Analytical Study and Design Analysis of Connecting Rod of Mahindra Pijo by Finite Element Analysis

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***ABSTRACT*: The main aim of this study is to analyze and optimize the Connecting Rod of Mahindra Pijo. This research demonstrates the performance of a connecting rod basically depend on its size optimization and material selection. The dimensions of the existing connecting rod are measured with the help of a vernier caliper and micrometer. The model of the connecting rod is designed in Solidworks with the measured dimensions and the material of the existing connecting rod is SAE 8620 Finite Element Analysis (FEA) is used for the static structural and steady-state thermal analysis of the connecting rod by considering the parameters such as equivalent stress, von misses strain, maximum principal elastic strain, safety factor and heat flux. A modification is done in the design of existing connecting rod. The existing material of connecting rod is replaced with Ti 6al 4v and crank radius is reduced to 40 mm and fillet of piston radius is increased to 50mm. which results in reduce the mass, to reduce the failure and increase the performance of the connecting rod.**

***Keywords*: Connecting Rod- I-section, Design Modification, Material Selection**.

I. INTRODUCTION

Internal Combustion(IC) engine has consisted of many parts like cylinder, piston, connecting rod, crank, and crankshaft. The connecting rod is one of the essential parts of an engine. The main function of connecting rod is to transmit the reciprocating motion of the piston to rotary motion of the crankshaft. Connecting rod has piston end and the crank end. Piston end is attached with the piston. The crank end (big end) is attached to the crankshaft. The connecting rod should design in such a way that it can withstand the load without any failure during high cycle fatigue. The most important parts of connecting rod are piston end, crank end, and long shank. There are different types of shanks of the connecting rod like rectangular, tubular, circular, I-section and H-section in this research we select I- section.

Fig.1.1: Connecting Ro

II. LITERATURE SURVEY

Singh et al. [1] investigate the strain load stress, total deformation and analysis of factor of safety of piston end of connecting rod of various materials. They replace the existing material by Beryllium alloy, magnesium alloy. FEA analysis is carried out on the 5 material Al360, forged steel, Beryllium alloy (alloy 25), titanium alloy, ti-13v-11cr-3al and magnesium alloy. In this, they design a 3d model on SOLIDWORKS 2016 and analysis is carried out by ANSYS 16.2 software. After the analysis, they concluded that the design and optimized connecting rod is used to replace existing connecting rod due to its lightweight by approx. 15%.

G. Naga et al. [4] explains weight optimization in the connecting rod of the IC engine by various materials like Genetic steel, aluminum, titanium and cast iron. The model connecting rod is made on Pro-E and analysis is done on ANSYS. They carry out the various load analysis in static and stress analysis of the connecting rod. Design optimization for appropriate material to minimize the deflection. The load acting on the connecting rod as a function of time are obtained. The relation for obtain the load for the connecting rod at the given constant speed of crankshaft is also determined. They find out that the connecting rod can be designed and optimized under a tensile load corresponding to 360^0 crank angles at the maximum engine speed as one extreme load and the crank pressure as the other extreme load which result to cost reduction and weight reduction. The bending stresses are calculated for tensile bending stresses about 266.86333 N/mm^2 and also found that connecting rod made up of genetic steel shows less deformation and stress then titanium, cast iron and Aluminium.

G.Sailaja, and S. Irfan Sadaq [3] [l] investigated about the static and model analysis of connecting rod. They replace the material of connecting rod from carbon steel and Aluminium alloy from Beryllium alloy. They analyze connecting rod to determine the dynamic behavior of the connecting rod by considering deformation, strain, and stress. These parameters help connecting rod to determine/identify a section of failure due to stresses induced. The model of the connecting rod is designed on SOLIDWORKS and the analysis is done on FEA. They concluded that the portion closer to the smaller end is more chance of failure due to higher crushing load due to the gudgeon pin assembly. The maximum von-misses stress, strain, and maximum displacement are minimized in the connecting rod of Beryllium alloy that is why the life of Beryllium connecting rod is longer.

Sujal et al. [44] describe the design evaluation and optimization of connecting rod parameters. To get a suitable design for connecting rod they change the design parameters in the existing design. They take a single cylinder 4-stroke petrol engine. They do the structural analysis of the connecting rod. The design of the connecting rod is created by PRO-E wildfire and analysis is done on FEA software. The static analysis is done to determine. Elastic strain, total deformation, shear stress, von-misses stress and von-misses strain at different loading condition to get the safe design. The results of the analysis are used to determine fatigue strength, fatigue life, damage, factor of safety, stress biaxiality indication. They concluded that the weight of the connecting rod is reduced by 0.477g and reduces the inertia forces and reduces the stresses at the piston end.

Nikhil et al. [5] in their study the material of connecting rod is replaced by aluminum (Al 360) based composite material reinforced with silicon carbide and fly ash and they also describe the model and analysis of connecting rod. FEA analysis was done on two materials of 180cc engine connecting rod. They take parameters like von misses stress and deformation was obtained from ANSYS software. Compared to the existing material the new material found to have less weight and better stiffness. It resulted in a reduction of 39.48% of weight, with 64.23% reduction in displacement. The optimized connecting rod is comparatively much stiff than the existing connecting rod.

