# Optimization of Connecting Rod Parameters using CAE Tools

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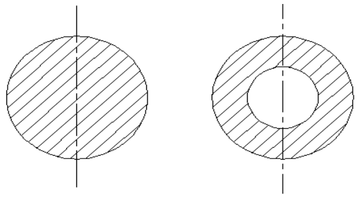
**Abstract — Aim of this work is to optimize weight and reduce inertia forces on the existing connecting rod, which is obtained by changing such design variables in the existing connecting rod design. The model was developed in Pro/E wildfire 5.0 and then imported as parasolid (xt) form in ANSYS workbench. In this work finite element analysis of the single cylinder four stroke petrol engine connecting rod is considered as case study. The Von Mises stress, strain and total deformation determined for the same loading conditions and compared with the existing results. Based on the observation of static FEA and the load analysis result, the load for the optimization study was selected same as on existing connecting rod. The current work consists of static structural analysis. The static analysis was carried out under axial and buckling load. The model is also selected for fatigue analysis to determine the fatigue strength.**

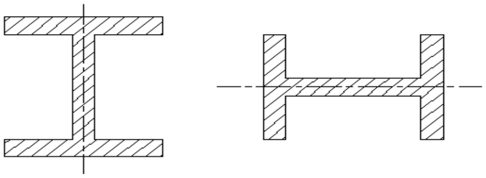
Keywords — **Connecting Rod, Pro/E wildfire 5.0, Finite Element Analysis, Optimization, ANSYS Workbench.**

## I. INTRODUCTION

The connecting rod is used to transfer linear, reciprocating motion of the piston into rotary motion of the crankshaft. The maximum stress occurs in the connecting rod near the piston end due to thrust of the piston. The tensile and compressive stresses are produced due to the gas pressure, and bending stresses are produced due to centrifugal effect. From the viewpoint of functionality, connecting rods must have the highest possible rigidity at the lowest weight. So the connecting rods are designed generally of I-section to provide maximum rigidity with minimum weight. The maximum stress produced near the piston end could be decreased by increasing the material near the piston end. The classification of connecting rod is made by the cross sectional point of view i.e. I – section, H – section, Tabular section, Circular section. In low speed engines, the section of the rod is circular, with flattened sides. In high speed engines either an H – section or Tabular section is used because of their lightness. The rod usually tapers slightly from the big end to the small end.



Circular section



I and H Section

Mr. Pranav G Charkha and Dr Santosh B Jaju[1] carried out the Finite Element Analysis and optimization of connecting rod using ANSYS work bench 9. The study consists of two types of analysis, static analysis and fatigue analysis. The main objective of this study was to explore weight reduction opportunities for a production forged steel connecting rod. The study was performed on four stroke petrol engine connecting rod which is made up of structural steel. The weight reduction is achieved by static analysis under static load conditions, and 9.24% weight is reduced as compared to the existing connecting rod. Pravardhan S. Shenoy and Ali Fatemi [2] presented the FE analysis procedure for optimization for connecting rod weight and cost reduction. A study was performed on a forged steel connecting rod with a consideration for improvement in weight and production cost. Weight reduction was achieved by an iterative procedure. This study results in an optimized connecting rod that was 10% lighter and 25% less expensive, as compared to the existing connecting rod. A. Mirehei et al. [3] carried out the fatigue analysis of connecting rod of universal tractor (U650). The objective of the research was to determine the lifespan of connecting rod due to cyclic loading. The results were carried out under fully reversed loading. The numbers of critical points were also located from where the crack propagation initiates. Allowable number of load cycles and using fully reverse Loading was gained 108. It was suggested that the results obtained could be useful to bring about modifications in the process of connecting rod manufacturing. Vasile George Cioata, Imre Kiss [4] presented a method used to verify the stress and deformation in the connecting rod using the finite element method with Ansys v.11. The study only analyses the connecting rod foot. The obtained results provided by this method were compared to the results obtained by classic calculation, in similar conditions of application, and after wards conclusions were drawn.

## II. OBJECTIVES

The main objective of this work is to reduce weight of the existing connecting rod with desired strength. In this paper, only the static FEA of the connecting rod was performed. The aim of the project is to determine the Von Misses stresses, Shear stresses, Equivalent Alternating stress, Total Deformation, Fatigue Analysis and Optimization in the existing Connecting rod. If the existing design shows the failure, then suggest the minimum design changes in the existing Connecting rod. 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 [1]. Two cases are analysed one with load applied at the crank end and restrained at the piston end, and the other with load applied at the piston end and restrained at the crank end. An axial Load is applied on the connecting rod at the small end, and cylindrical support is given at the crank end. The same loading conditions also applied for the buckling load. For fatigue failure analysis the loading conditions are fully reversed.

