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Finite Element and Numerical Analysis of Connecting Rod

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ABSTRACT

The study you mentioned is a comprehensive and well-conducted investigation into the buckling stress of connecting rods. The authors used a variety of methods, including numerical analysis, finite element analysis, and stress analysis, to identify the minimum buckling stress at various locations in the connecting rod. They also evaluated the performance of different materials, including carbon Nano composite and aluminum alloy, in terms of their ability to resist buckling. The results of the study showed that the connecting rod can be redesigned to reduce its weight and buckling stress. The authors also found that both carbon Nano composite and aluminum alloy are suitable materials for replacing the existing connecting rod. The findings of this study have important implications for the design and manufacturing of connecting rods. The ability to reduce the weight and buckling stress of connecting rods can lead to improved fuel efficiency and performance in automotive engines.

Keywords- Connecting Rod, ANSYS, Optimization, Material, Review

1. INTRODUCTION

The connecting rod is a critical component of an automobile engine. It is responsible for transmitting the force from the piston to the crankshaft, which converts the reciprocating motion of the piston into the rotational motion of the crankshaft. The connecting rod is also responsible for keeping the piston in place and preventing it from rotating. The number of connecting rods in an engine depends on the number of cylinders. For example, a V8 engine has 8 cylinders and therefore 8 connecting rods. The connecting rods are arranged in pairs, with each pair connecting a single piston to the crankshaft. The connecting rod is a complex and critical component of an automobile engine. It must be strong enough to withstand the forces generated by the piston, but it must also be lightweight to minimize the overall weight of the engine. Connecting rods are typically made of forged aluminum or steel, and they are often hollow to reduce weight. The connecting rod is a vital part of an automobile engine. It is responsible for converting the reciprocating motion of the piston into the rotational motion of the crankshaft, which powers the vehicle. A properly functioning connecting rod is essential for the smooth operation of an automobile engine.

1.1 Here are some of the factors that can affect the performance of a connecting rod:

a. Material: The material used to make the connecting rod can affect its strength, weight, and cost. Forged aluminum and steel are the most common materials used for connecting rods.

b. Design: The design of the connecting rod can affect its strength, weight, and stiffness. The connecting rod must be strong enough to withstand the forces generated by the piston, but it must also be lightweight to minimize the overall weight of the engine.

c. Manufacturing: The manufacturing process used to make the connecting rod can affect its strength, weight, and surface finish. The connecting rod must be made to precise tolerances to ensure that it fits properly and functions correctly.

1.2 A connecting rod that is damaged or worn can cause a number of problems, including:

a. Engine misfires

b. Reduced power output

c. Increased fuel consumption

d. Engine noise

e. Engine vibration

f. Engine damage

2. MODELLING OF CONNECTING ROD AND INTRODUCTION TO FEM

CATIA v5 is used to model connecting rods. It is used to create a wide variety of items. It is used to build 3D parts, product simulations, and a variety of other manufacturing goods. Its feature satisfies the entire product description, which includes kinematic definition as well. Functional tolerances, as well. Product design can be done with CATIA, from sketching to 3D models. It offers 3D solid modelling as well as ergonomics simulation of the product. It is frequently used in the automotive and aerospace sectors for part and tool design. It is a comprehensive design software suite that incorporates CAD/CAM/CAE.

2.1 Design of connecting rod

The design of connecting rod is taken from the fig shown below. It shows various parts and dimensions of connecting rod.

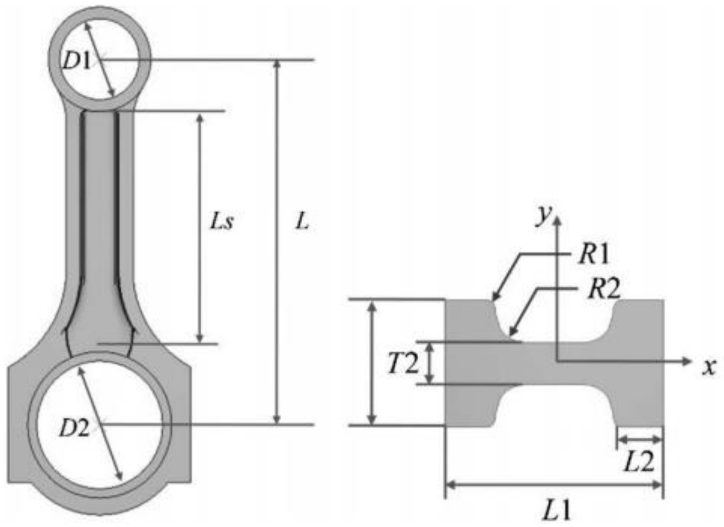


Fig. 1 Design parameters and buckling axes of the cross-section in a connecting rod

