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Analytical Study and Optimization of Connecting Rod by ANSYS of Bajaj XCD-135

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ABSTRACT: The main aim of this study is to analyze and optimize the Connecting Rod of Bajaj XCD. . In this research work, the existing connecting rod of Bajaj XCD-135 cc material AISI-5120 is replaced by Titanium 13V-11Cr-3al. The model is designed with the help of SOLIDWORKS and analysis is done by ANSYS workbench 17.1 software. For the optimization, a modification is done in the design of existing connecting rod. Crank radius is reduced to 25 mm and the piston radius is reduced to 20 mm which results in reduction of weight, to reduce the failure and increase the performance of the connecting rod.

KEYWORDS- IC engine Connecting Rod, Types, Material, and Static Structural Analysis.

I. INTRODUCTION

Connecting rod is used to connect the piston to the crank or crankshaft in a reciprocating engine. The connecting rod connects the reciprocating piston to rotating crankshaft also transmitting the thrust of the piston to the crankshaft. Connecting rod of automotive should be lighter so that its fuel consumption is less and it provides comfort and safety to passengers, it leads to a decrease in the weight of the vehicle. Thus it results in the invention and implementation of quite new materials which are light and meet design requirements.



Fig 1: Connecting Rod

II. LITERATURE SURVEY

Harsh et al. [1] in this study existing connecting rod of Bajaj Pulsar 150cc was taken. The material of the existing connecting rod is 20CrMo. The existing rod was heavy in weight so, the existing connecting rod was replaced with the new composite material AL6061+B₄C. The model of the new connecting rod was prepared on the Parametric Modeling software and then the analysis of the connecting rod was done on the Finite Element Analysis (FEA) tool. By the FEA analysis, it was concluded that the weight of the connecting rod was reduced up to 106 grams.

Mohamad Gani et al. [2] describes the model and analyze the connecting rod. Aluminium connecting rod is replaced by Boron Silicate for Suzuki GS 150R motorbike. The model of the connecting rod is designed by using CATIA V5 Software and analyzed in ANSYS Workbench Software. Parameters included are von misses stress, vom misses strain,

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deformation and weight reduced for connecting rod. The material of existing connecting rod is replaced by Carbon steel to Aluminium Boron Carbide. They concluded that the equivalent stress for both materials is same. The number of cycles of Aluminium boron Silicide is (2095×10^4) is more than the existing carbon steel connecting rod (7046.36×10^3) .

Kuldeep et al. [3] investigated that material of the connecting rod is replaced from carbon and aluminum alloy to Aluminum based composite material reinforced with Silicon carbide and fly ash. They designed a model and analyzed connecting rod. FEA analysis was carried out by using two materials. The parameters considered for their study are von misses stress-strain and displacements were obtained from ANSYS software. The new material results in 43.48% of weight, with a 75% reduction in displacement. They concluded that the weight of the connecting rod is reduced by changing the material of the existing connecting rod by Al360 to Hybrid ALFASiC composites.

Sandeep et al. [4] this paper explains about the failure of connecting rod. The existing connecting rod of Swaraj 724 Tractor was made of C70 alloy steel. The model of the connecting rod was prepared on the CATIA V5 Software. The analysis of the connecting rod was done by applying load on the bigger end and the smaller end is fixed. The failure of the connecting rod is by finding the maximum stress point in the connecting rod. The different loads are being applied on the connecting rod. Then, they concluded that the connecting rod of Swaraj 724 tractor was twisted from the center due to high crushing load.

Balaji et al. [5] investigated that the model and analysis of connecting rod. Connecting rod is replaced by AlSiC for 125cc motorbike. A parametric model of connecting rod is designed by using CREO software. The parameters like Von misses stress, strain, deformation and weight reduction is done by ANSYS software. They concluded that the optimization of connecting rod weight and manufacturing cost can be reduced.

III. OBJECTIVES

- The comparison between existing and modified connecting rod design to improve the performance under working stress.
- Determining optimum design parameters to minimize the failure of connecting rod.

IV. THEORETICAL CALCULATION OF ENGINE

Engine Type: 4 Stroke, Natural air cooled

Bore: 54mm

Stroke: 58.8mm

Displacement: 134.6cc

Maximum Power: 10.2Ps@7500rpm

Maximum Torque: 11.58Nm@5000rpm

Compression Ratio: 9.8:1

Density of Petrol (C_8H_{18}): 737.22Kg/m^3

Temperature of Petrol: 288.706K

Mass of Petrol: $737.22 \times 10^{-9} \times 134.6 \times 10^3$
 $= 0.09922981 \text{Kg}$.

