STATIC STRUCTURAL ANALYSIS OF KNUCKLE JOINT

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ABSTRACT

The aim of the present paper is to study and calculate the stresses in Knuckle joint using analytical method. A knuckle joint is used to connect two rods under tensile load. These joints are used for different types of connections e.g. tie rods, tension links in bridge structure. In this, one of the rods has an eye at the rod end and the other one is forked with eyes at both the legs. In this study, modelling and analysis of a knuckle joint is performed by using Finite Element Method. The commercial finite element package ANSYS version 17 is used for the solution of the problem. The knuckle joint takes tensile loads often, thus there is a need for quality design tools. The modelling of the knuckle joint is done using 3D software. Here CATIA V5 has been used for modelling. The simulation part will be carried out using the Analysis software, ANSYS. With the Boundary constrains and the tensile load applied, the knuckle joint is analyzed and the values are tabulated.

Keywords: FEM, Knuckle Joint, Stress Analysis

I INTRODUCTION

A knuckle joint is used to connect two rods which are under the action of tensile forces, when a small amount of flexibility or angular moment is necessary. It is basically a tensile joint. However, if the joint is guided, it may support a compressible load. This joint can be readily disconnected for adjustments or repairs. The common examples of the knuckle joints are: link of a roller chain, tension link in a bridge structure, tie rod joint of roof truss, tie rod joint of jib crank, etc. A typical knuckle joint consists of three parts: an eye, a fork, and a knuckle pin. The end of one rod is formed into an eye and the end of other rod is formed into fork with an eye in each of the fork leg. The eye is inserted into the fork and after aligning the holes in the eye and fork, the knuckle pin is inserted through them. The knuckle pin has a head at one end and at the other end it is secured by a collar and a taper pin or split pin.

The simple definition of stress is that force divided by area. If the force is perpendicular to the area and pulling away from it, the stress is tensile. If the force is perpendicular to area and pushing towards it, the stress is compressive.

Both tensile and compressive stresses come under general category of direct stress. The knuckle joint has wide applications such as bicycle chain, Tractors, Automobile wipers, cranes, robotic joints structural members.etc

II FAILURE OF KNUCKLE

A knuckle joint may be failed on the following three modes

- Shear failure of pin (single shear).
- Crushing of pin against rod.
- Tensile failure of flat end bar.

III DESIGN OF KNUCKLE JOINT

Consider a knuckle joint connecting two rods and subjected to an axial tensile force P.

- P = axial tensile force on rods, N
- d = diameter of the rod, mm
- dp = diameter of the knuckle pin, mm
- D = outside diameter of the eye, mm
- t = thickness of the single eye, mm
- t_1 = thickness of the fork, mm
- d_h = diameter of the pin head and outside diameter of the collar, mm
- t_2 = thickness of pin head and collar, mm
- σ_t = permissible tensile stress for fork end, N/mm^2
- τ = permissible shear stress for fork end, N/mm^2