## III. MATERIAL PROPERTIES OF CONNECTING ROD

| Material selected | Structural steel |
|---|---|
| Young's Modulus,(E) | 2.0 X 10$^5$ MPa |
| Poisson's Ratio | 0.30 |
| Tensile Ultimate strength | 460MPa |
| Tensile Yield strength | 250 MPa |
| Density | 7850kg/m3 |
| Behavior | Isotropic |

## IV. MODEL OF CONNECTING ROD

The model of connecting rod was generated in pro/E wildfire 5.0. The model of connecting rod is shown in fig.1.

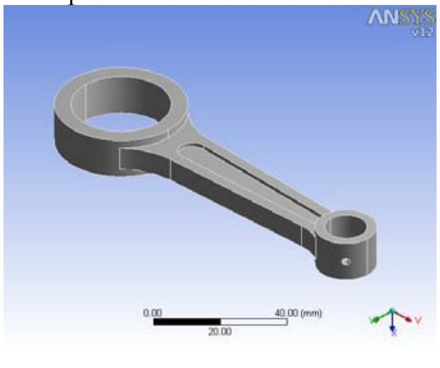


Fig. 1 CAD model of connecting rod

## V. MESH MODEL

The meshed model of connecting rod is shown below:

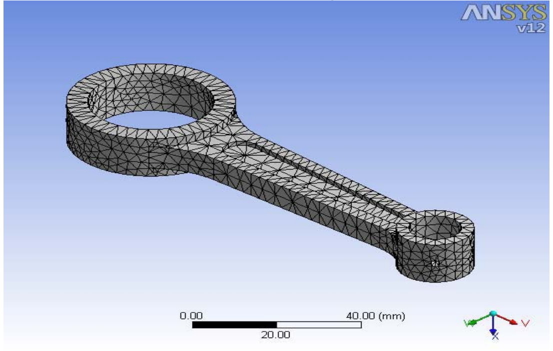


Fig.2 Meshed model of connecting rod

## VI. FEA RESULT OF CONNECTING ROD

The load applied at the piston end and cylindrical support was given at the crank end. Two cases are analyzed for each case, one with load applied at the crank end and restrained at the piston pin end, and the other with load applied at the piston pin end and restrained at the crank end. The analysis carried out under axial and buckling loads. Here the tensile or compressive load was equal to 4319N and buckling load is equal to 21598N. And after that comparisons were made for optimization purpose. The static results are shown in figures given below.

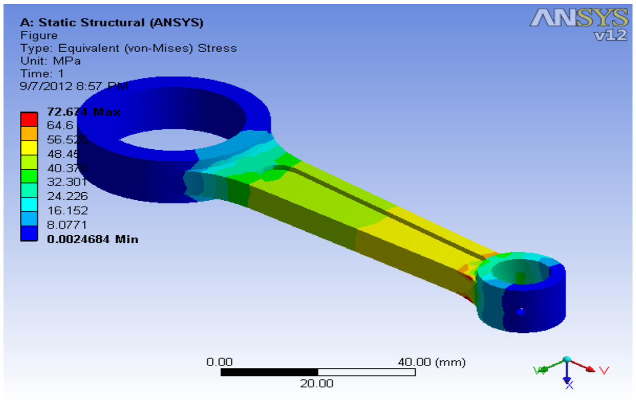


Fig 3 Equivalent Stress (For load=4319N)

