International Journal of Research Publication and Reviews, Vol 4, no 1, pp 2133-2142, January 2023

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design and Numerical Analysis of Connecting Rod with Different Materials

Shaik Rafi[1], N Amara Nageswara Rao[2]

M. Tech Student[1], Assistant Professor[2]

[1,2]Department of Mechanical Engineering, Nimra College of Engineering and Technology, Vijayawada-521456.

ABSTRACT

The connecting rod is an important part of an internal combustion engine. It connects piston and crank shaft. So, it must be strong enough to transfer the force exerted by the piston to crank shaft. Usually, connecting rods are manufactured by forging process with forged steel. In this work, the material of the connecting rod has changed forged steel to Aluminium. The life of connecting rod at 50 kN load is 79,792 for Aluminium and for Steel it was just 33,279 cycles. Further, the weight of the component was reduced to 0.77 from 2.22 kg i.e., weight was reduced by 185%.

1. INTRODUCTION

A connecting rod is crucial component in IC engine assembly, and it connects piston to crank shaft. It takes force from the piston and transfer it to crankshaft. Therefore, it has to be designed at most care to sustain both in compression and tension. The cross-section has been chosen very carefully to avoid buckling.

Lee et al. [1] established a FEM model of connecting rod involving pin and crankshaft to realize the contact conditions at the pin and crank ends of the connecting rod. They employed this model to calculate the buckling stresses under compressive load of 64.7 kN. The authors used stress sensitivity to the reduction of the cross area of the shank of a typical connecting rod to reach the weight reduction of the connecting rod while observing other criteria including yield and fatigue. Vivek et al. [2] conducted experimental and numerical investigations to study the performance of connecting rod concerning the aspects of rigidity and weight of test samples. They studied the effects of compression due to ignition in the combustion chamber and tensile stress due to inertia caused by reciprocating motion of piston and related components on these variables. Production of connecting rods for most of the auto applications are conducted by forging of wrought steel or powder material. However, the parts made of casting processes are likely to have blown holes which are highly destructive in terms of durability and life span of connecting rods under dynamic loading conditions. In contrast, although the forging process of wrought steel is economical, the secondary machining operations are required to bring the dimensions of manufactured connecting rods within the specified tolerances [3]. Saharash et al. [4] applied the loading and boundary condition of experiments in a finite element model of the connecting rod. The results showed that compression between the contact faces and stress at the junction of web and flange of the connecting rod are very high. Modified design of connecting rod represented significant reduction of maximum stress in the results of finite element model and considerable increase of the life span of this part of engine in laboratory tests. Gritza et al. [5] studied the relationship between the forces of big-end pin and progression of fatigue cracks in the bolts of connecting rod, finite element modelling and analysis of fracture mechanics were carried out. The authors reported that the failure of the engine was because of initiation and progression of cracks in the groves of shanks of the bolts. Shaari et al. [6] conducted topology optimization process of a typical connecting rod to minimize the mass of this component of engine and cost of production while the robustness of connecting rod under the applied loads is maintained. The tensile and buckling analysis were performed under the tensile and compression loads equal to 26.7 kN. Also, the authors conducted mesh refinement in FEM process to ensure the convergence and accuracy of the calculated results. Romani et al. [7] analysed stress distribution in the connecting rod using ANSYS finite element software. For this purpose, the forces due to the combustion and the forces caused by inertia of piston, gudgeon pin and connecting rod in motion were calculated and applied in the ANSYS software. The results showed that the maximum stresses develop between the contact faces of the gudgeon pin and the small-end of the connecting rod and between the crank pin and the big-end of the connecting rod. The authors used the results of the stress analyses to modify the design of the connecting rod. He et al. [8] investigated the effects of applied loads of connecting bolts on the mechanism of cracking caused by loading and fatigue through finite element simulation and comparison of the results with microscopic observations. The microscopic images of fracture surfaces showed that cracks were initiated at the groves of tooth of the contacting faces because of fatigue and propagation of these cracks perpendicular to the surface. Results of tensile tests of standard samples prepared from the broken connecting rod revealed that low tensile strength of the connecting rod material was the main cause of the fracture under the loading conditions

2. DESIGN AND ANALYSIS

2.1 Problem statement

To design a connecting rod for an I.C. engine running at 1800 r.p.m. and developing a maximum pressure of 3.15 N/mm2. The diameter of the piston is 100 mm; mass of the reciprocating parts per cylinder 2.25 kg; length of connecting rod 380 mm; stroke of piston 190 mm and compression ratio 6:1. Take length to diameter ratio for big end bearing as 1.3 and small end bearing as 2 and the corresponding bearing pressures as 10 $N/mm^2$and 15 N/mm^2. The density of material of the rod may be taken as 8000 kg/m^3 and the allowable stress in the bolts as 60 N/mm^2 and in cap as 80 N/mm^2.

Table 1: Dimensions of Design

Parameters	**Values in mm**
Thickness of the flange and web t	7
Width of the section B	28
Depth of the section H	35
Length of the connecting rod	380
Nominal diameter of bolt d_b	12

2.1.1 Geometry import

According to the problem statement the design calculation has done, and I section has chosen for cross-section. The key design parameters are tabulated in Table 1 and drawing has attached in Annex 1.