Molecular weight of Petrol (C_8H_{18}): 0.114224Kg/mole

For gas equation $PV = m \cdot R_{\text{specific}} \cdot T$

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$$R_{\text{specific}} = \frac{8.3143}{0.114224} = 72.784313 \text{ J/KgK}$$

$$\text{Pressure} = \frac{\text{mass} \times R_{\text{specific}} \times \text{Temperature}}{\text{Displacement}}$$

$$= \frac{0.09922 \times 72.78431 \times 288.706}{134.6} = 15.4849689 \text{ Mpa}$$

$$\text{Maximum Gas Force} = \pi D^2 / 4 \times P_{\text{max}}$$

$$= (\pi \times 54^2) / 4 \times 15.4849689$$

$$= 35475.22373 \text{ N or } 35.475 \text{ KN.}$$

V. METHODOLOGY USED

Step I: Modeling of connecting rod as per the dimensions measured by vernier caliper and micrometer in SOLIDWORKS.

Step II: The 3-D model was imported in ANSYS Workbench 17.1 in STEP format.

Step III: Material properties of AISI-5120 were defined in engineering data in ANSYS workbench.

Step IV: The material AISI-5120 was assigned to the connecting rod in the mechanical interface.

Step V: Mesh was generated for connecting rod using element 56788.

Step VI: Inner section of piston end was fixed.

Step VII: In the static structural analysis, the pressure is applied to the inner section of the crank end and fillets of piston end and crank end of 15.49Mpa.

Step VIII: Analysis solution was performed and stresses values were checked for the connecting rod.

Step IX: Analysis solution was performed and stresses values were checked for the connecting rod, Von-misses stresses, Von-misses strain, Total Deformation, Maximum Principal Stress, and Factor of Safety analysis was used to compare the results.

Step X: Geometry of connecting rod was modified in SOLIDWORKS and the existing material is replaced by titanium Ti-13V-11Cr-3Al and all the steps from step1 to step9 were performed again to get the results. The results of existing connecting rod and with modified geometry were compared.

Table 1: Dimensions of Existing Connecting Rod

Length of Connecting Rod	95 mm
Outer Diameter of Crank End	42 mm
Inner Diameter of Crank End	32 mm
Outer Diameter of Piston End	20 mm
Inner Diameter of Piston End	14 mm

Table 2: Material Properties of AISI-5120

Yield Strength (Mpa)	Ultimate Tensile Strength (Mpa)	Young's Modulus (Gpa)	Poisson Ratio	Density (g/cm ³)
397.6	500	190	0.27	7.85

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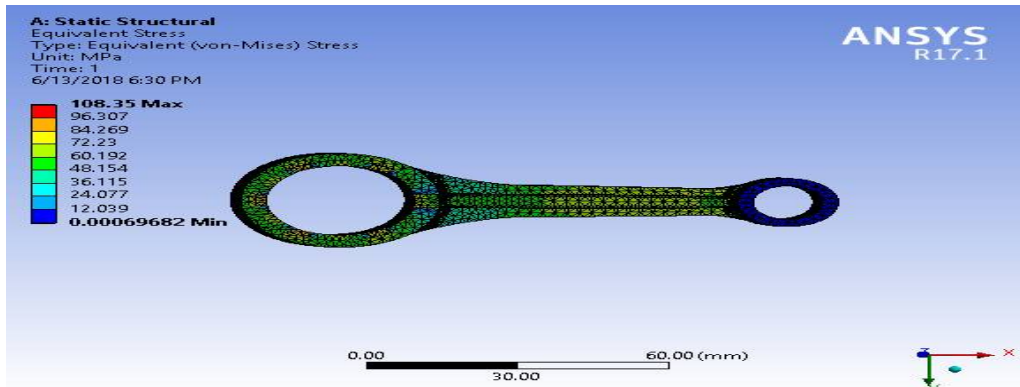