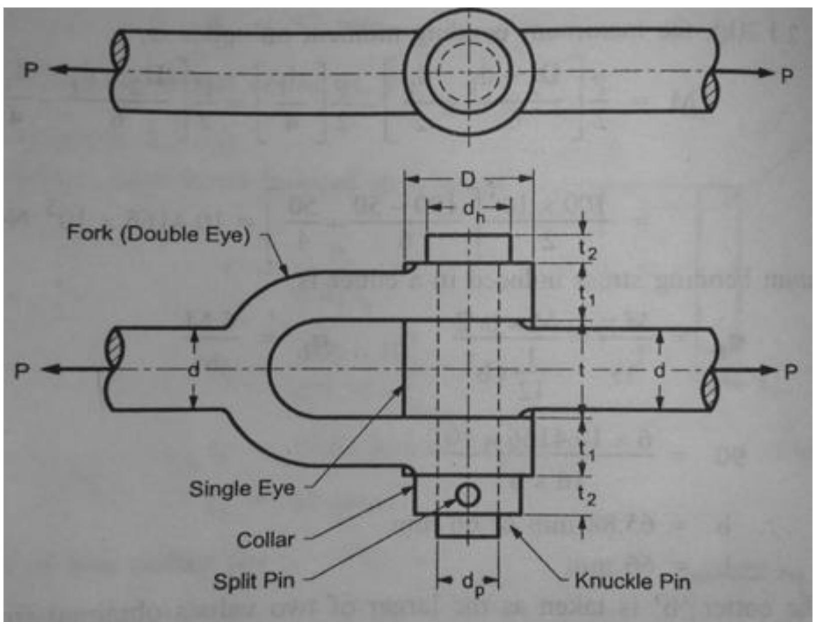

Fig.3.1 2D Design of Knuckle Joint

IV GEOMETRIC MODELLING

CAD model of steering knuckle was developed in 3D modelling software CATIA V5. it consists of Fork end, Single eye, Collar, Split pin, knuckle pin.

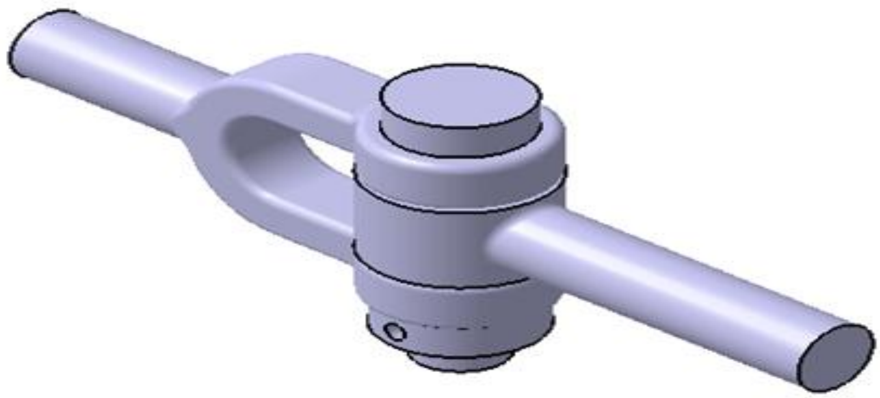

Fig. 4.1 Solid model of Knuckle Joint

V ANALYTICAL DESIGN:

Assumptions:

1. Rod diameter d = 40mm
2. Load applied P = 9810 N (1Ton)
3. Diameter of knuckle pin (dp) = d

   dp = 40mm
4. Thickness of single eye (t) = 1.25d = 1.25x40

   t = 50mm
5. Thickness of fork (t_1) = 0.75d = 0.75x40

   t_1 = 30mm
6. Outer diameter of eye (D) = 2d = 2x40

   D = 80mm
7. Failure of fork end in tension (σ_t)

   $\sigma_t = 4.0875\ N/mm^2$
8. Failure of fork end in shear (τ)

   $\tau = 4.0875\ N/mm^2$

Note: The tensile stress induced is calculated. This value must be less than the permissible tensile stress for the safety against the tensile failure.

VI MATERIAL SELECTION

There are several materials used for manufacturing of knuckle joint such as S.G. iron (ductile iron), white cast iron and grey cast iron. But grey cast iron mostly used. Forged steel are most demanding material for this application. For this Structural steel is used

Structural Steel

- Modulus of Elasticity : 2.0e5 MPa
- Poisson's ratio : 0.30
- Density : 7.85e-6 kg/mm^3
- Yield Strength : 250 MPa

VII MESHING

The process for generating a mesh of nodes and elements consists of three general steps:

- CATIA offers a large number of mesh controls from which you can choose as needs dictate.
- Set the element attributes.
- Set mesh controls (optional).

It is not always necessary to set mesh controls because the default mesh controls are appropriate for many models. If no controls are specified, the program will use the default settings to produce a free mesh. Alternatively, you can use the Smart Size feature to produce a better quality free mesh.