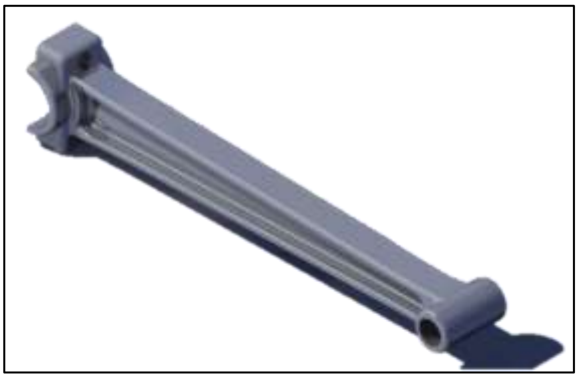

Figure 1: Geometry Model

Table 2: Material properties

Metal	**Youngs modulus**	**Poisson ratio**	**Yield Strength**	**Density**
	N/mm^2		N/mm^2	kg/mm^3
Aluminium	7.10E+04	0.33	280	2.77E-06
Structural steel	2.00E+05	0.3	250	7.85E-06

2.1.2 Meshing and Boundary conditions

The geometry model of connecting rod had discretised by using tetrahedron 3-D elements. The tetrahedron has 4 vertices, 6 edges, and is bounded by 4 triangular faces. The solving time for simulation is low in case of tetrahedron compared with hexahedron.