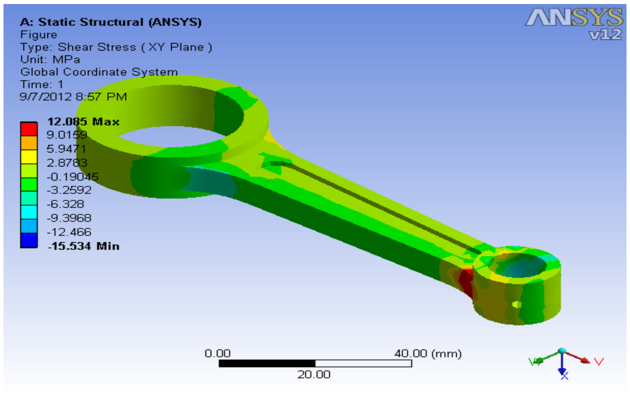
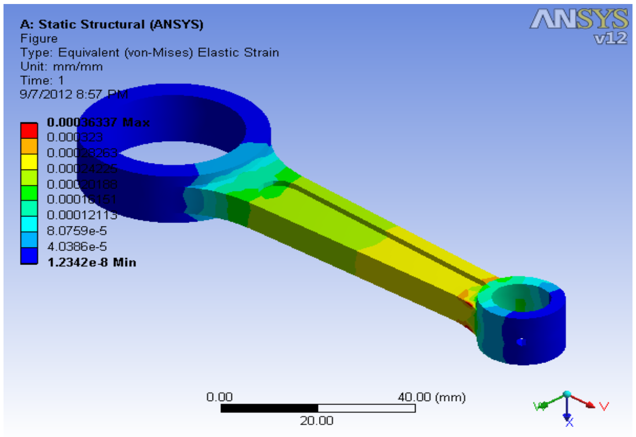


Fig 4 Shear Stress (For load =4319N)



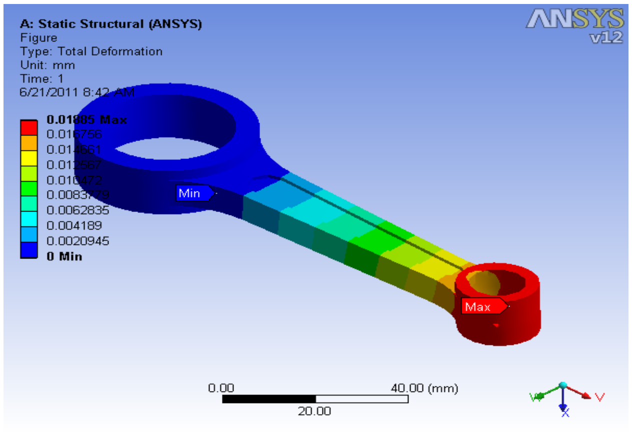


Fig.5 Equivalent Elastic strain (For load =4319N)

Fig.6 Total deformation (For load =4319N)

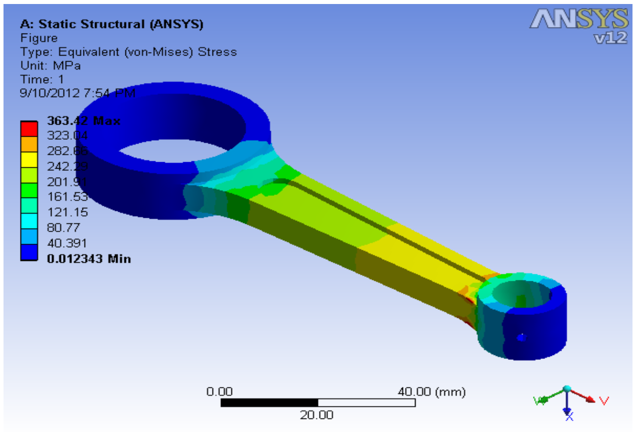


Fig.7 Equivalent Stress (For load =21598N)

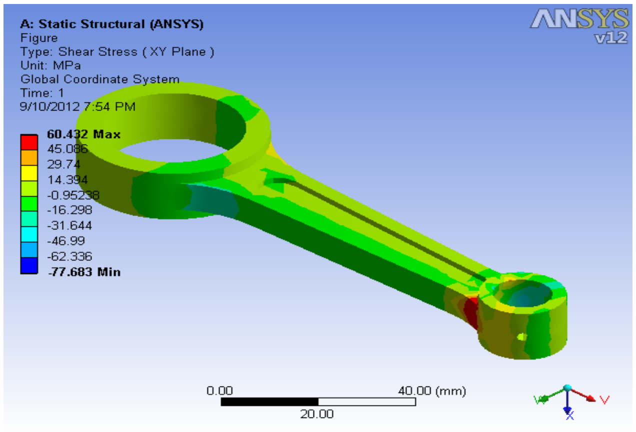


Fig. 8 Shear Stress (For load =21598N)