OBJECTIVES

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

III. THEORETICAL CALCULATIONS OF CONNECTING ROD

Engine Type: Mahindra Pijo, Diesel, 4 cylinders (SDI) Standard Diesel Injection
Bore: 90mm
Stroke: 83mm
Displacement: $2112cm^3$
Maximum Power: 62 Hp/4500rpm
Maximum Torque: 121Nm/2000rpm
Compression Ratio: 22.4
Temperature of Diesel: $20^{\circ}C = 293.15K$
Density of Diesel at $20^{\circ}C = 900\ Kg/m^3 = 900*10^{-9} Kg/mm^3$
Mass of Diesel = Density*Volume

$$= 900*10^{-9}*2112*10^3$$

$$= \frac{9*2112}{10000} = \frac{19008}{10000} = 1.9008Kg$$

Molecular weight of $C_{12}H_{24}$ = 12*12.010+24*1.008

$$= 144.12+24.192$$

$$= 168.312 = 0.168312\ Kg/mole$$

R (gas constant) = 8.3143
From gas equation PV = m*Rspecific*T

$$Rspecific = \frac{8.3143}{0.168312} = 49.3981415 J/KgK$$

PV= Rspecific*Temperature

$$P = \frac{mass*Rspecific*Temperature}{Diplacement}$$

$$P = \frac{1.9008*49.3981*293.15}{2112}$$

$$P = \frac{27525.5856}{2112}$$

P = 13.0329477Mpa

IV. METHODOLOGY USED

Step 1: Modeling of connecting rod as per the dimensions measured by vernier caliper and micrometer in SOLIDWORKS.

Step 2: The 3-D model was imported in ANSYS workbench 17.1 in STEP format.

Step 3: Material properties of SAE 8620 were defined in engineering data in ANSYS workbench.

Step 4: The material SAE 8620 was assigned to the connecting rod in the mechanical interface.

Step 5: Mesh was generated for connecting rod using element 77693.

Step 6: Inner section of piston end was fixed.

Step 7: In the static structural analysis, the pressure is applied at an inner and outer section of the crank end and fillets of piston end and crank end of 13.033Mpa.

Step 8: In steady state thermal analysis, Heat Flux is finding by applying radiation.

Step 9: Analysis solution was performed and stresses values were checked for the connecting rod, von-misses stresses, von-misses strain, directional deformation, a factor of safety, maximum principal elastic strain, and heat flux was used to compare the results.

Step 10: Geometry of connecting rod was modified in SOLIDWORKS and the existing material is replaced by Titanium 6al 4v and all the steps from step 1 to step 9 was performed again to get the results. For the revised geometry, the results of existing connecting rod and with modified geometry were compared

Material Properties of SAE8620

Density	7.8 g/cm^3
Tensile Strength	640 Mpa
Yield Strength	390 Mpa
Young's Modulus	190 Gpa
Bulk Modulus	140 Gpa
Shear Modulus	7.4803E+10 Pa
Thermal Conductivity	46.6 W/m-K
Poisson Ratio	0.27