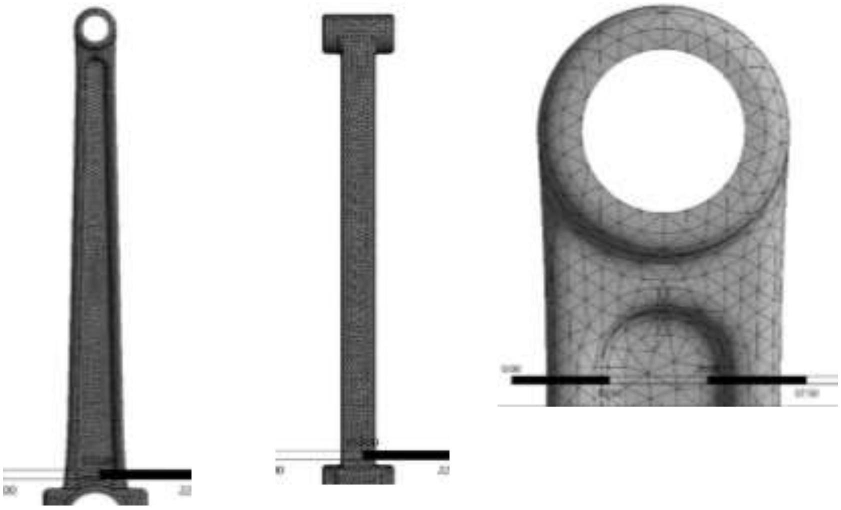

Figure 2: Grid generation

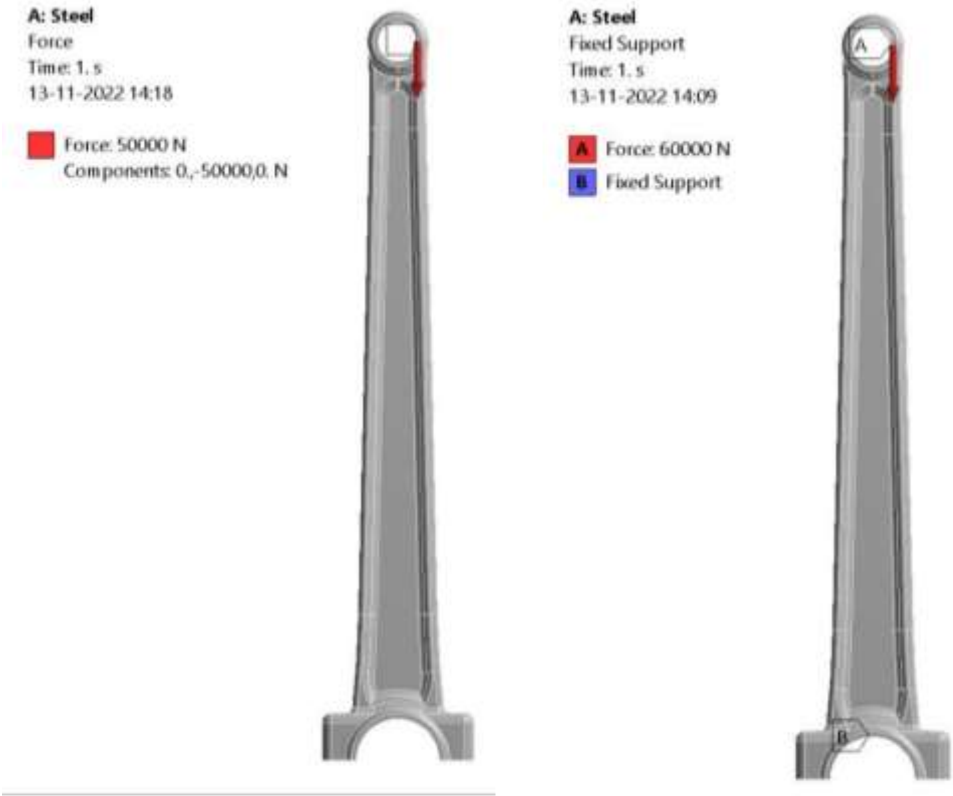

Figure 3: Boundary conditions

4. RESULT AND DISCUSSION

4.1 Linear static analysis

4.1.1 Von-misses Stress

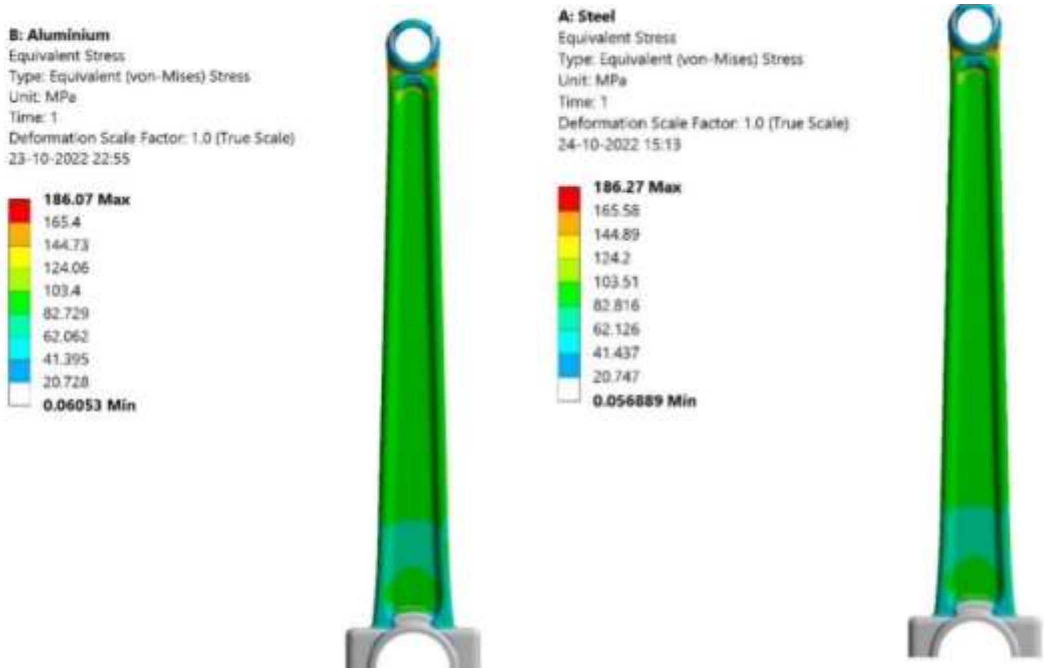

Figure 4: Von-misses stress at 50kN load

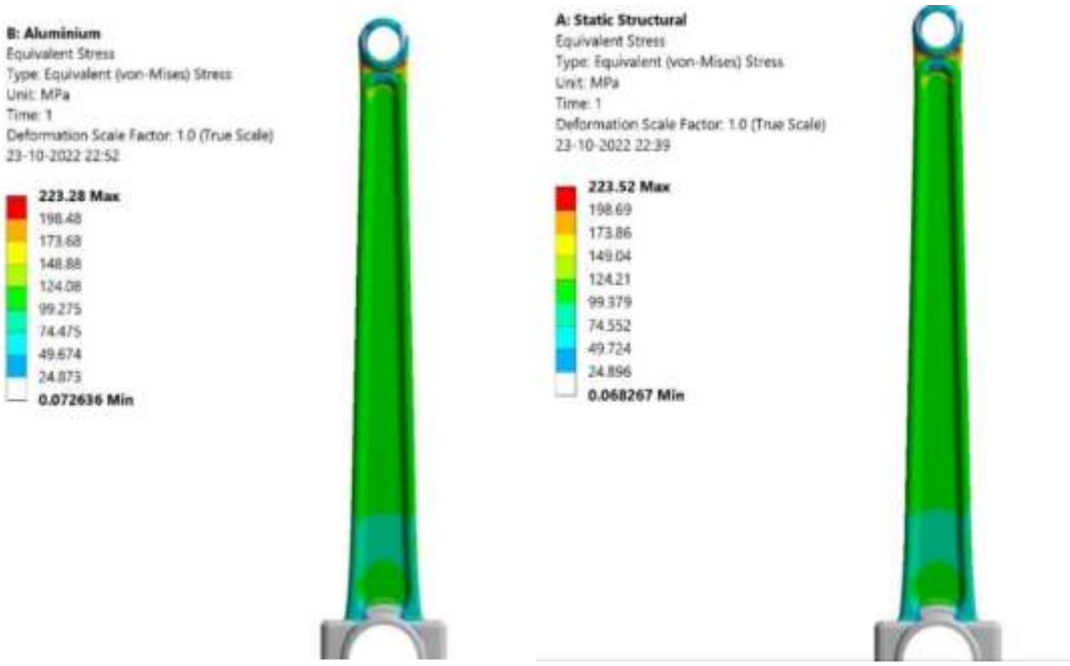

Figure 5: Von-misses stress at 60kN Load

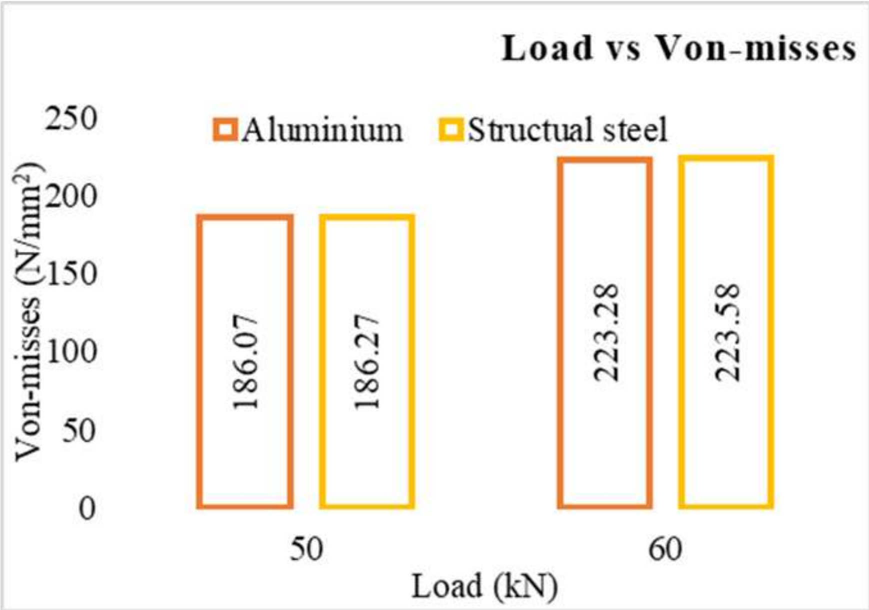

Figure 6: Load vs Von-misses plot

4.1.2 Deformation

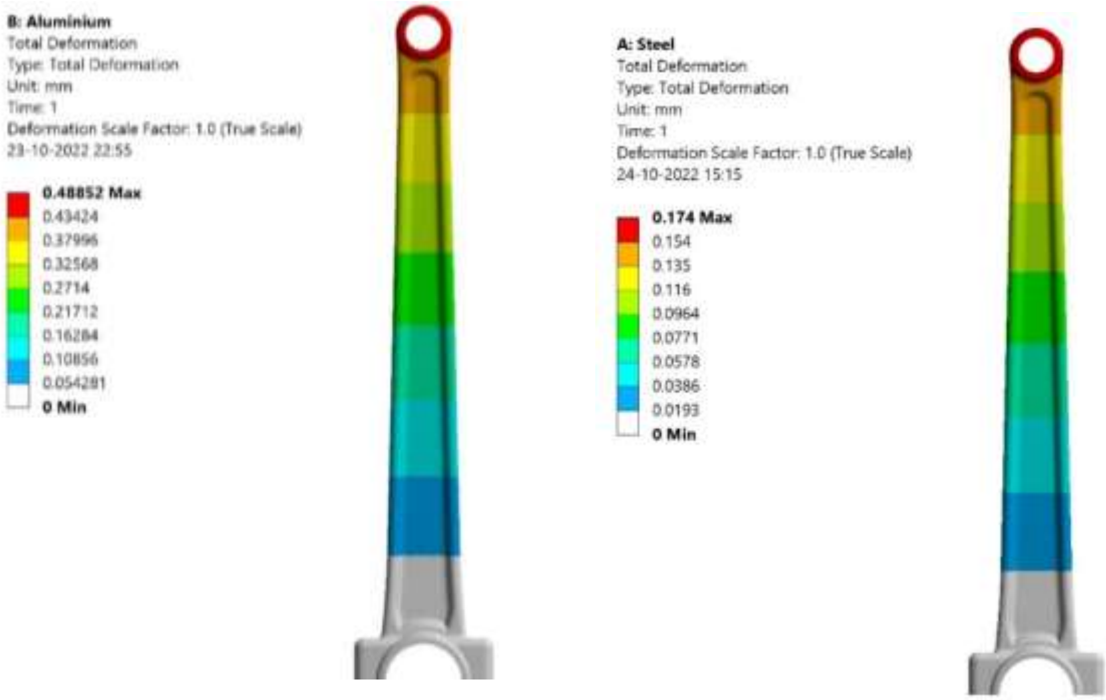

Figure 7: Deformation at 50kN load