Table 1 Design parameters of connecting rod

Design parameter	Initial value(mm)
Frontal profile	
Diameter of small bore(D1)	31
Diameter of big bore(D2)	49
Effective length(L)	140
Shank length(Ls)	57
Shank Sections	
Fillet radius1(R1)	1.0
Fillet radius (R2)	3.5
Total width(L2)*	26
Total thickness(T1)*	15
Side width(L2)	6.0
Middle Thickness(T2)*	5.5

2.2 Generation of mesh

Connecting rod meshing is accomplished by selecting tetrahedral elements with varying element lengths. The equivalent stress is then measured at four locations along the connecting rod in the shank region. The results are provided in the table for approximately all regions of connecting rod convergence with uniform element length. A connecting rod finite element mesh is produced using global element length, and an element length is adjusted at the chamfer area. This mesh has 226409 elements with a length of 226409. The convergence at the chamfer area is produced using the local mesh size.

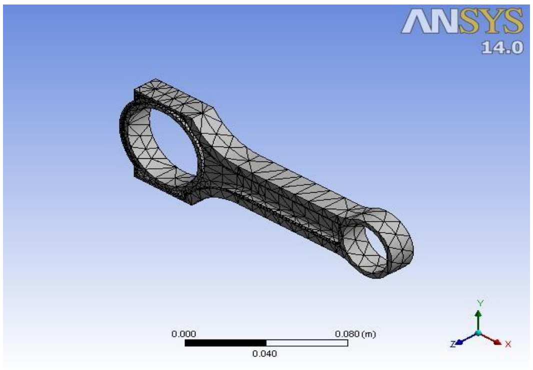


Fig. 2 Mesh generation in connecting rod

2.3 Boundary condition:

For static tensile loading connecting rod is assumed to have alternate loading in contact surface area. The pressure at contact surface is given as:

P = Po cosθ

This load is distributed at 180´ of crank angle. Now the total load is given by:

$$Pt=\int_{-\pi/2}^{\pi/2} Po(\cos 2\theta) r\, td\theta = Po\ rt\pi/2$$

$$\text{Where } Po=Pt/\ (r\ t\pi/2)$$

Pt = tensile load at connecting rod For compressive load acting on connecting rod the two ends of connecting rod are assumed to load distributed at 120'. Normal pressure at this condition is given as

P = Po

Total load is calculated by

$$Pc=\int_{-\pi/3}^{\pi/3} Po(\cos\theta) r\, td\theta = Po\ r\ t\sqrt{3}$$

$$\text{Where } Po=Pc/(\ r\ t\sqrt{3})$$

Two cases were analysed for each dimension one having tension and other having compression. The load applied at connecting rod is 64.7kN.