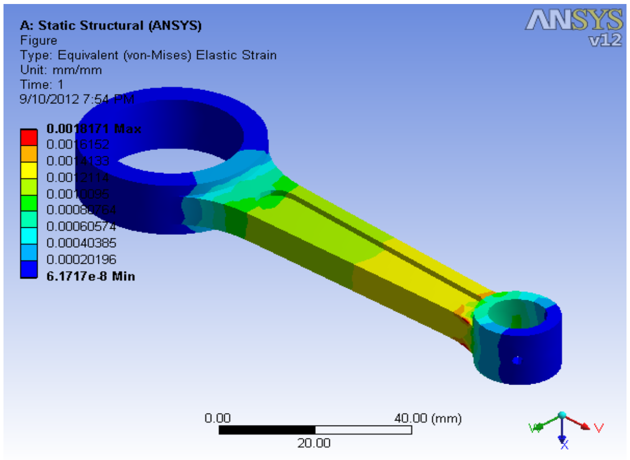


Fig. 9 Equivalent Elastic strain (For load =21598N)

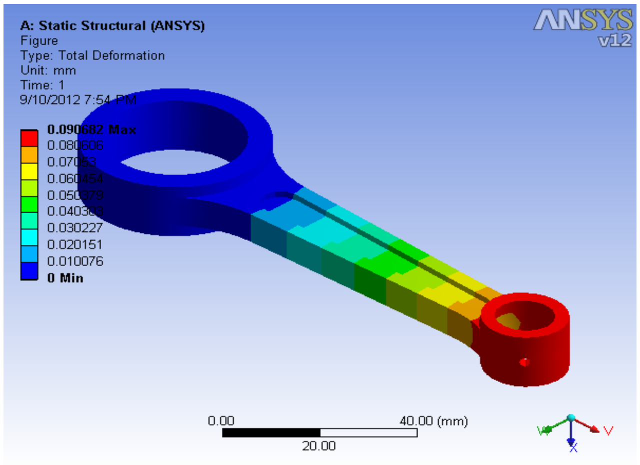


Fig. 10 Total deformation (For load =21598N)

Comparison Table (For Stress Analysis) Respective Figures (From 3-10):

| Name | For load = 4319 N | | For load = 21598 N | |
|---|---|---|---|---|
| | Min. | Max. | Min. | Max. |
| Equivalent Von Mises stress | $2.46\times10^{-3}$ MPa | 72.67 MPa | 0.123 MPa | 363.42 MPa |
| Shear stress | -15.53 MPa | 12.08 MPa | -77.68 MPa | 60.43 MPa |
| Equivalent elastic strain | $1.23\times10^{-8}$ mm/mm | $3.63\times10^{-4}$ mm/mm | $6.17\times10^{-8}$ mm/mm | $1.81\times10^{-3}$ mm/mm |
| Total deformation | —— | 0.0181mm | —— | 0.906mm |

Table-1: - Comparison Table (For Static Analysis)

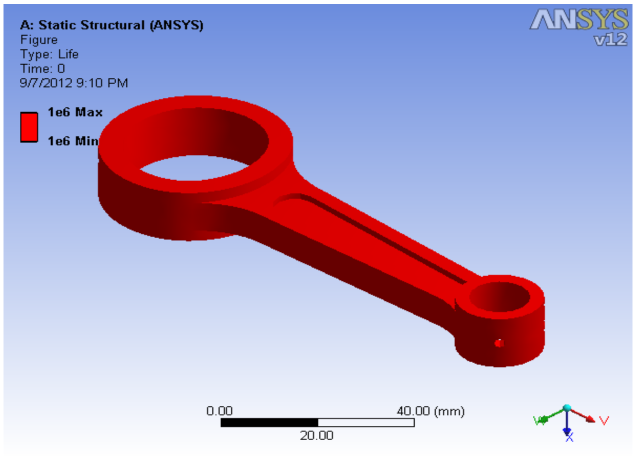


Fig.11 Life (For Load = 4319)

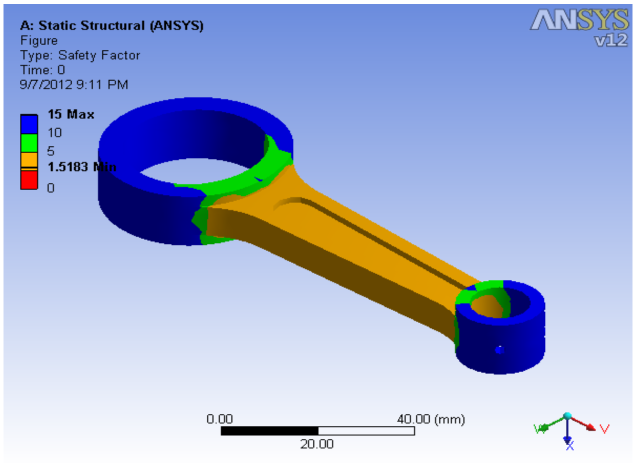


Fig. 12 safety factor (For load = 4319 N)