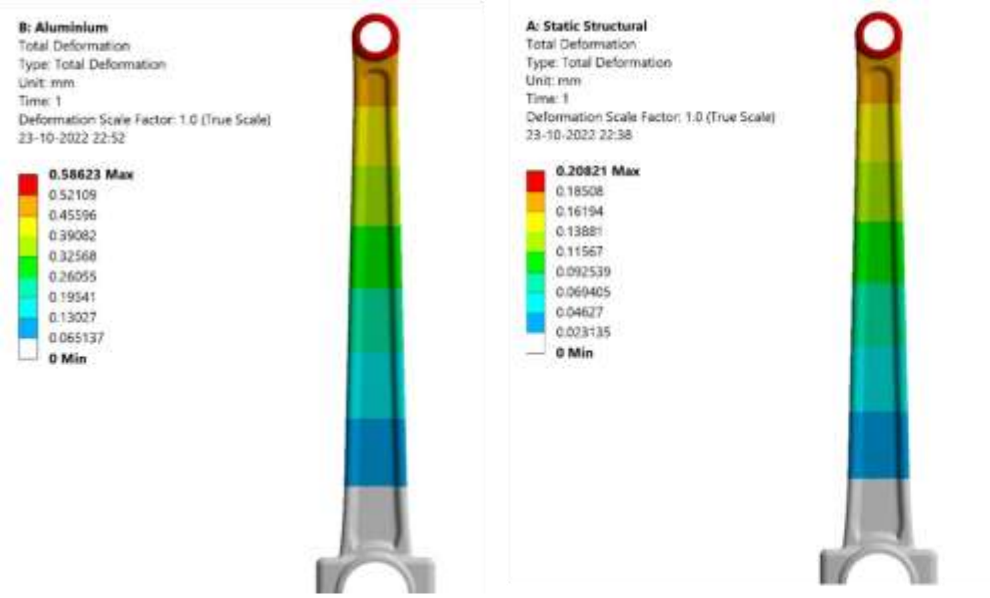

Figure 8: Deformation at 60kN load

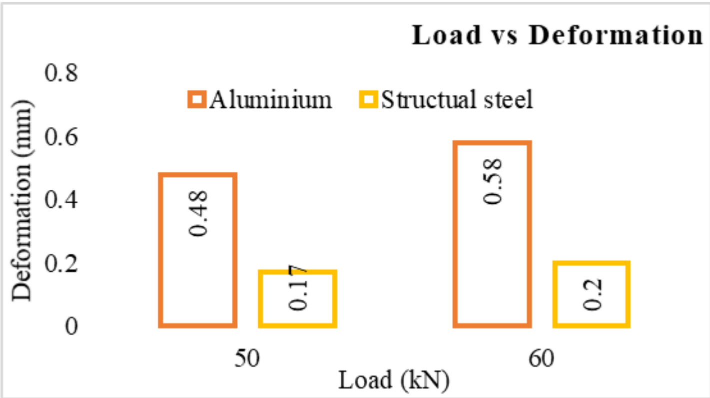

Figure 9: Deformation vs load plot

4.2 Durability analysis

4.2.1 Life

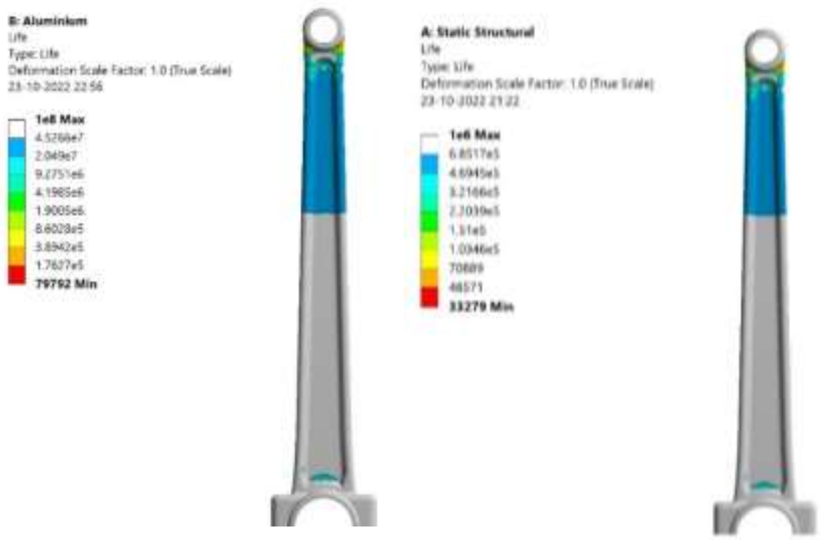

Figure 10: Fatigue life at 50 kN load

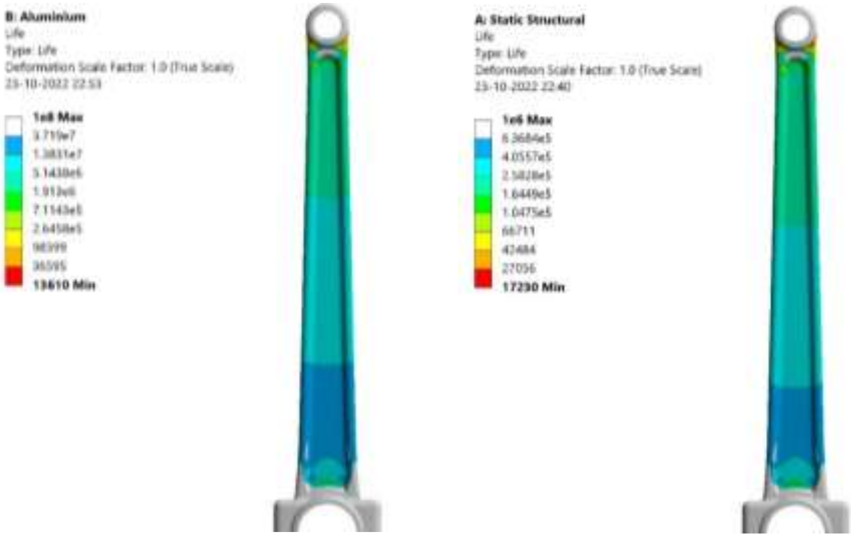

Figure 11: Fatigue life at 60 kN load

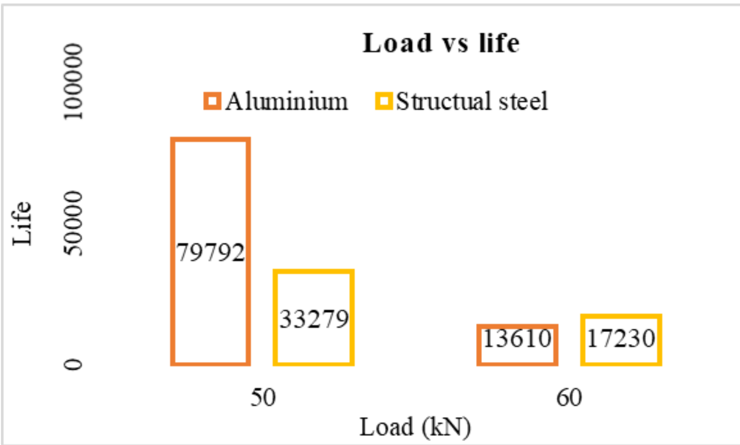

Figure 12: Load vs life plot

3.3 Modal analysis

3.3.1 Mode shapes

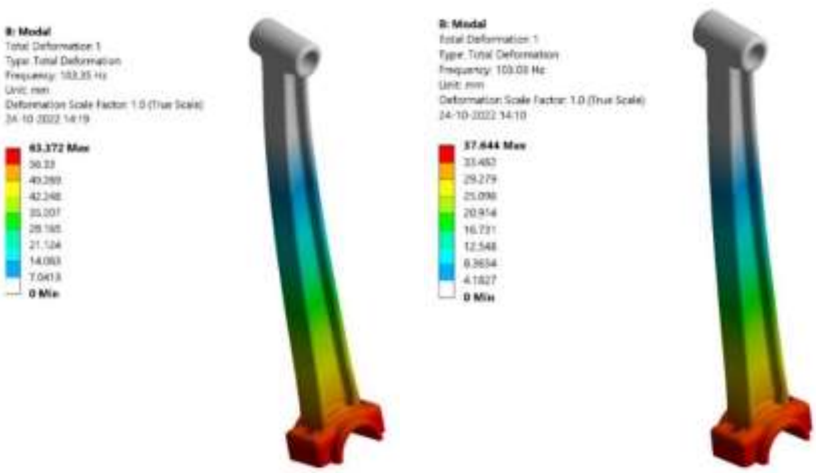

Figure 13: Mode shape 1

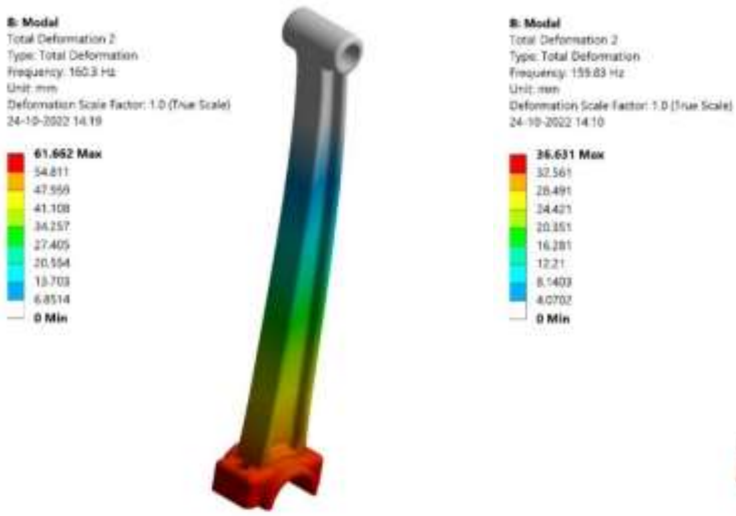