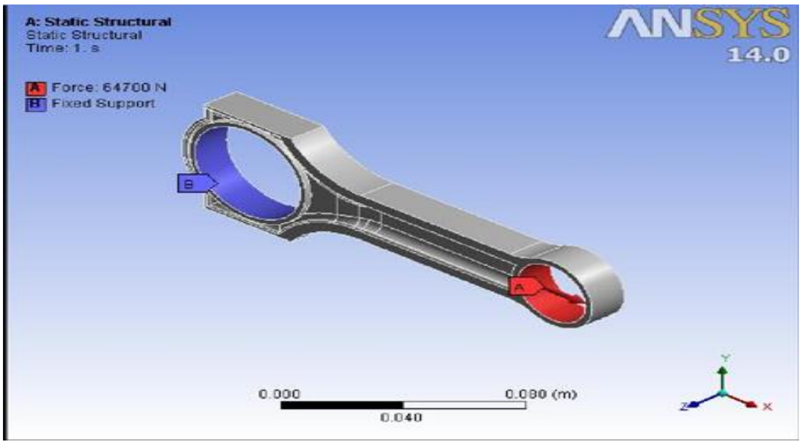


Fig 3. Tensile load applied at piston end

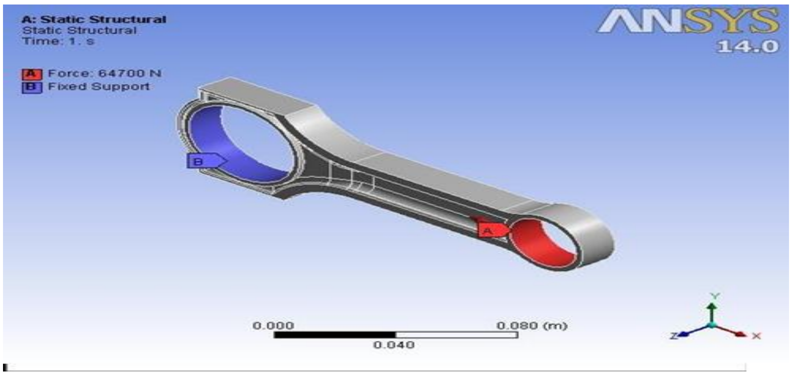


Fig.4 Compressive load applied at piston end

3. Numerical Analysis of Connecting rod

Applied loads: the compressive load of 64.7KN is applied on connecting rod.

Buckling stress calculation through rankines formula:

$$\sigma_{cr}^{e} = \frac{\pi^2 E}{(K_y \frac{L}{r_y})2}$$

Classical buckling stress is of connecting rod is calculated from Rankines formula.

Rankines formula is harmonic mean of Euler formula and yield strength than can be written as

$$\sigma_{cr} = (\frac{1}{\sigma_{cr}^{e}} + \frac{1}{\sigma_{cr}^{p}})\text{-}1$$

Buckling stress prediction via finite element analysis:

$$\sigma_{cr}^{FEM} = \frac{P_{cr}}{A}$$

The elastic buckling stress is obtained by dividing buckling load with area of shank cross section. Finally critical buckling stress is obtained by:

$$\sigma_{cr} = (\frac{1}{\sigma_{cr}^{FEM}} + \frac{1}{\sigma_{cr}^{p}})\text{-}1$$

The connecting rod used is made of C70s6 with elastic modulus 210gpa and poisons ratio 0.3 the overall focused was on shank portion. The connecting rod is assumed to be fixing on crank end and displacement is allowed on piston pin end when compressive load of 64.7kn has been applied.

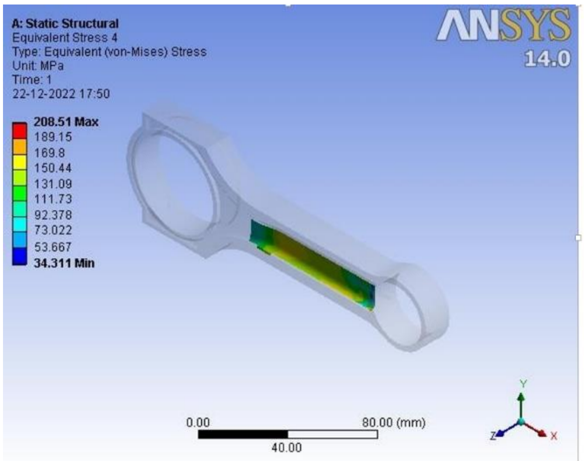


Fig 5. Minimum Equivalent stress when piston pin tensile load is applied at piston pin end End (Location 2)

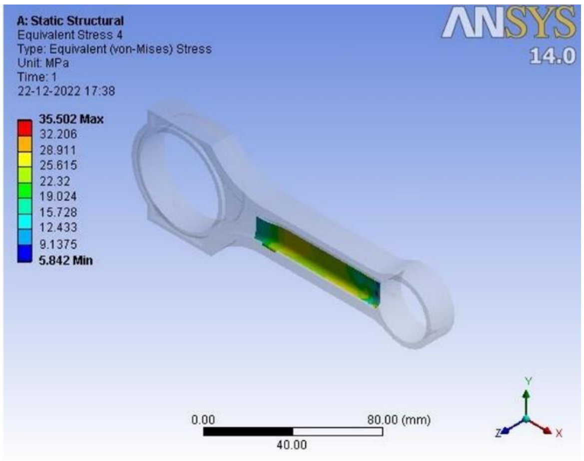


Fig .6 Minimum Equivalent stress when Compressive load is applied at (Location 2)