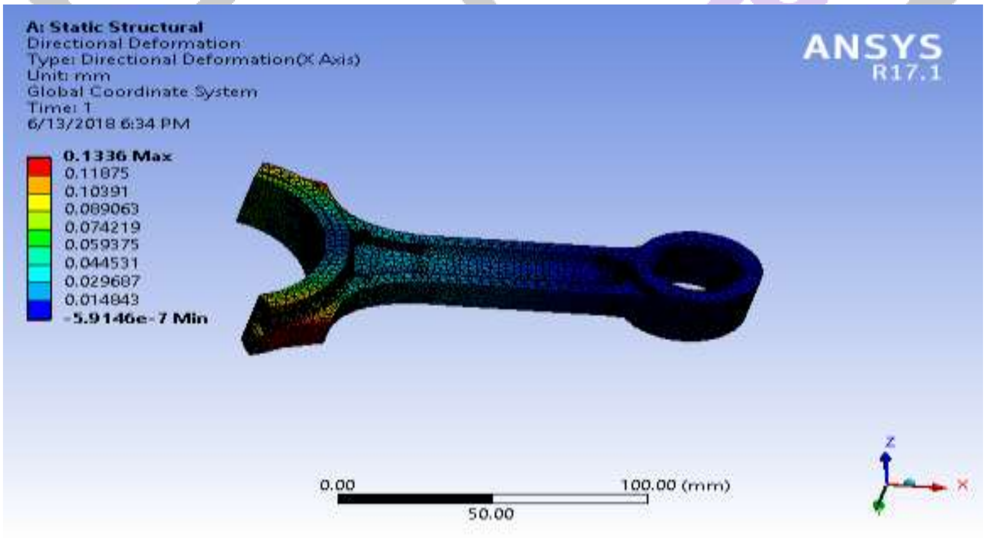

Fig.2. Directional Deformation of Existing Connecting Rod

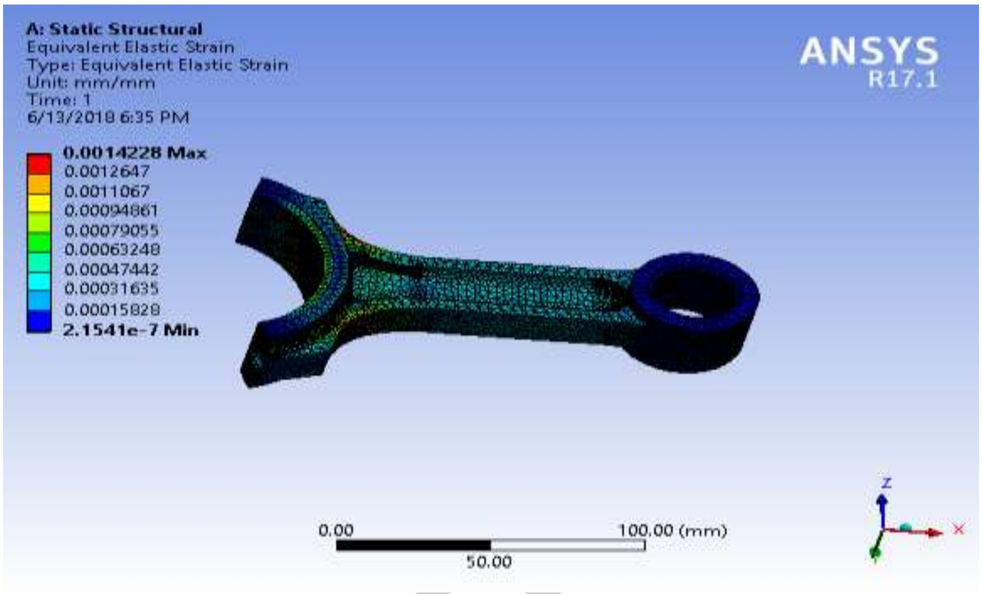

Fig.3. Von-Misses Strain of SAE 8620

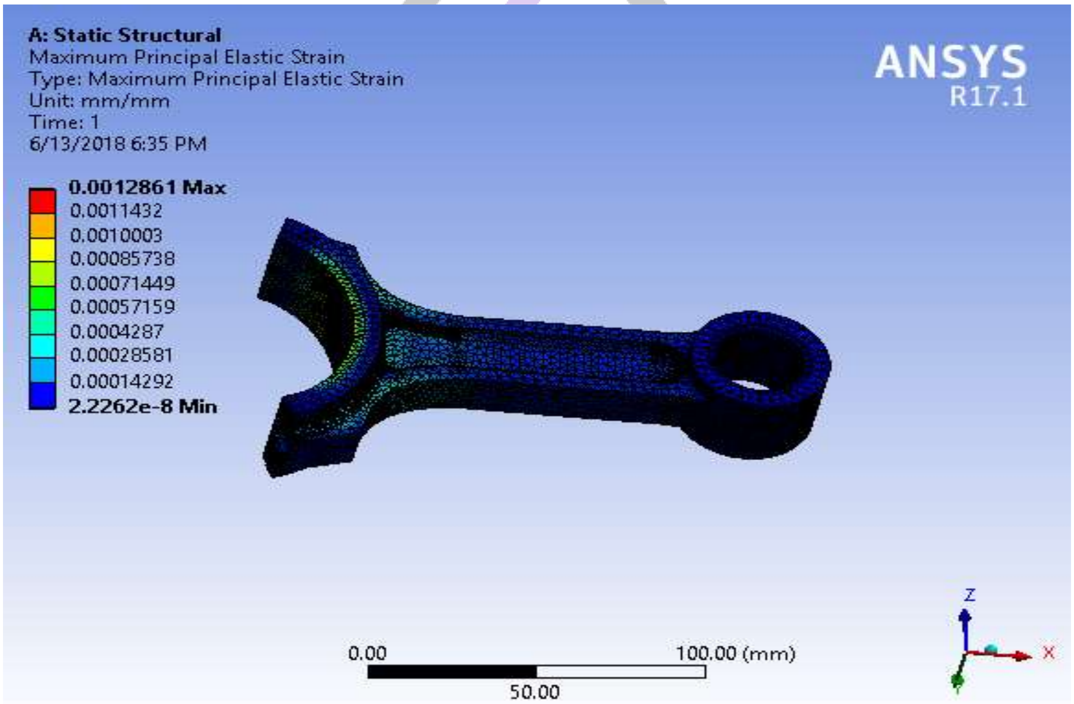

Fig. 4. Maximum Principal Strain of Existing Connecting Rod

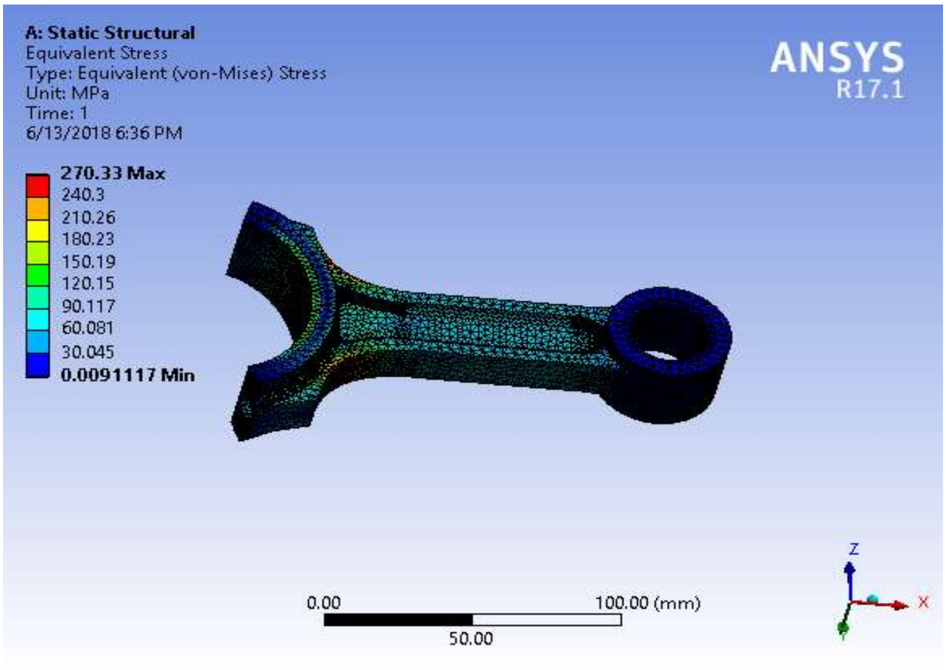