Fig 2: Von misses stress of AISI-5120

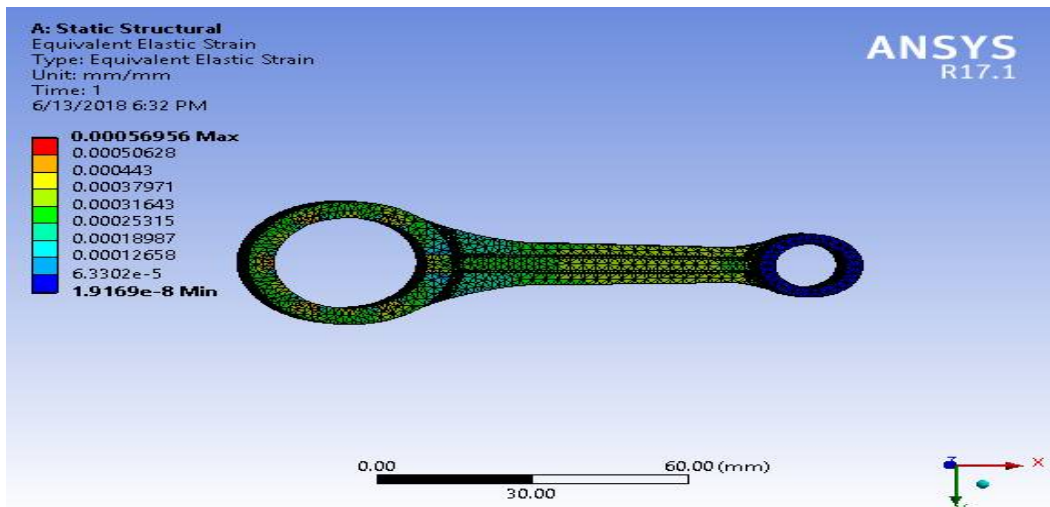


Fig 3: Von misses strain of AISI-5120

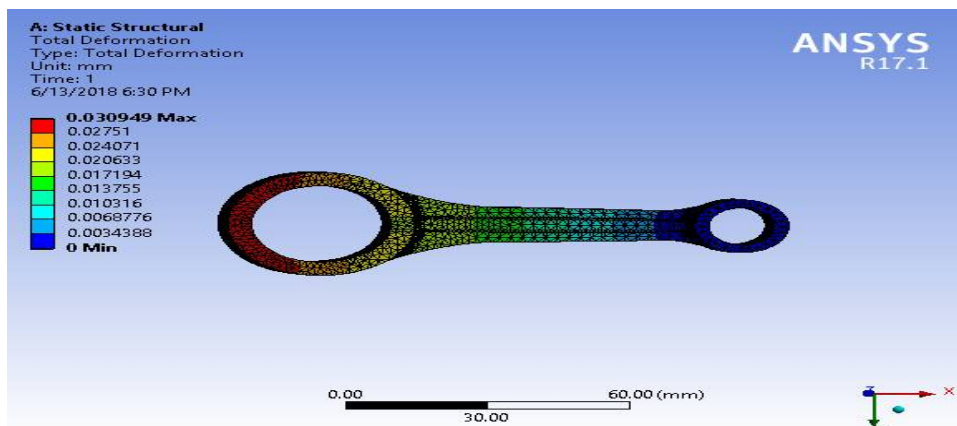


Fig 4: Total Deformation of AISI-5120

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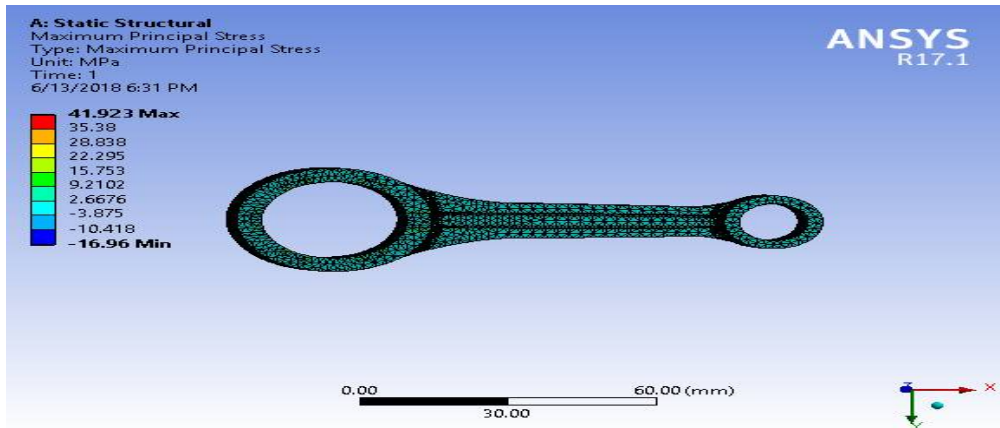