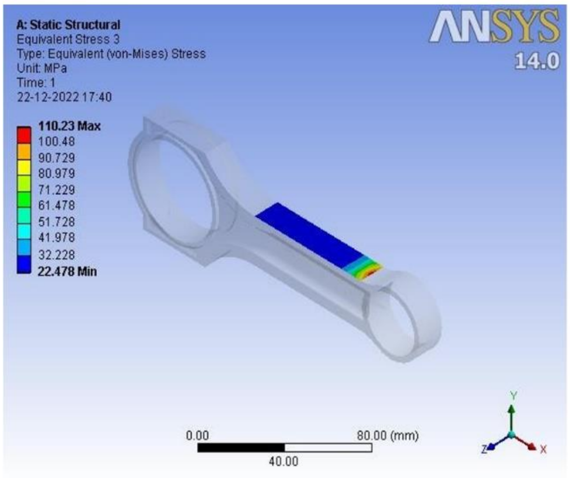


Fig .7 Minimum Equivalent stress when piston pin tensile load is applied at piston pin end End (Location 3)

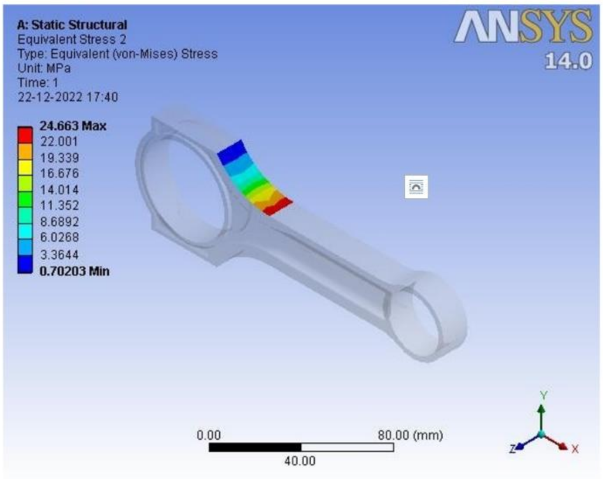


Fig .8 Minimum Equivalent stress when Compressive load is applied at (Location 4)

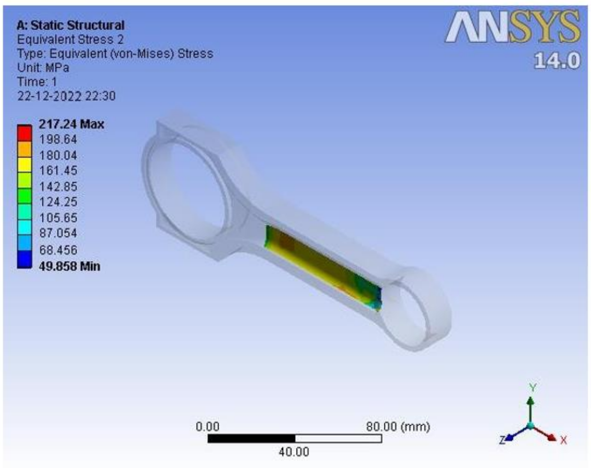


Fig .9 Maximum Equivalent stress when piston pin tensile load is applied at piston pin end End (Location 2)

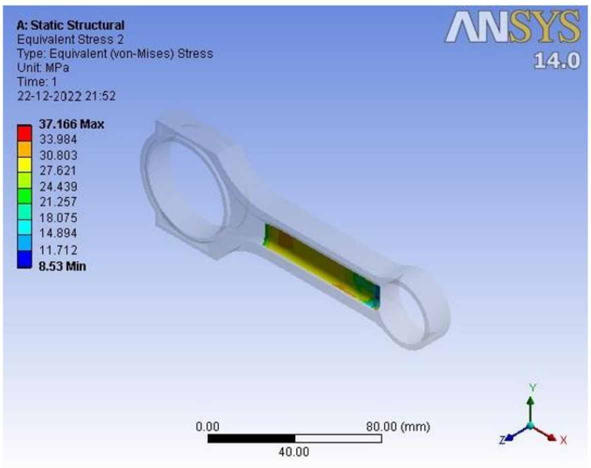


Fig .10 Maximum Equivalent stress when Compressive load is applied at (Location 2)

