Loading

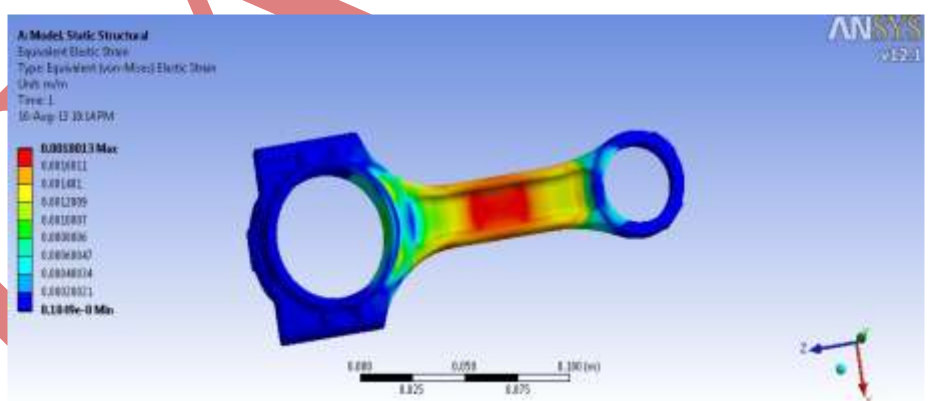

Fig. 6. Von Misses Strain In Small End Compressive Loading

CASE II- BIG END COMPRESSIVE LOADING

In big end compressive loading we applied compressive load on big end side and its coressponding fixed point to the smaller and as shown in fig. 7.followed by fig. 8 &9 indicate a Von misses stress and Strain producing due to this compressive force.

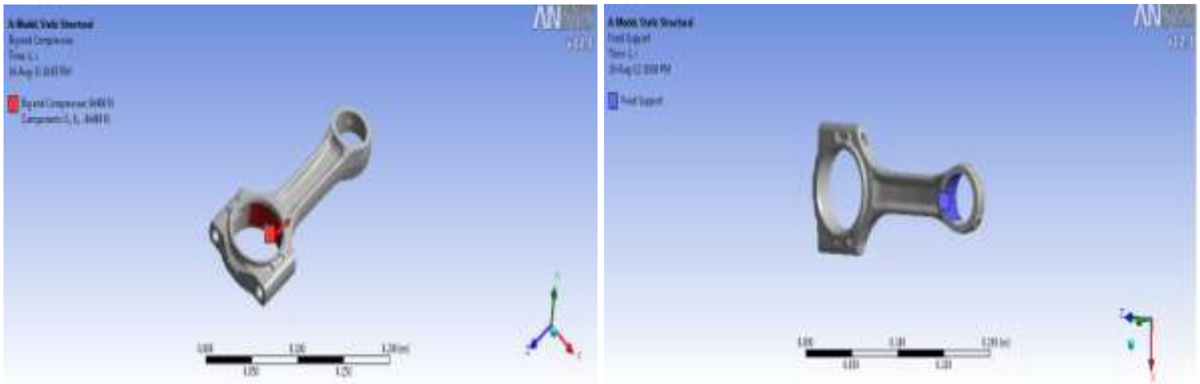

Fig. 7 Force and Fixed Support Applied for Big End Compressive Loading (86400N)