Figure 14: Mode shape 2

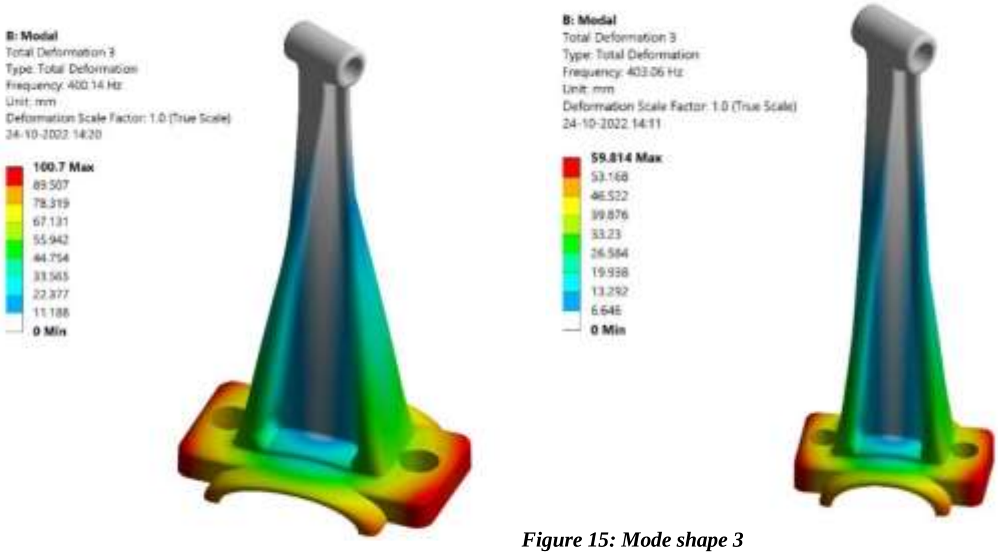

Figure 15: Mode shape 3

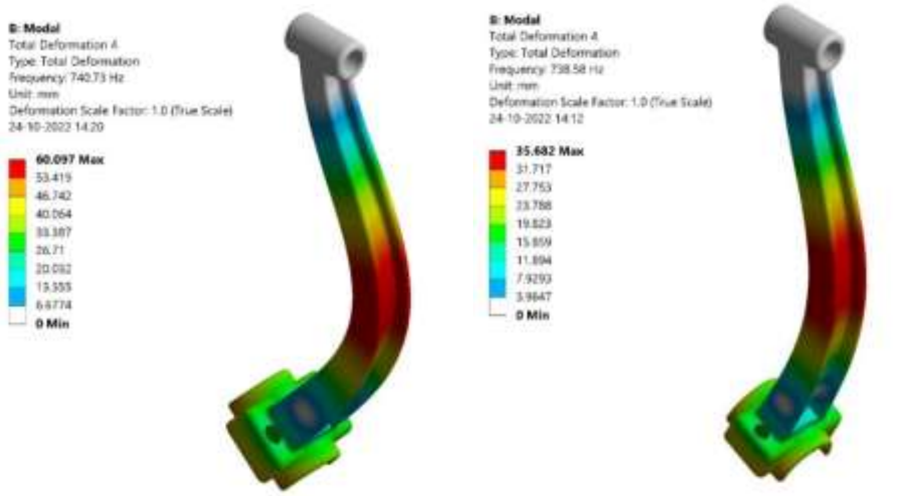

Figure 16: Mode shape 4

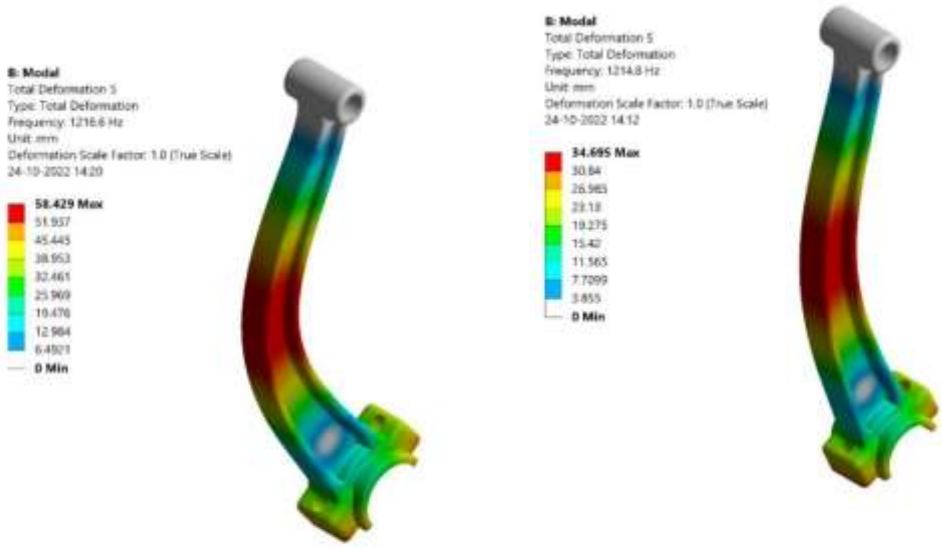

Figure 17: Mode shape 5

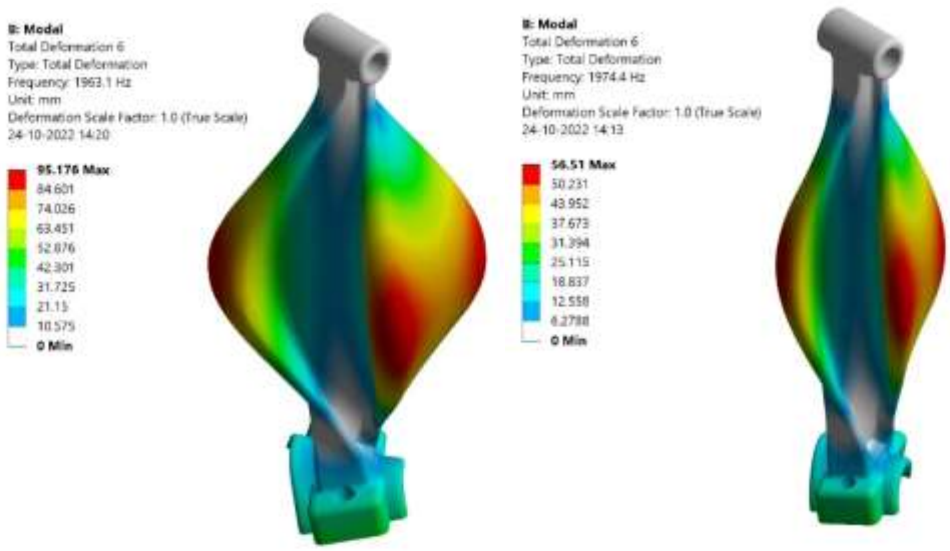

Figure 18: Mode shape 6

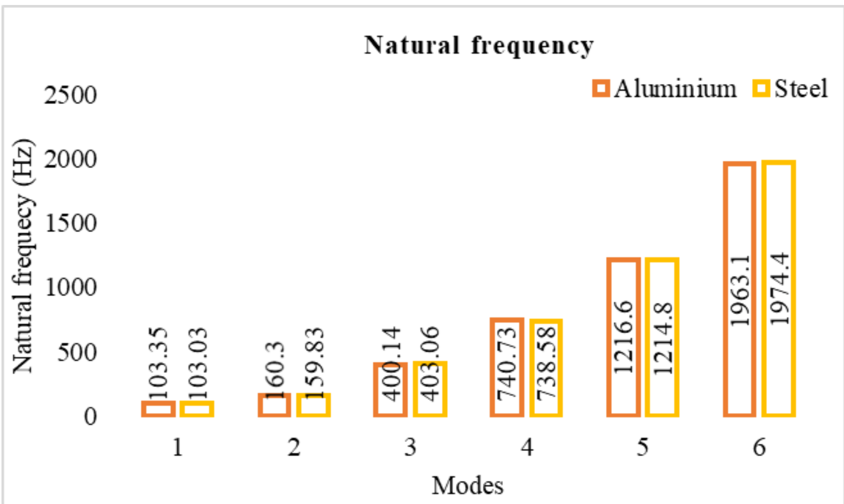

Figure 19: Modes vs frequency

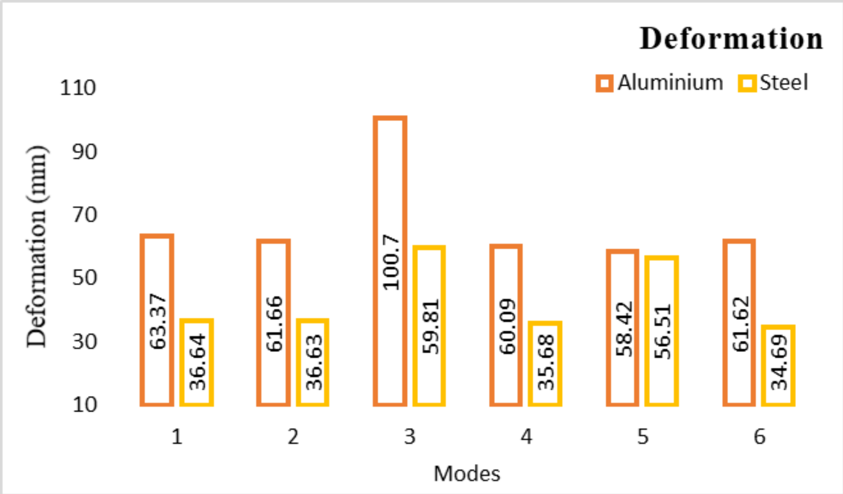

Figure 20: Mode vs deformation plot

3. CONCLUSION

After performing liner-static, durability and modal analysis on connected rod with two different materials at two loads following results are concluded.