Fig.5. Von-Misses Stress of SAE 8620

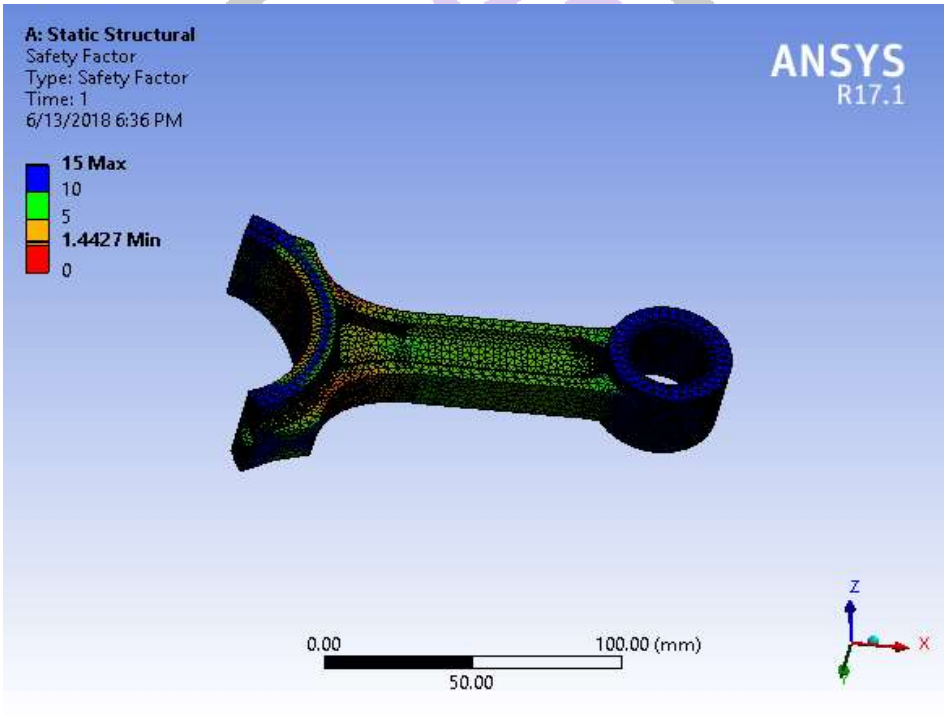

Fig.6. Factor of Safety of Existing Connecting Rod

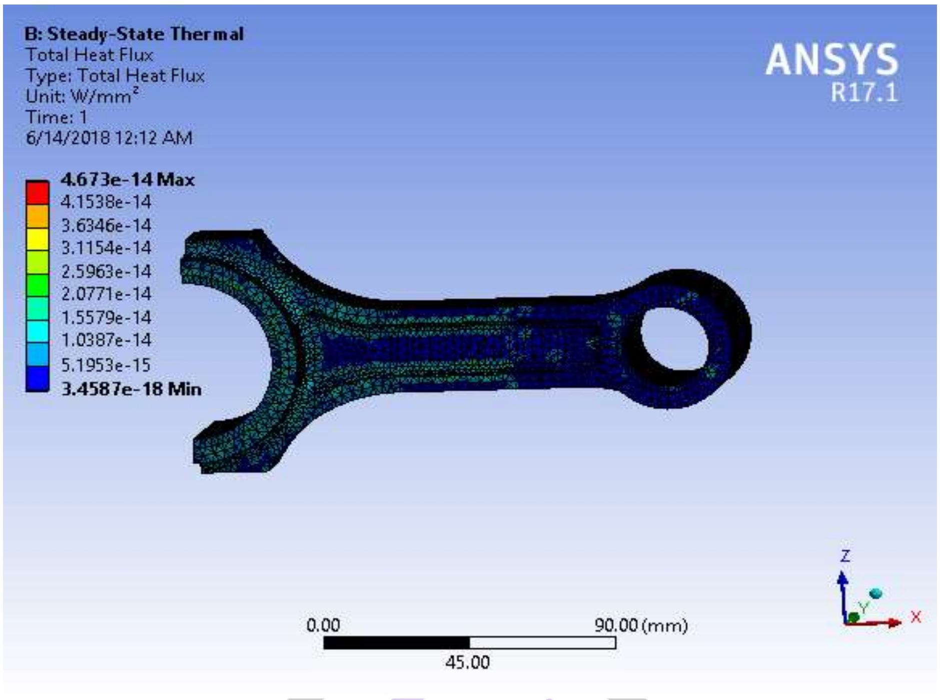

Fig.7. Heat Flux of Existing Connecting Rod

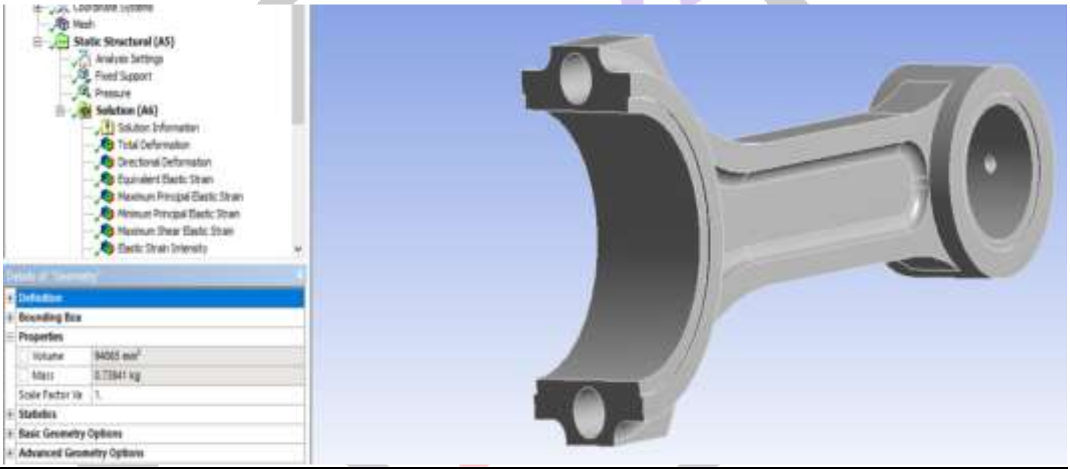

Fig. 8. Mass of Existing Connecting Rod

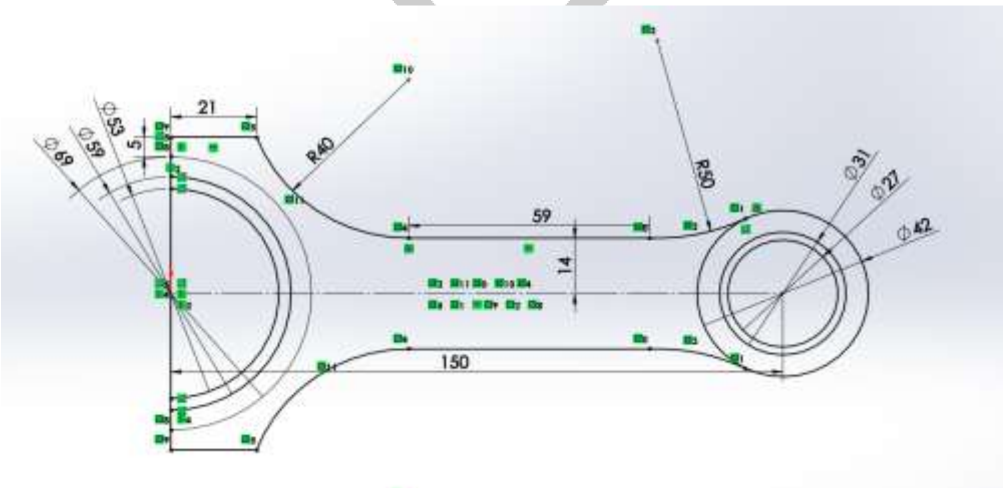

Fig.9. 2D Drawing of Modified connecting rod

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The material properties of Titanium 6al 4v are as given below:

Yield Strength (Mpa)	Ultimate Strength (Mpa)	Young's Modulus (Gpa)	Poisson Ratio	Density (g/cm^3)	Thermal Conductivity (W/mK)
1110	1170	113	0.33	4.43	6.8