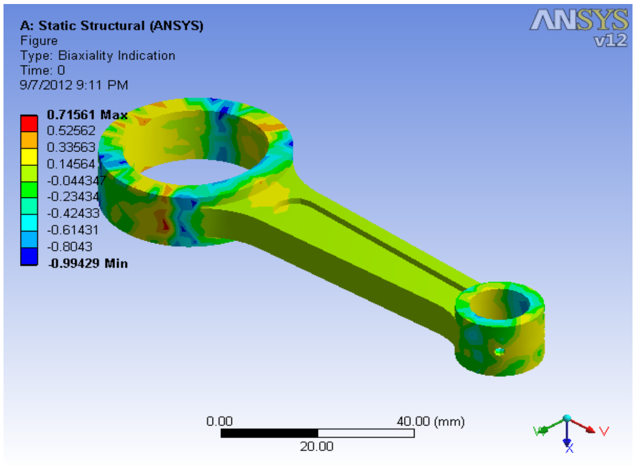


Fig. 13 Biaxiality indication (For load = 4319)

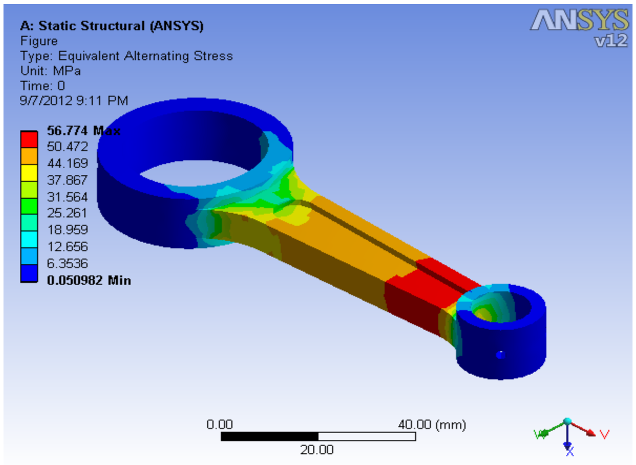


Fig. 14 Equivalent Alternating Stress (For load = 4319 N)

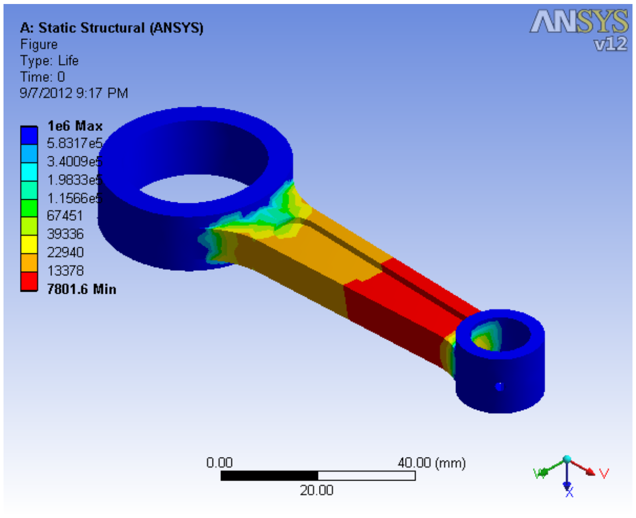


Fig. 15 Life (For load = 21598 N)

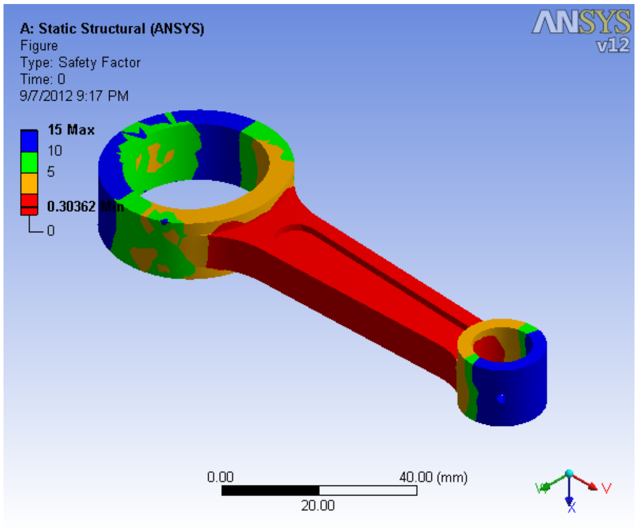


Fig. 16 Safety factor (For load = 21598N)