Fig 5: Maximum principal stress of AISI-5120

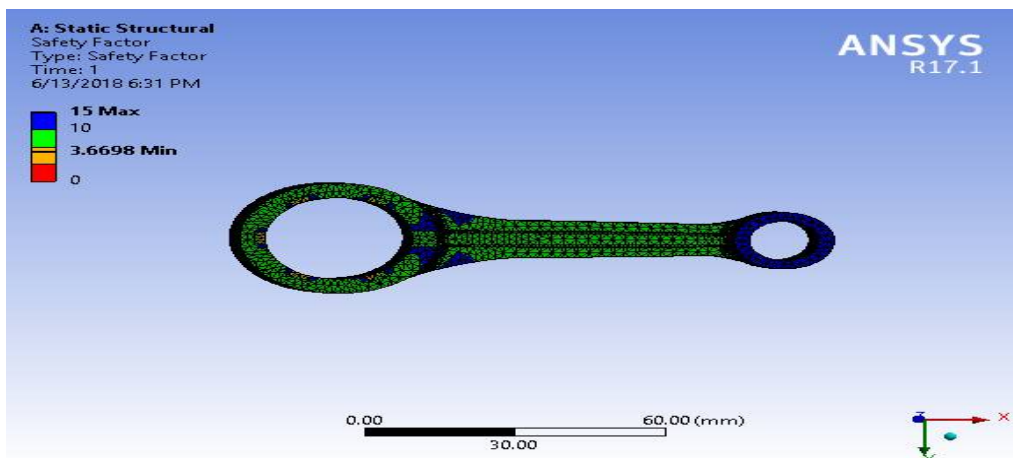


Fig 6: Safety factor of AISI-5120

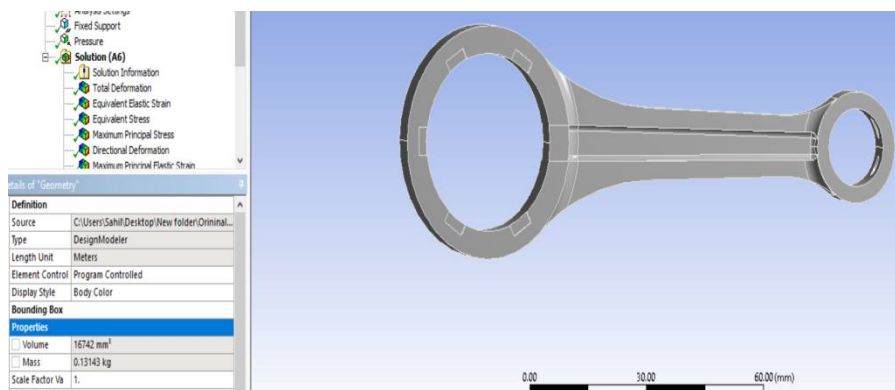


Fig 7: Mass of Connecting rod AISI-5120

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VI. GEOMETRIC MODIFICATIONS IN THE EXISTING CONNECTING ROD

1. Fillets radius of the crank end is reduced to 25mm.
2. Fillets radius of piston end is reduced to 20mm.
3. Replacement of the existing material of connecting rod.

Table 3: Material Properties of Ti-13V-11Cr-3al

Yield Strength (Mpa)	Ultimate Tensile Strength (Mpa)	Young's Modulus (Gpa)	Poisson Ratio	Density (g/cm ³)
1140	1210	110	0.30	4.8