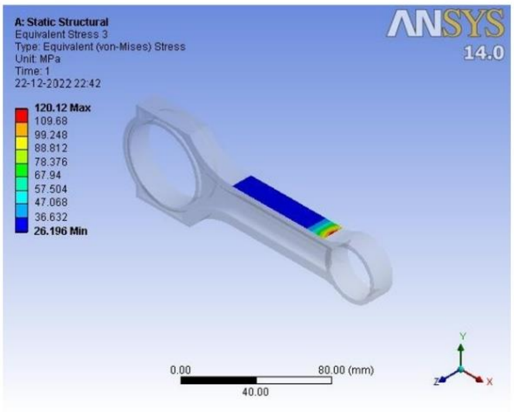


Fig .11 Maximum Equivalent stress when tensile load is applied at piston pin end End (Location 3)

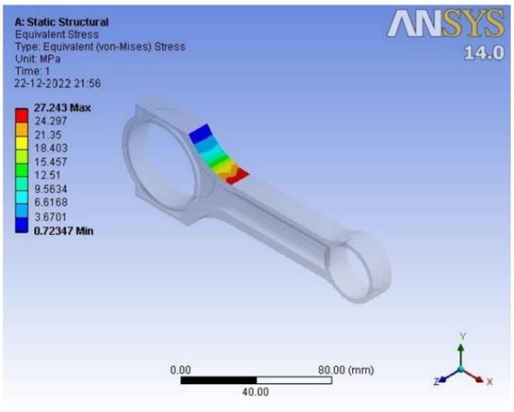


Fig .12 Maximum Equivalent stress when Compressive load is applied at piston pin (Location 4)

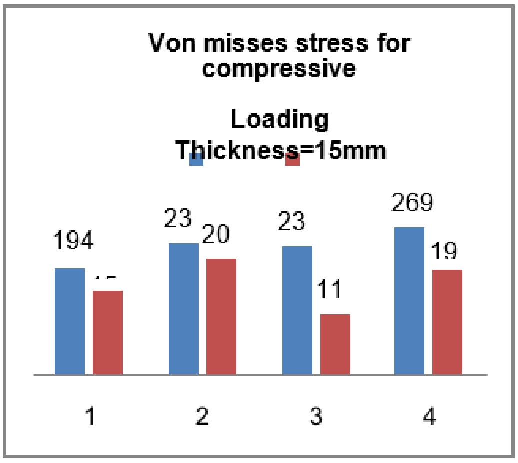


Fig .13 Von misses stress for compressive Loading (thickness=14.75mm)

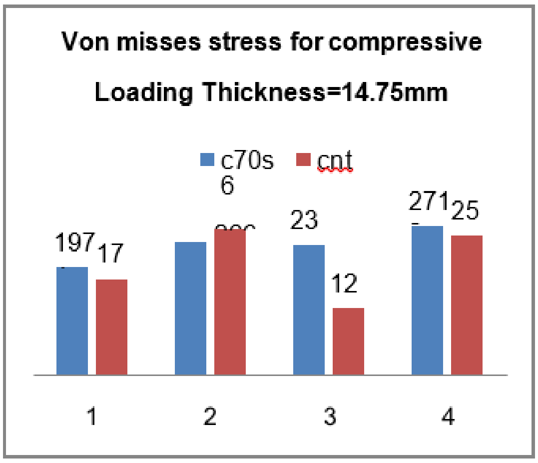


Fig .14 Von misses stress for compressive Loading (thickness=15mm)

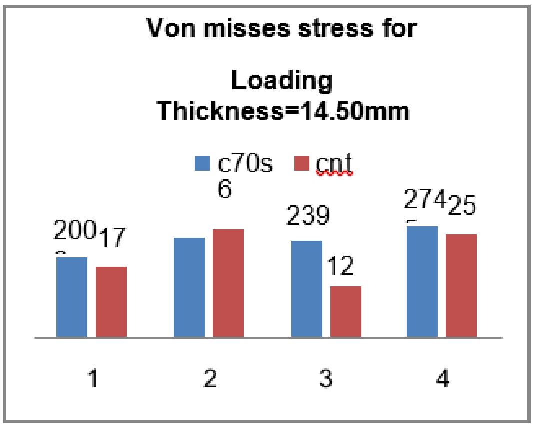


Fig .15 Von misses stress for compressive (thickness=14.25mm)