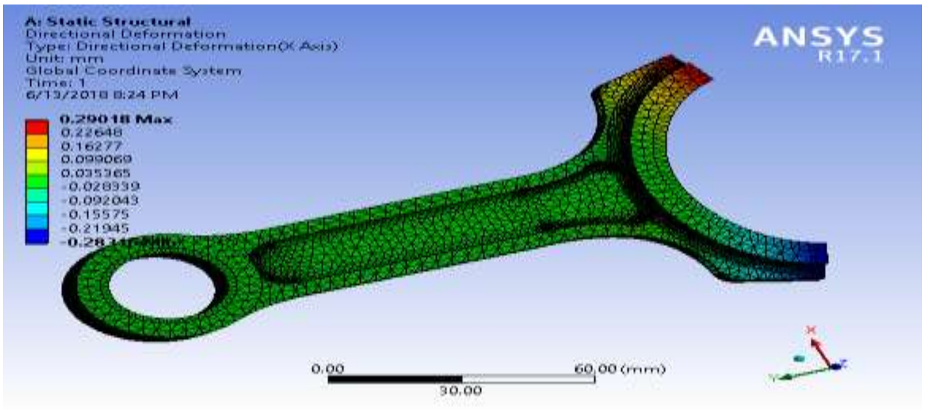

Fig.10. Directional Deformation of Modified Connecting Rod

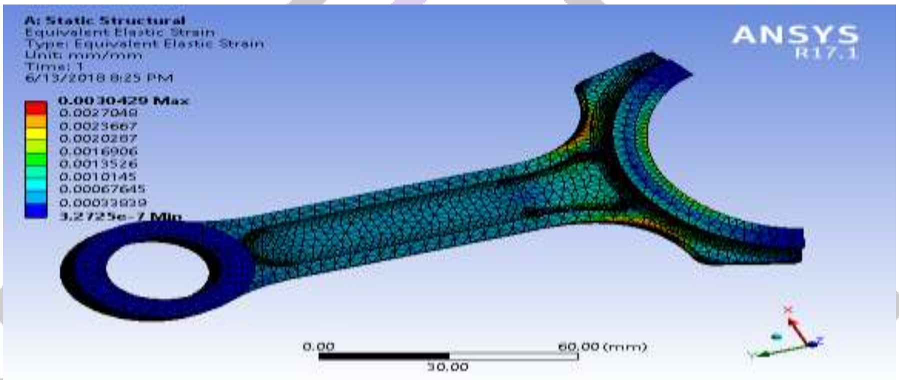

Fig.11. Von-Misses Strain of Ti 6al 4v

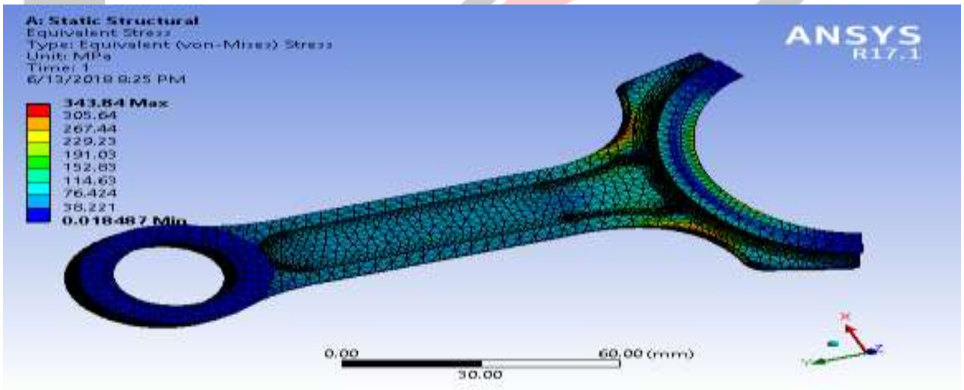

Fig.12. Von-Misses Stress of Ti 6al 4v

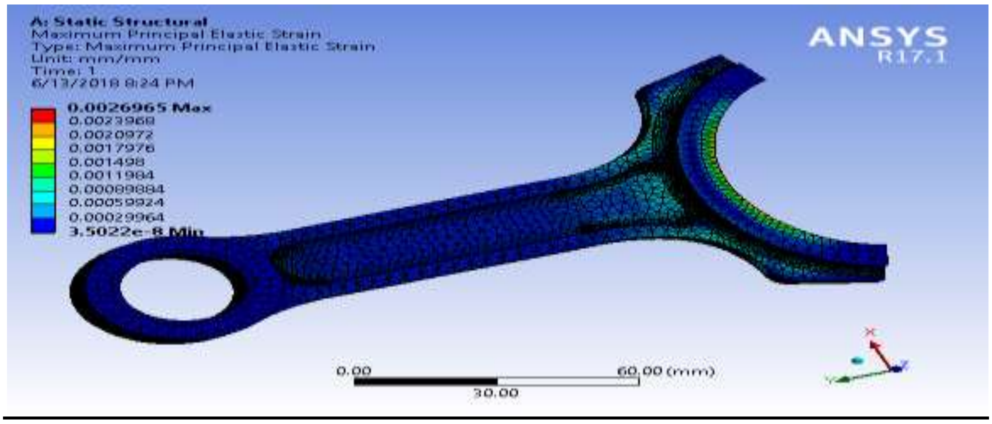

Fig.13. Maximum Principal Elastic Strain of Modified Connecting Rod

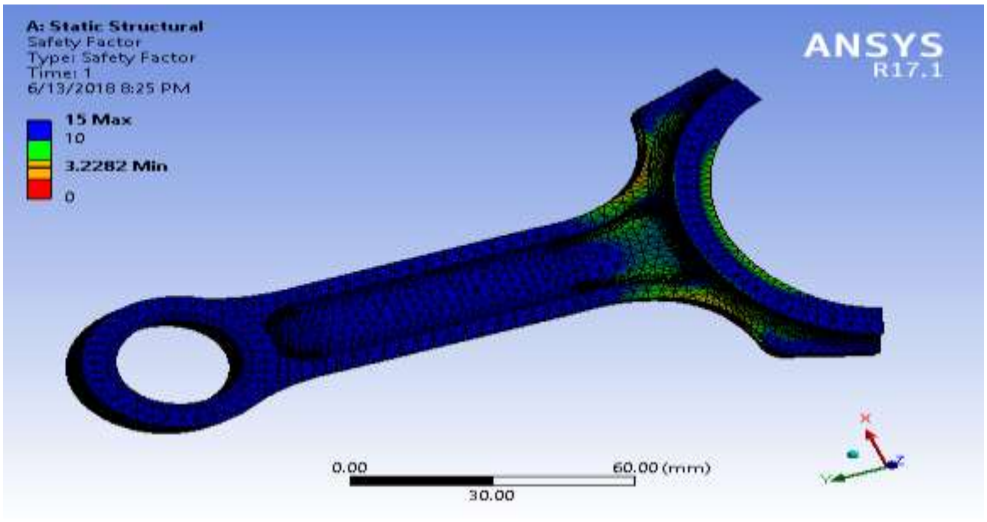

Fig.14. Safety Factor of Modified Connecting Rod

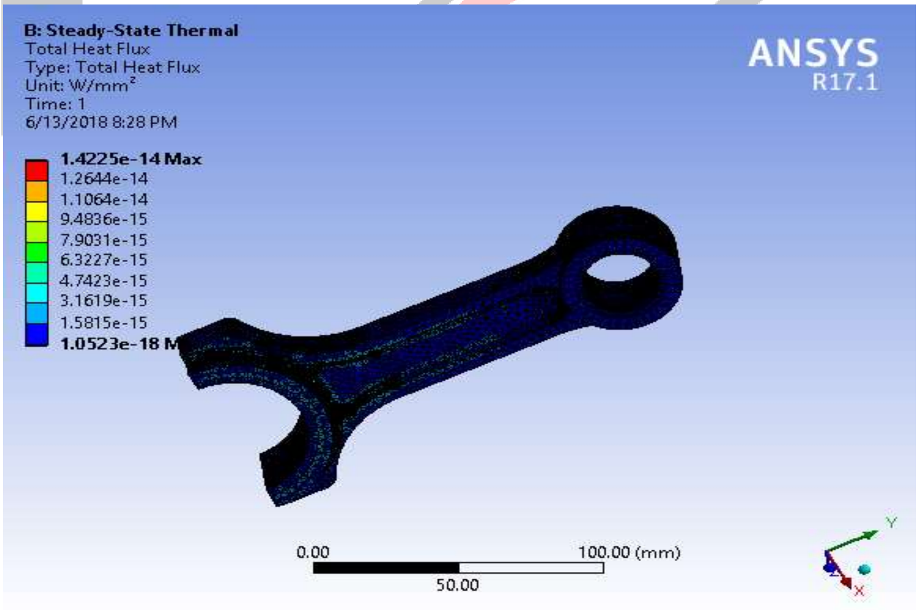

Fig.15. Heat Flux of Modified Connecting Rod

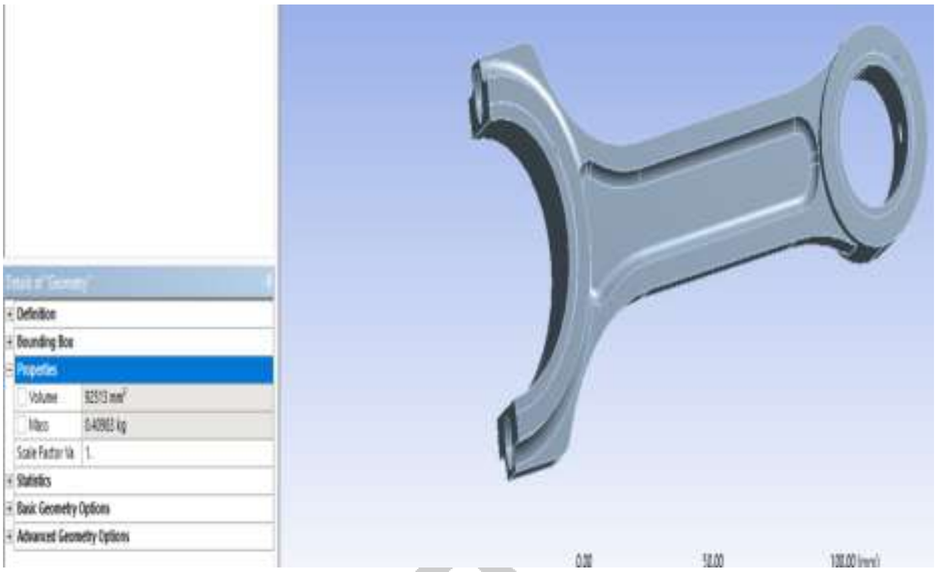

Fig.16. Mass of Modified Connecting Rod

V. RESULTS AND DISCUSSION

S. NO.	Connecting rod Description	Existing Rod	Modified Rod
1	Directional Deformation	0.1336 mm	0.29018 mm
2	Von-Misses Strain	0.0014228	0.0030429
3	Maximum Principal Elastic Strain	0.0012861	0.0026965
4	Von- Misses Stress	270.33Mpa	343.84Mpa
5	Factor of Safety	1.4427	3.228
6	Heat Flux	4.673e-14 W/mm^2	1.4225e-14 W/mm^2
7	Mass	0.73841 kg	0.40983 kg

VI. CONCLUSION:

This research is regarding the mass and stress reduction opportunities that forged steel connecting rod of SAE 8620 and Ti 6al 4v offer. In this research, static structural and steady-state thermal analysis is performed on the model created in SOLIDWORKS and analysis is performed in FEA. In this Von-mises Stress, Von-mises Strain, Directional Deformation and Heat Flux and factor of safety are measured. Mass of the existing connecting rod is reduced by 44.4%. Von- misses stress is 343.84 Mpa which means it can withstand more stress than existing connecting rod 270.33 Mpa. Von-misses strain is 0.0030429 so it can withstand more strain. Directional Deformation of existing con rod is 0.1336 mm which means after applying 13.033 Mpa pressure but modified con rod deformation is 0.29018 mm.

