Buckling Analysis of Connecting Rod for Different Materials

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Abstract

connecting rod is a transitional part between piston and crankshaft which converts reciprocating motion of piston into rotary motion. Connecting rod is combination of piston end which is also called small end, crank end or the big end and shank. Connecting undergoes forces generated by combustion in the engine. The continuous reciprocating motion of an engine will results in axial load and bending stresses on the connecting rod. Connecting rod experiences high cyclic load. For good engine performance connecting rod should be well rigid and light in weight.

This study is about design and analysis of four wheeler connecting rod. In this paper, firstly proper geometrical model was developed using UG NX10.0. Geometry is taken from the literature [1]. The stresses were found in existing connecting rod for the given loading conditions using FEA software ANSYS 11.0. The analysis was carried out on two different materials such as forged steel, Aluminum 7075 and results for deformation, stresses, buckling load multiplier have been compared.

Index Terms— *Aluminium 7075, Buckling, Connecting rod, Simulation,*

I. INTRODUCTION

Connecting rod is an intermediate like between piston and the crank. This undergoes high cyclic loading due to continuous push and pull motion from piston to crank pin. Connecting rod converts reciprocating motion of piston to rotary motion of crank. The Connecting rod experiences cyclic fatigue loading this is due to contributions from both gas forces and inertial forces. The connecting rod must be light in weight to minimize the inertial forces. The collapse of connecting rod is a common cause of engine failure. at the beginning of expansion stroke due to combustion pressure top dead canter of connecting rod experiences compression, or when it is at bottom dead centre. Conversely the shank undergoes tension, due to inertial forces exerted by the mass of the piston and of the gudgeon pin, at top dead centre at beginning of induction

Stroke. The fatigue stresses within the connecting rod shank are therefore reversed.

Connecting rod fails due to insufficient strength to hold the load. By maximize the strength, automatically it will longer the life cycle of connecting rod. The optimization of connecting rod improves the engine performance and also strengthens the product that ensures the safety of human being.

II. FINITE ELEMENT ANALYSIS

This study includes design and analysis of four wheeler connecting rod. In this paper, firstly proper geometrical model was developed using UG NX10.0. Geometry is taken from the literature [1]. The stresses were found in existing connecting rod for the given loading conditions using FEA software ANSYS 16.0.

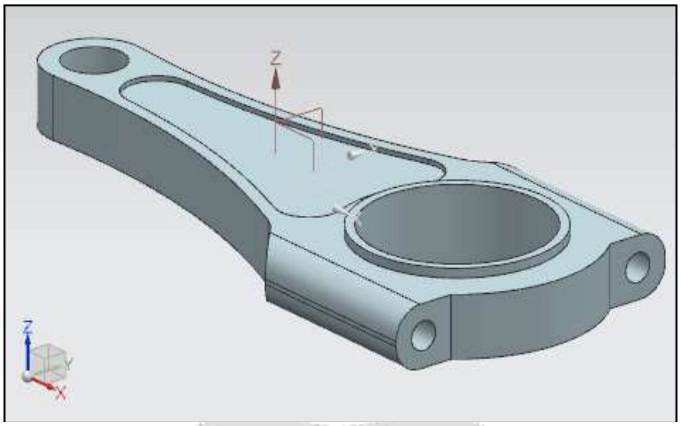

Fig. 1. CAD model of connecting rod

A. Material Properties

The connecting rod has been simulated for buckling load for two materials such as forged steel and Aluminium 7075. Material properties assign to the model is listed below:

Forged steel:

• Yield stress= 625 MPa
• Ultimate tensile strength= 827 MPa
• Density = 7820 kg/m3
• Poisson's ratio = 0.3
Young's Modulus = 206.7 GPa

Aluminium 7075:

• Ultimate tensile strength= 572 MPa
• Yield stress = 503 MPa
• Density = 2810 kg/m3
• Poisson's ratio = 0.33
• Young's Modulus = 71.7 GPa

B. Meshing

Above connecting rod model is meshed in ANSYS Workbench 16. A tetrahedral element was used for the solid mesh. The total number of elements 31373 and total number of nodes 49139 were generated.

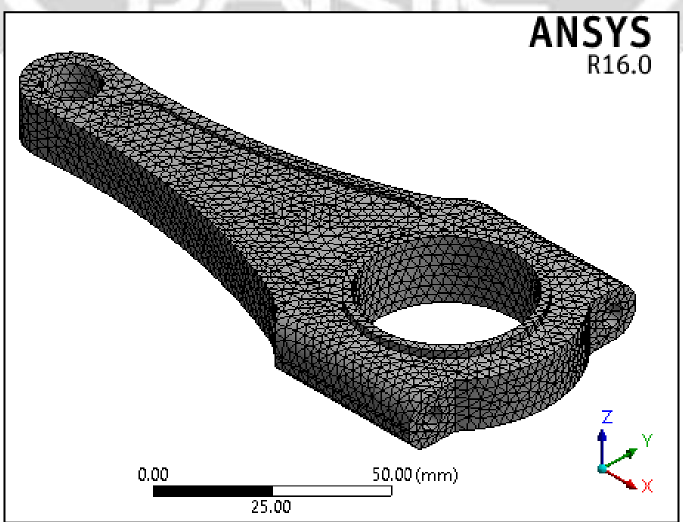

Fig. 2. Meshed model of connecting rod

C. Loading and Boundary Conditions

Above figure shows the connecting rod model with boundary conditions applied. For this analysis connecting rod is placed at the top dead center during the commencement of the power stroke. Hence, the crank is constrained in all degrees of freedom and the load is applied at the piston end of the connecting rod [1]. So, the compressive load of 28586N is applied to piston end and crank end is kept fixed for forged steel and AA2618 and Al composite [1].