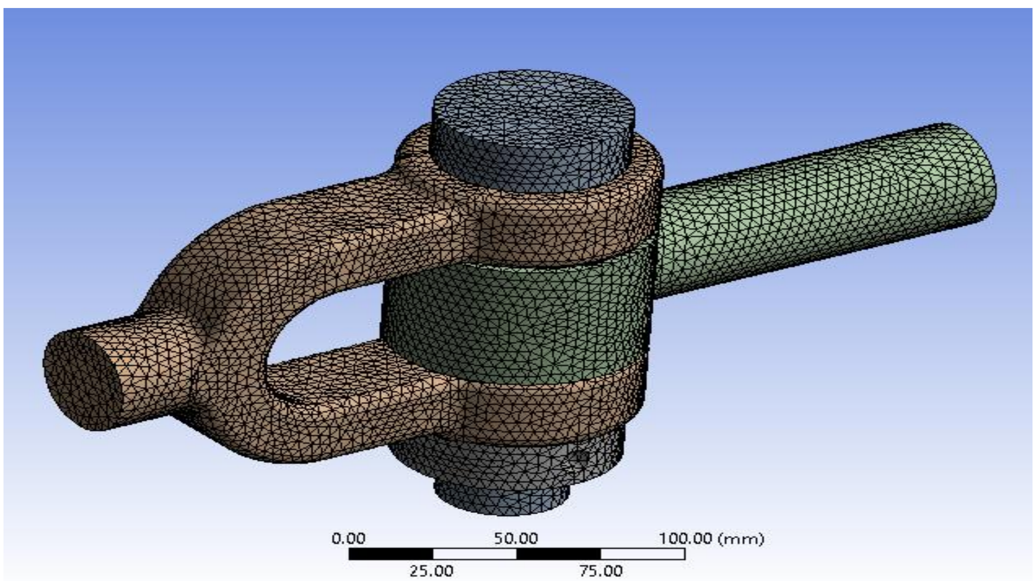

Fig. 7.1 Meshing of Model in ANSYS

- Element Type: Second order Tetrahedron
- Elements count: 151529
- Nodes count: 224387

VIII BOUNDARY CONDITION

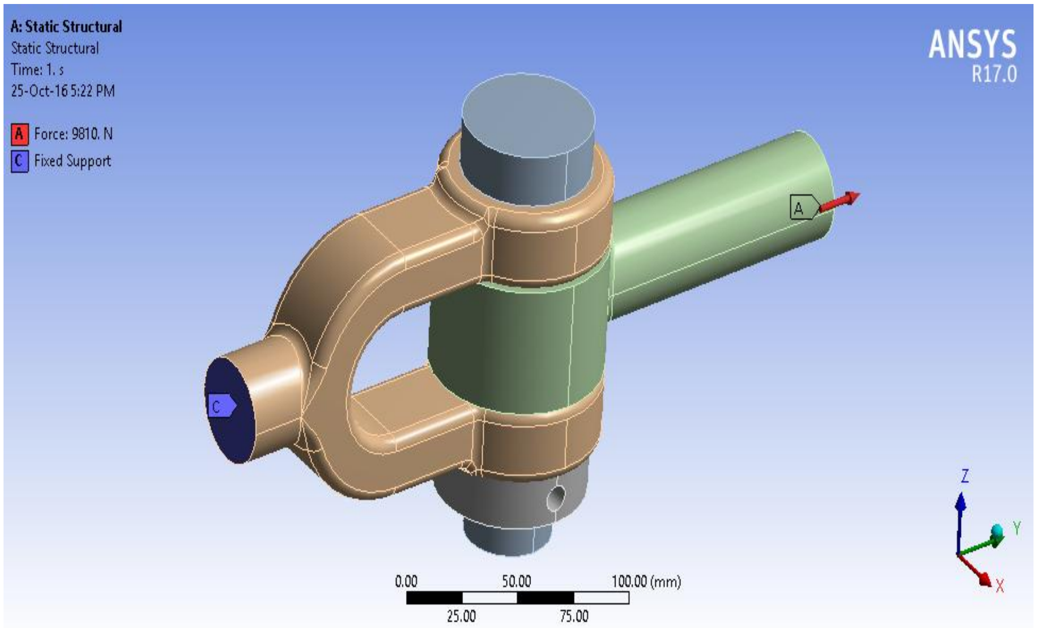

Fig. 8.1 Boundary condition in ANSYS

The knuckle pin is fixed at one end at point C on the fork side. The axial tensile force of 9810 N is applied on the other end.