REFERENCES

[1] Singh Vikas, Verma Sumit Kr, “Design and Analysis of Connecting Rod for Different Material Using Ansys Workbench 16.2” International Journal for Research in Applied Science & Engineering Technology, Vol. 5 Issue V, May 2017 IC, Value, 45.98, ISSN. 2321-9653.

[2] Rao G. Naga Malleshwara, “Design optimization and analysis of a connecting rod using Ansys”, International Journal of Science and Research (IJSR), pp. 225-229, 2013.

[3] Sailaja G., Sadaq S. Irfan, Yunus Shaik Vaseem “Dynamic analysis of a connecting rod using FEA”, International Journal on Mechanical Engineering and Robotics, , Vol-5, pp. 1-4,2017.

[4] Kadam Sujata D., Date Rohini R., Kadam Ashwini K., Malgave Sujit S,“Review on optimization of connecting rod by using composite material”, International Journal of Scientific Research and Management Studies, Vol. 4, Issue 2, pp. 50-55.

[5] Thakare Nikhil U., Bhusale Nitin D., “Finite element analysis of connecting rod using Ansys”, International Journal of Advances in Science Engineering and Technology,Vol. 3, pp. 82-86, , 2015.

[6] Singh Puran, Pramanik Debashis, Singh Ran Vijay, “Fatigue and structural analysis of connecting rod’s material due to (C.I) using FEA”, International Journal of Automotive Engineering and Technology, Vol. 4, Issue 4, pp. 245-253,2015.

[7] Bhandari V.B. “Design of Machine Elements” TATA McGraw Hill Publications, Jan.2008.