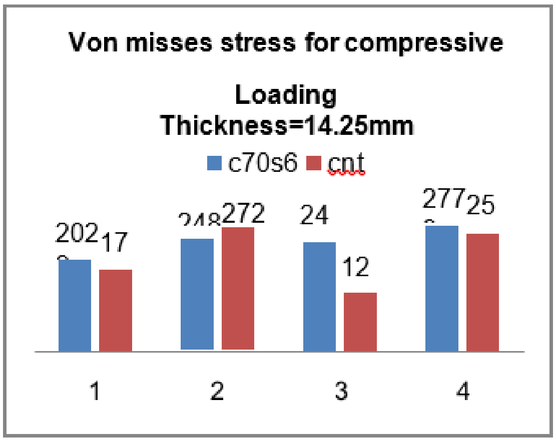


Fig .16 Von misses stress for compressive Loading (thickness=14.50mm) Loading

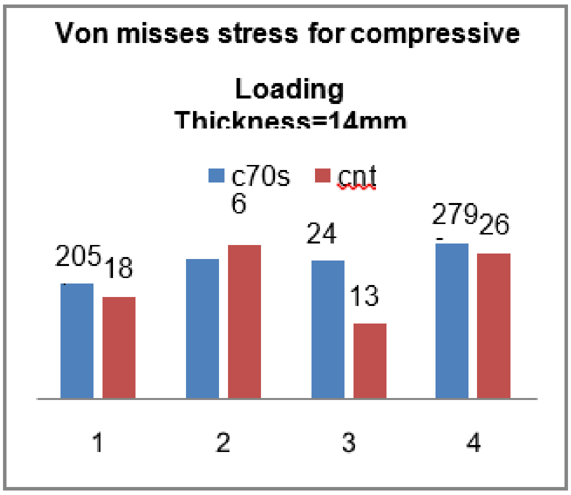
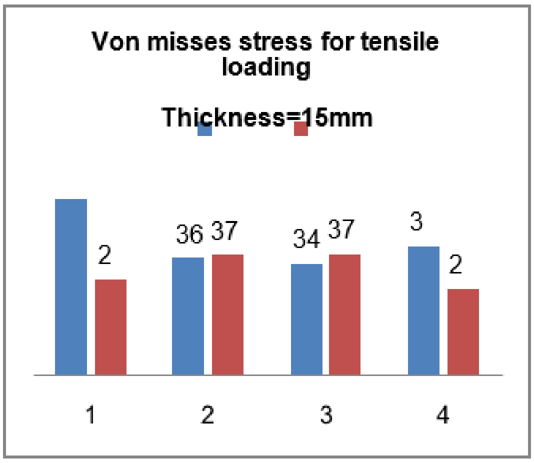


Fig .17 Von misses stress for compressive Loading (thickness=14mm)



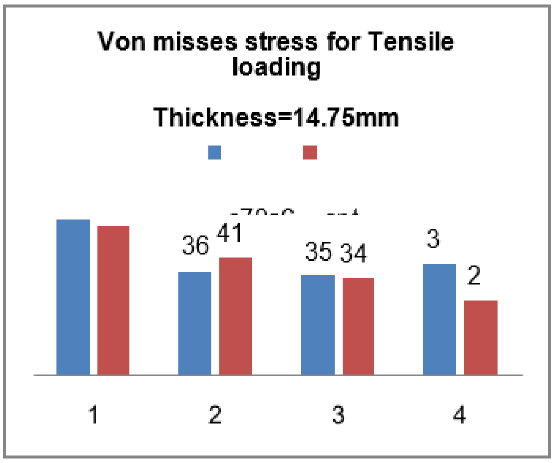
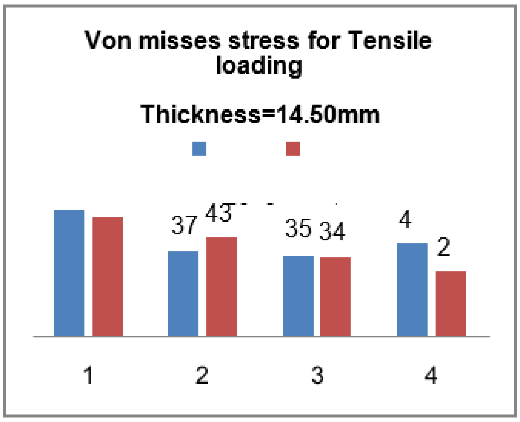