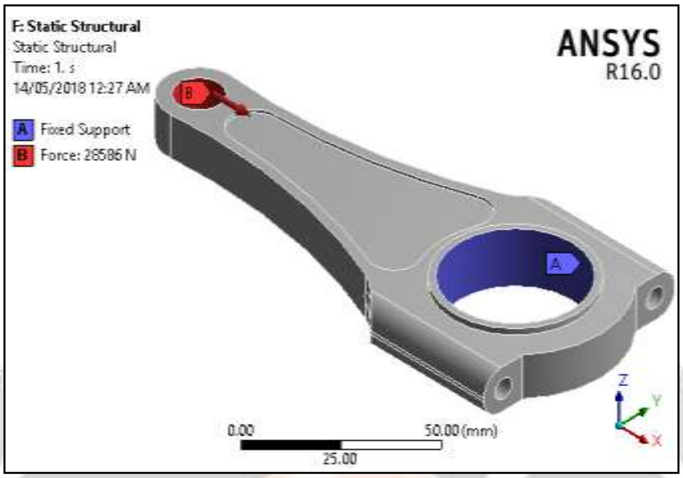

Fig. 3. Boundary Conditions

D. Simulation results for connecting rod

By applying the calculated load to the ball joint following results are obtained as shown in figure 4-5.

Results for Forged steel:

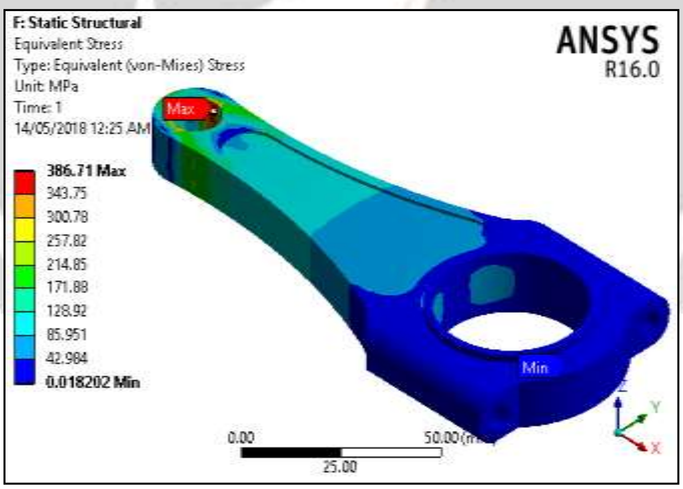

Fig. 4. Equivalent Von-Mises Stress

It is seen from the above simulation result that maximum stress occurs at very small area at piston end. The stress values is 386.71 MPa. This value is well below its yield strength of the forged steel which is 625MPa. Hench we can say that this connecting rod is safe under applied load as its allowable stress level is 413.5 MPa. If we measure directional deformation at this location it is 0.065mm.

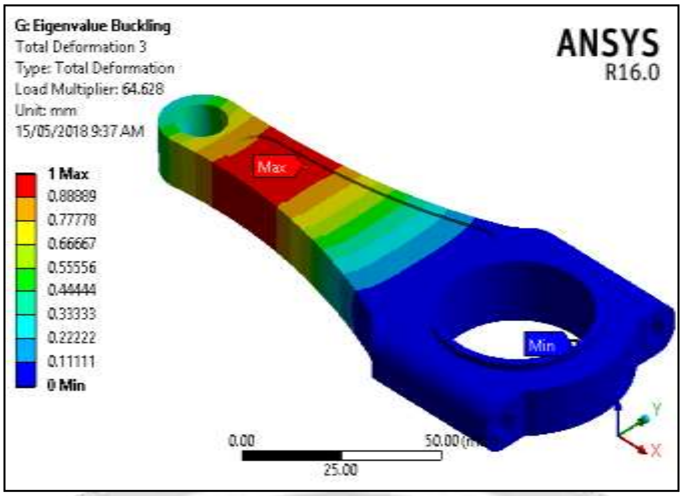

Fig. 5. Buckling mode

It is observed that the buckling factor is 64.62 which means that the connecting rod designed can withstand loads as high as 64 times the load applied.