[8] Ramakrishna G., Venkatesh P.H.J, “Modelling and analysis of connecting rod using 4340 Alloy Steel And AlSiC-9”, International Journal of Engineering Science and Research and Technology, ISSN: 2277-9655, pp. 54-58.

[9] Balaji V. Jaya, Paul Abylin, Moncy Mobin, “Design and analysis of connecting rod using Aluminium Silicon Carbide”, International Journal of Nano Corrosion Science and Engineering, ISSN Online: 2395-7018, pp. 116-124,2016.

[10] Desai Fanil, Jagtap Kirankumar, Deshpande Abhijeet, “Numerical and experimental analysis of connecting rod”, International Journal of Emerging Engineering Research and Technology, Vol. 2, Issue 4, pp. 242-249, 2014.

[11] B. Kuldeep, L.R Arun, “Analysis and optimization of connecting rod using ALFASiC composites”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 6, pp. 2480-2487, 2013.

[12] P. Arshad Mohamed Gani, T. Vinithra Banu, “Design and analysis of Metal Matrix Composite connecting rod”, International Journal of Engineering Research and General Science, Vol. 3, Issue 2, pp. 2091-2730,2015.

[13] More Gajanan Dinkarrao, Mane V.V, “Overview of fatigue failure of connecting rod used in a light commercial vehicle (LCV) through FEA”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, pp. 1-6, 2016.

[14] Saurabh Kunal, Singh Akhand Pratap, “A review paper on design analysis of internal combustion components”, International journal of advance research in Science and Engineering, Vol. 06, pp. 495-498, 2017.

[15] Kumar Amit, P. P Bhingole and Kumar Dinesh, Dynamic analysis of Bajaj Pulsar 150cc connecting rod using Ansys 14.0, Asian Journal of Engineering and Applied Technology, Vol. 3, No. 2, pp.19-24, 2014.