- The von-misses stress and deformation of connecting rod are within the design limits with proposed aluminium material.
- At 50kN load component manufactured with Aluminium has more design life than steel.
- Weight of the component was reduced to 0.77 from 2.22 kg i.e., the weight was reduced by 185%.

4. REFERENCE

[1] Lee MK, Lee H, Lee TS, Jang H (2010) Buckling sensitivity of a connecting rod to the shank sectional area reduction. Mater Des 31:2796–2803

[2] Pathade VC, Patle B, Ingale AN (2012) Stress analysis of I.C. engine connecting rod by FEM. IOSR J Mech Civ Eng 1:117–125.

[3] Wang Q, He F (2004) A review of developments in the forging of connecting rods in China. J Mater Process Technol 151:192–195.

[4] Khare S, Singh OP, Dora KB, Sasun C (2012) Spalling investigation of connecting rod. Eng Fail Anal 19:77–86.

[5] Griza S, Bertoni F, Zanon G, Reguly A, Strohaecker TR (2009) Fatigue in engine connecting rod bolt due to forming laps. Eng Fail Anal 16:1542–1548.

[6] Shaari MS, Rahman MM, Noor MM, Kadirgama K, Amirruddin AK (2010) Design of connecting rod of internal combustion engine: a topology optimization approach. In: National Conference in Mechanical Engineering Research and Postgraduate Studies (2nd NCMER), Malaysia, UMP Pekan, pp 155–166.

[7] Ramani HB, Kumar N, Kasundra PM (2012) Analysis of connecting rod under different loading condition using analysis software. Int J Innov Eng Res Technol 1(9):1–5.

[8] He BY, Shi GD, Sun JB, Chen S, Nie R (2013) Crack analysis on the toothed mating surfaces of a diesel engine connecting rod. Eng Fail Anal 34:443–450.