Fig .18 Von misses stress for tensile (thickness=14.75mm)

Fig .19 Von misses stress for tensile Loading (thickness=15mm) Loading



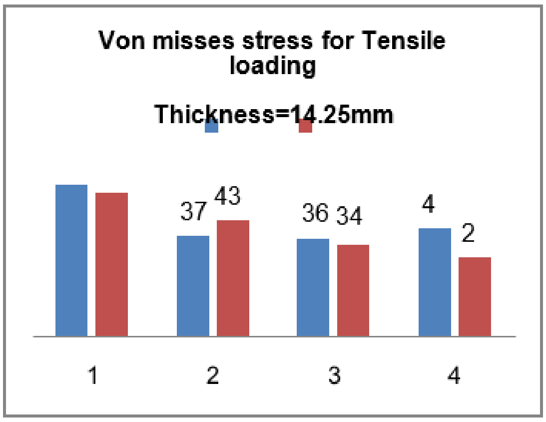


Fig .20 Von misses stress for tensile Loading (thickness=14.25mm)

Fig .21 Von misses stress for tensile Loading (thickness=14.50mm)

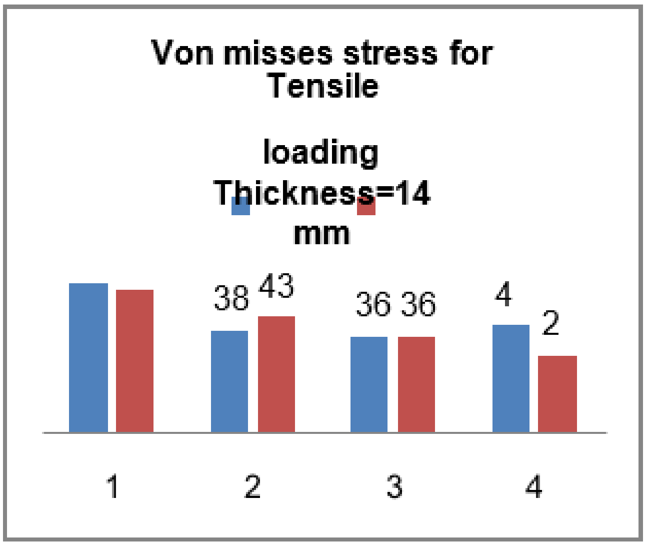


Fig .22 Von misses stress for tensile Loading (thickness=14mm)

In case of aluminium alloy as shown in table 5.2, under maximum compressive load, the maximum stress occurs at location 2, ranging from 264 to 275 MPa for the reduction of cross section. And minimum stress occurs at location 3 ranges from 110 to 134 MPa. Under maximum tensile load the maximum stress ranges from 50 to 53 MPa at location 1 and minimum stress occurs at location 4 ranges from 25 to 29 MPa which is lower than the stress of C70s6

Conclusion

In numerical analysis, various connecting rod design variables are changed, and the slenderness ratios calculated for each case. After that, the rankines formula is used to calculate critical buckling stress for each new design of connecting rod, and FEM analysis is also performed, and the results are compared.

In another section of the thesis, two materials are employed instead of C70S6. Carbon nanotube reinforced with aluminium alloy and aluminium alloy are the two materials. The thickness of the connecting rod has been lowered by.25mm in this example. The von misses stresses at four connecting rod sites have been calculated for each design. All four areas are examined for compressive and tensile loads. The tension at various connecting rod locations is calculated, and the findings of all three materials are compared.

Following this investigation, it was discovered that carbon Nano composite can be utilised in place of C70S6 because it has a very low buckling stress value. The most sensitive place with the highest stress value is site 2, which is less than C70S6. All of the computed stresses at all four locations are less than C70S6. As a result, this material can be utilised instead of C70S6.Also, in the case of aluminium, the value of stresses is lower when compared to the reference material, implying that the existing material can be replaced with an aluminium alloy as well. However, when comparing carbon nano composite and aluminium alloy, the former exhibits less stress than the latter. When material cost is a factor, aluminium is a good choice.

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