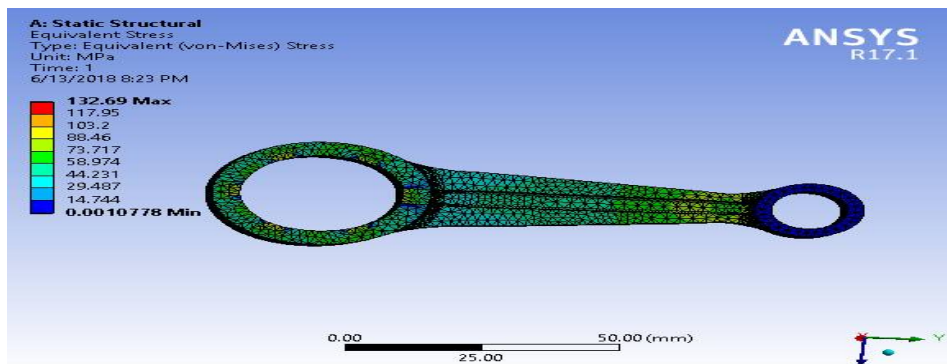


Fig 8: Von misses stress of Ti-13V-11Cr-3al

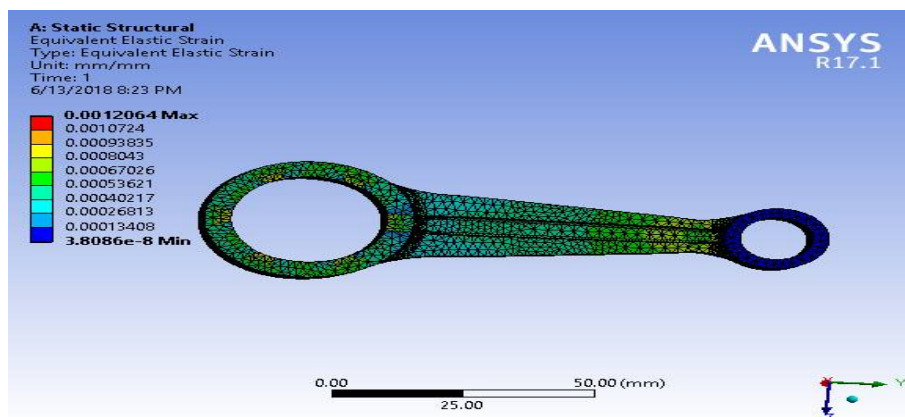


Fig 9: Von-misses strain of Ti-13V-11Cr-3al

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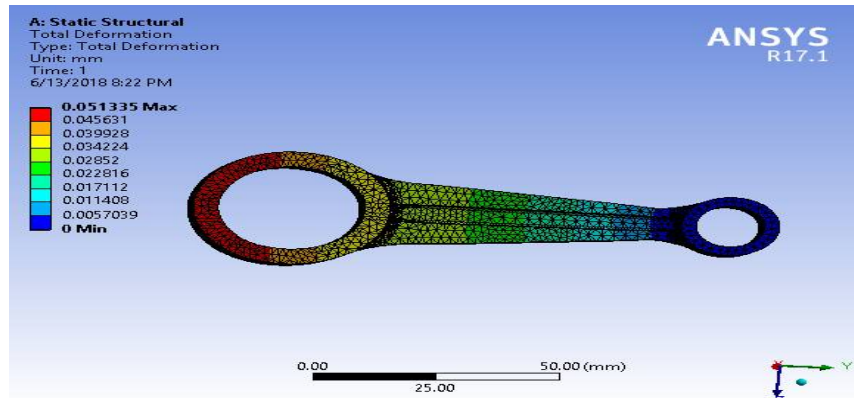