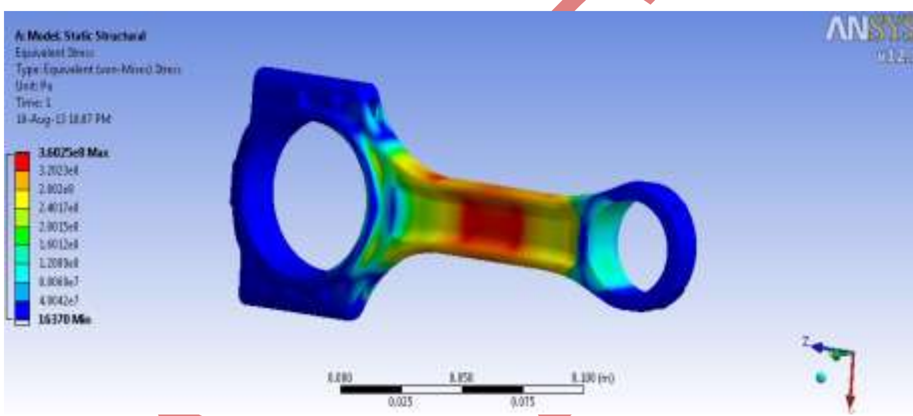

Fig. 8 Von Misses Stress in Big End Compressive Loading

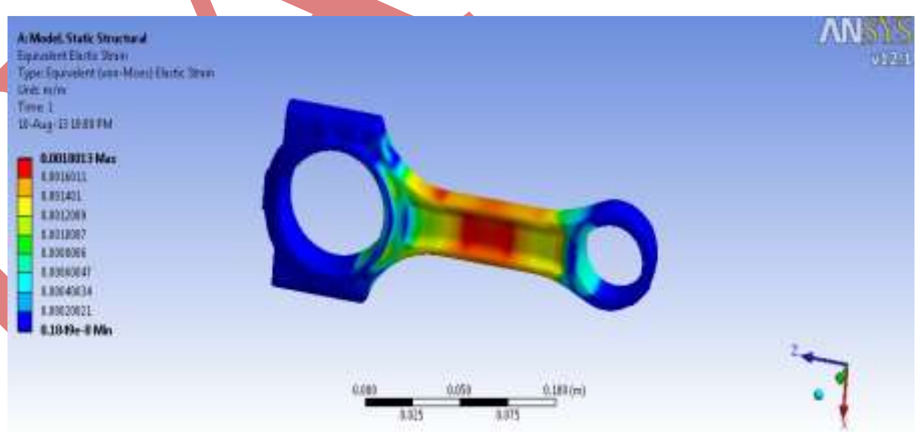

Fig. 9 Von Misses Strain in Big End Compressive Loading

Now from the resultant stress and strain for both side compressive forces are as shown below table.

Table No.-2 RESULTANT STRESS, STRAIN AND F.O.S.

End Condition	**Load (N)**	**Max. Stress (MPA)**	**Max. Strain**	**F.O.S**
SmallEnd Compression	86400	359.19	1.7	1.67
BigEnd Compression	86400	360.24	1.8	1.66

VI. OPTIMIZATION

Aim of the optimization process is to minimize the material of the connecting rod under the effect of a load range (max. compression to max. tensile). Due to material reduction automatically 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. So this reason new design (modified or optimized) can be replace to existing design for lower value of weight and cost. This requires some of the dimensions in the existing connecting rod to be maintained.suraj pal et al (2012) [4] found from their experimental data that stress is found maximum at the piston end and design parameter of connecting rod with modification gives sufficient improvement (reducing weight of connecting rod 0.477 gm) in the existing results.The model after the optmization again cross check for stress and strain analysis to get F.O.S. value which is inrange of 1.6 to 1.9 that means its safe.

ANNA ULATOWSKA (2008) [5] has work on optimization topology on connecting rod. And he can conclude Results are scaled to 270 MPa in order to show how stresses are compensated after optimization and scaled to 300 MPa in order to show how maximum stresses are decreased after optimization. It is shown that before optimization it is a few point with stress concentration, but all model has moderate stress. After optimization it is clear (from their result of optimization) that stress is more uniform, which was the object of this studies. M.S. Shaari et al (2010) [6] prepared structural modeling, finite element analyze and the optimization of the connecting rod for robust design for weight and cost improvement. In this paper author use SOLIDWORKS software for Modeling of connecting rod and Finite element modeling and analysis were performed using MSC/PATRAN and MSC/NASTRAN software. Linear static analysis was carried out to obtain the stress/strain state results. From the FEA analysis results, TET10 predicted higher maximum stress than TET4 and maximum principal stress captured the maximum stress. The crank end is suggested to be redesign based on the topology optimization results. The optimized connecting rod is 11.5 % lighter and predicted low maximum stress compare to initial design. For future research they suggest that the weight reduction should cover on material suggestion.Here rim curvature at the big end side is totally free from the stress so it is a place where we can absorve excess material so we can remove a material over here.By optimization we can reduce a mass of connection rod up to 0.702 from 0.792 Kg(10% Reduction).

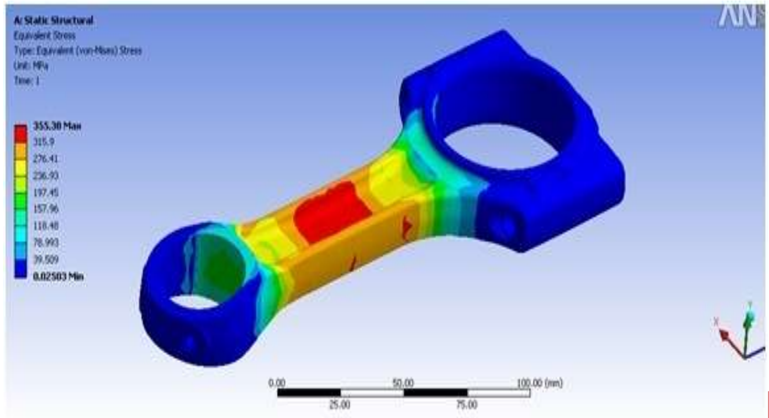

Fig.8. Von Misses Stress in Compressive (BigEnd) of Optimized Design

Table No.-3 COMPARISION OF EXISTING AND OPTIMIZED DESIGN

End Condition In compression	Load (N)	Max. Stress (MPA) Of Existing Design	Max. Stress (MPA) Of New Design	F.O.S
SmallEnd	86400	360.24	355.36	1.8
BigEnd	86400	359.19	344.40	1.8

VII. FUTURE SCOPE

To improve analysis data of our experiments we can analysis connecting rod by

- Fatigue analysis
- Failure analysis
- Dynamic analysis

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