IX Results

9.1 Von Mises

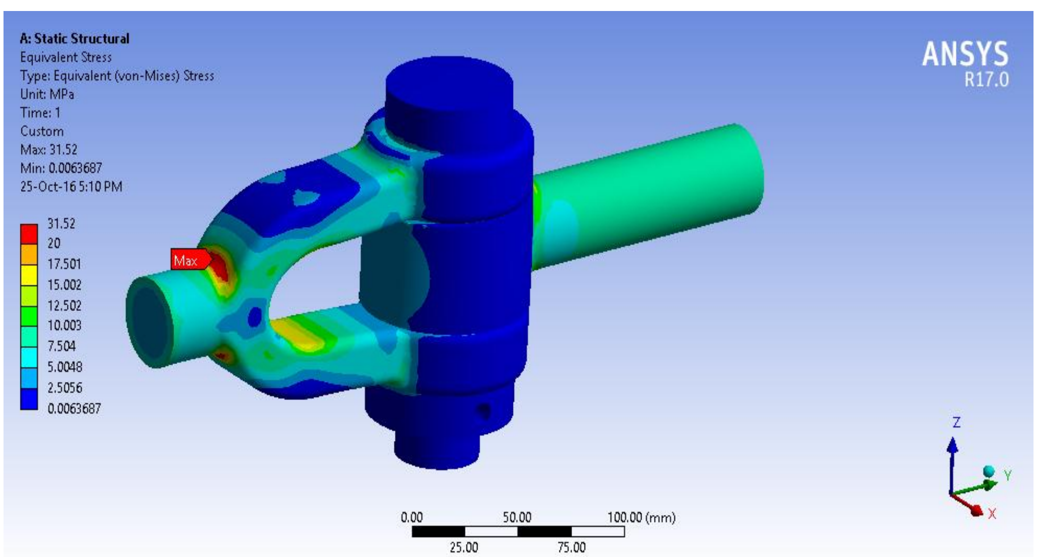

Fig. 9.1.1 Von Mises stresses by using ANSYS

Application of the tensile axial force with given boundary conditions produces different stresses in the knuckle pin the maximum stress is developed at the fork end which is 31.52MPa

9.2 Deformation

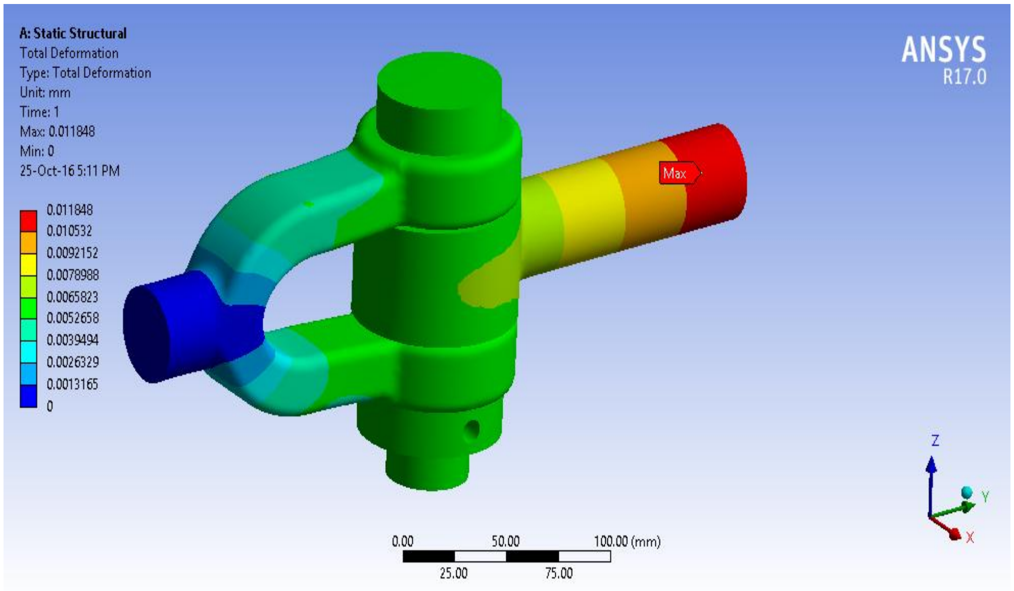

Fig. 9.2.1 Deformation Results in ANSYS

X CONCLUSION

In this paper the tensile stresses for knuckle joint in static condition are calculated and analysed with ANSYS. The maximum von mises stress is 31.52 MPa and minimum stress is 0.0063687Mpa. Allowable yield stress of steel is 210 MPa and our obtained von misses stress i.e. 31.52 MPa which is so much less than the yield stress. It forms the basis of optimization.

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