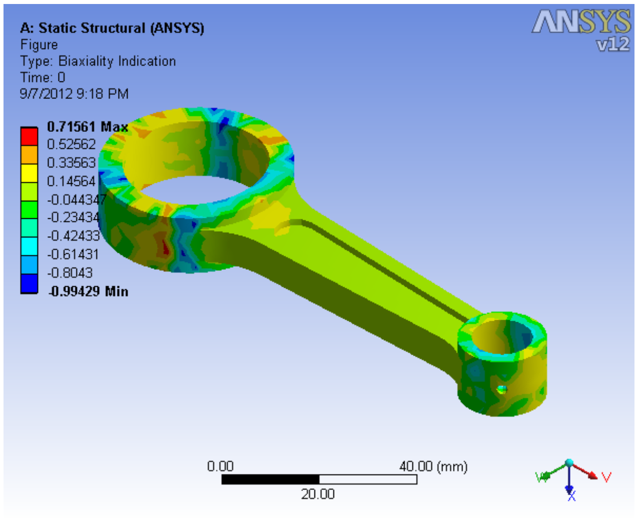


Fig. 17 Biaxiality indication (For load = 21598N)

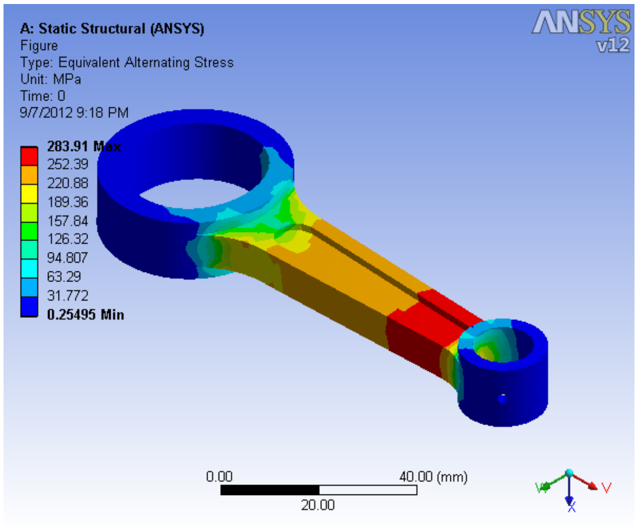


Fig. 18 Equivalent Alternating Stress (For load = 21598N)

Comparison Table (For Fatigue Analysis) Respective Figures (From 11-18):

| Name | For load = 4319 N | | For load = 21598 N | |
|---|---|---|---|---|
| | Min. | Max. | Min. | Max. |
| Life | 1x10$^{6}$ | 1x10$^{6}$ | 7801.6 | 1x10$^{6}$ |
| Damage | 1000 | 1000 | 1000 | 1.28x10$^{5}$ |
| Safety factor | 1.51 | 15 | 0.303 | 15 |
| Biaxiality Indication | 0.99 | 0.71 | -0.99 | 0.71 |
| Equivalent Alternating Stress | 0.0509 MPa | 56.77 MPa | 0.254 | 283.91 MPa |

Table-2. Comparison table (For fatigue Analysis)

## VII. RESULT FOR OPTIMIZATION

The optimization task was to minimize the mass of the connecting rod under the effect of a load range for two extreme loads, the peak compressive gas load and the tensile load within the limits of the allowable stresses. The result of weight reduction for optimized connecting rod is given below in table 3.

| ORIGINAL | OPTIMIZED | REDUCTION (PERCENTAGE) |
|---|---|---|
| 0.131 kg. | 0.127 kg. | 3.05 % |

Table-3. For weight optimization

## VIII. CONCLUSION

- It was 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.
- Fatigue strength plays the most significant role (design driving factor) in the optimization of this connecting rod.
- Optimization was performed to reduce weight of the existing connecting rod. This optimization can also be achieved by changing the current forged steel connecting rod into some other materials such as C-70 steel etc.

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