Fig 10: Total Deformation of Ti-13V-11Cr-3al

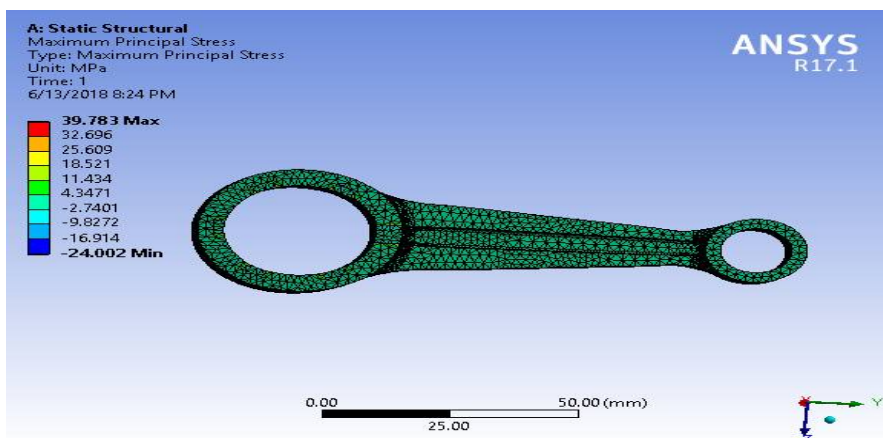


Fig 11: Maximum principal stress of Ti-13V-11Cr-3al

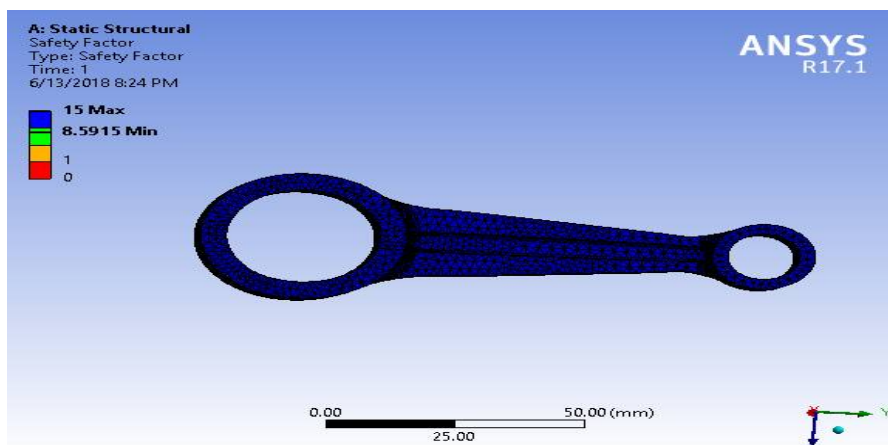


Fig 12: Safety factor of Ti-13V-11Cr-3al

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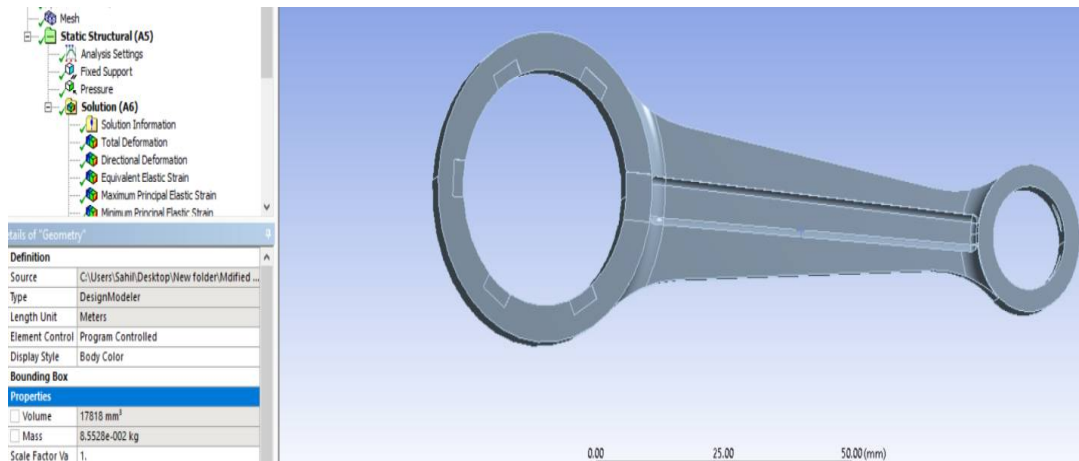


Fig 13: Mass of Ti-13V-11Cr-3Al

VII. RESULT

Table 4: Results Comparison

S. NO.	Connecting rod Description	Existing Rod	Modified Rod
1	Von-Misses Stress	108.35 Mpa	132.69 Mpa
2	Von-Misses Strain	0.00056956	0.0012064
3	Total Deformation	0.030949 mm	0.051335 mm
4	Maximum Principal Stress	41.923 Mpa	39.783 Mpa
5	Factor of Safety	3.6698	8.5915
6	Mass	0.13143 Kg	0.085528 Kg

VIII. CONCLUSION

Von-Misses stress of modified connecting rod is 132.69 Mpa which is more than existing connecting rod which has 108.35 Mpa which means that the modified connecting rod can withstand more stress than the existing connecting rod. The Von-misses strain of modified connecting rod is 0.0012064 which is more than the existing connecting rod 0.00056956 which means that the modified connecting rod can withstand more von-misses strain. Total Deformation of existing rod is 0.030949 mm which means after applying 15.49 Mpa pressure it deforms 0.030949 mm but after applying same pressure on modified connecting rod it deforms 0.051335 mm. The Maximum Principal stress of modified connecting rod is 39.783 Mpa but of the existing connecting rod is 41.923 Mpa which means it is nearby to the existing connecting rod. The factor of Safety increases from 3.6698 to 8.5915. It increases due to improvement in above parameters. Mass of the existing connecting rod is reduced by 34.92%.

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IX. LIMITATIONS

- Total deformation is more in modified Connecting Rod than the existing Connecting Rod.
- Maximum Principal Stress is better in existing Connecting Rod than the modified Connecting Rod.

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