Results for Aluminium 7075:

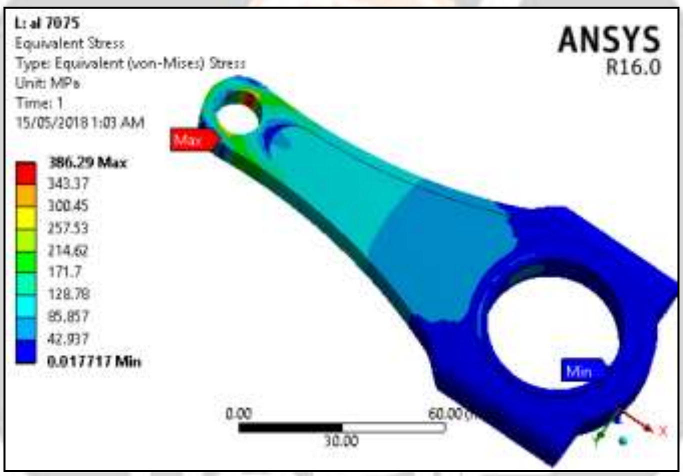

Fig. 6. Equivalent Von-Mises Stress

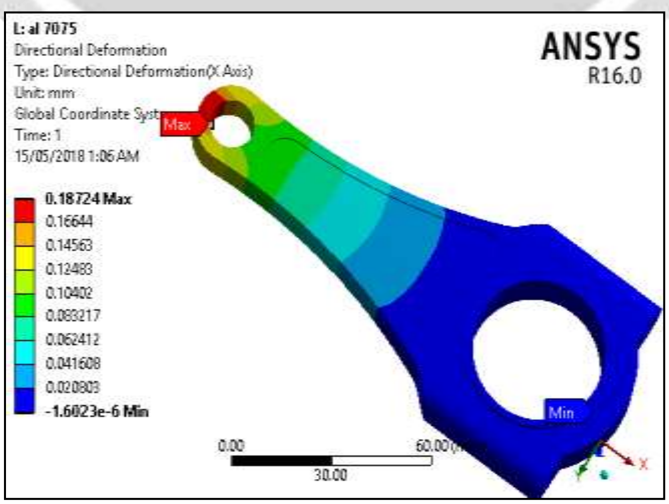

Fig. 7. Directional Deformation (X-axis)

As shown in above fig very small area at small end of connecting rod experiences maximum stresses. The value of maximum Von-Mises stress is 386.29 MPa. This stress is well below the yield strength of Aluminium 7075 of 503 MPa. So, we can say this design is safe under applied loading condition.
Figure 7 shows the directional deformation (X- axis) plot for Aliminium 7075.
The maximum deformation in x- direction occurs at the piston end at a value of 0.18 mm and minimum deformation occurs at crank end at a value of 1.602E-06 mm.

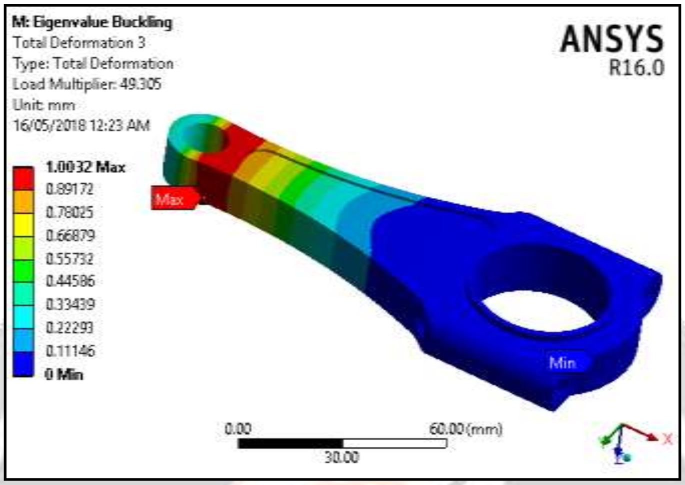

Fig.8. Buckling mode

We can see from above figure that buckling load factor for Aluminium7075 is 49.305 which means that the designed connecting rod can withstand loads as high as 49 times the load applied.

E. Comparison of Analysis Results

TABLE I
COMPARISON OF RESULTS

Sr.No	Parameter	Forged steel	Aluminium 7075
1	Von-Mises Stress	386.71 MPa	386.29 MPa
2	Max. Deformation	0.0648 mm	0.187 mm
3	Buckling load multiplier	64.62	22.46

Table I shows the comparison of results for stress, deformation and buckling load multiplier for forged steel and aluminium 7075.

III. CONCLUSION

Simulation is performed by applying same boundary conditions for both forged steel and aluminum 7075 as crank is kept fixed and load applied at the piston end is 28586N. For these boundary conditions Von mises Stresses developed in the forged steel are 386.71 MPa respectively, which are well below its ultimate strength of 827 MPa. Also the maximum deformation is 0.0648 mm which is very less. Also, the buckling load factor is 64.62 which mean that it can withstand a load as high as load applied. For above loading condition, Al 7075 can withstand a load as high as 49 times the load applied.
In case of Al7075, for the same boundary conditions Von-Mises stresses developed are 386.29 MPa which lies below its ultimate strength of 572 MPa and the maximum deformation value is 0.18 which is not that high.

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