STRUCTURAL STATIC ANALYSIS OF KNUCKLE JOINT

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Abstract— The rapid growth of technology in recent decades has led to the reduction of cost and weight of materials. The aim of the present paper is to study calculate the stresses in Knuckle joint using analytical method. Further study in this direction can made by using various directions of the pin and the capacity to withstand load. The present work is concentrating on which type of meshing is preferable for components. Here knuckle joint is modeled by making use of catia, later on that model is imported in Hypermesh and carried out both mesh those are hexahedral and tetra mesh. This model is solved by using Abacus software. The FEA results are compared with analytical results.

Keywords— Knuckle joint, FEA, hexahedral, tetrahedral, abaqus, hypermesh, axial load.

INTRODUCTION

A Knuckle joint is used to connect two rods under tensile load. This joint permits angular misalignment of the rods and may take compressive load if it is guided. These joints are used for different types of connections i.e. tie rods, tension links in bridge structure. In this, one of the rods as an eye at the rod end and other end is forked with eyes at the both the legs. A pin (knuckle pin) is inserted through the rod-end and fork end eyes and is secured by collar and a split pin. Normally, empirical relations are available to find different dimensions of the joint and they are safe from design point of view. The proportions are given in the figure.

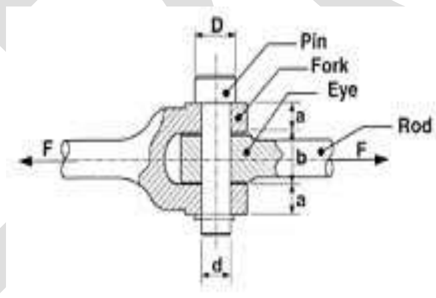


Fig 1 2D model of knuckle joint

MAJOR COMPONENTS OF KNUCKLE JOINTS:

- Single eye end
- Double eye end
- Knuckle pin
- Collar
- Taper pin / Split pin

GEOMETRIC MODELING

Early cad systems were basically automated drafting board systems which displayed a two dimensional representation of the object being designed. Operations could use these graphics systems to develop the line drawing the way they wanted it and then obtain a very high quality paper plot of the drawing. B y using these systems, the drafting process could be accomplished in less time, and the productivity of the designers could be improved. Although they were able to reproduce high quality engineering drawing efficiently and quickly, these systems stored in their data files a two dimensional record of the drawing. The drawing usually of three-dimensional objects and it was left to the human being who read these drawing to interpret the three dimensional shape from the two dimensional representation. The major drawback of the early CAD systems was that they were not capable of interpreting the three dimensionality of the object.

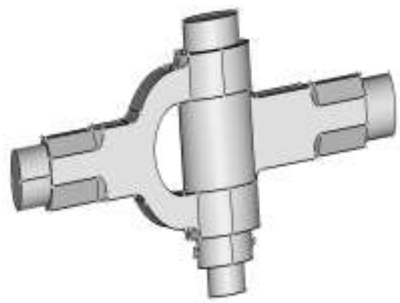
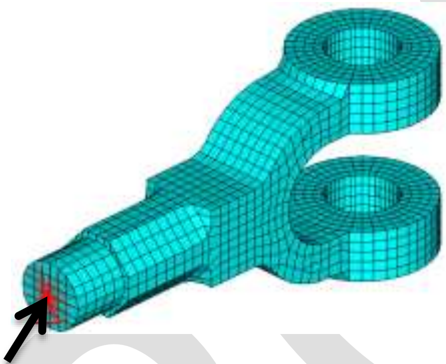
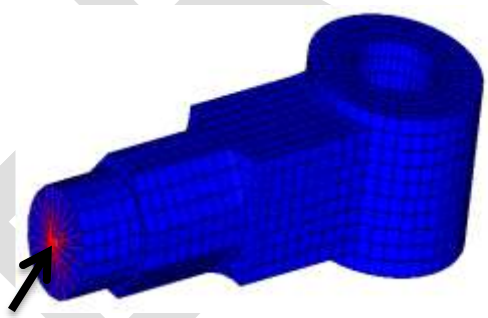


Fig 2. 3D model of knuckle joint

BOUNDARY CONDITION



Knuckle joint is hinged by the end surface of fork.



Tension force is applied on the end surface of eye

Table 1: Dimensions of knuckle joint

Sl no.	Parameters	Values
1	Diameter of rod	30mm
2	Diameter of pin	30mm
3	Diameter of pin head and collar	60mm
4	Thickness of eye	45mm
5	Thickness of fork	35mm
6	Thickness of eye end	36mm
7	Thickness of fork end	45mm
8	Thickness of collar	22.5mm
9	Thickness of pin head	15mm

Table 2: Material properties for steel

Mechanical property	**Value**	**Unit**
Density	7850	Kg/m^3
Coefficient of thermal expansion	$1.7e^{-005}$	
Specific heat	480	J/Kg/C
Thermal conductivity	15.1	W/m/C
Resistivity	$7.7e^{-007}$	Ohm
Compressive yield strength	2.07e008	Pa
Tensile yield strength	2.07e008	Pa
Tensile ultimate strength	$5.86e^{008}$	Pa
Reference Temperature	22	C
Young's modulus	21000	Pa
Poisson's ratio	0.31	
Bulk modulus	$1.693e^{011}$	Pa

RESULTS AND DISCUSSION

A.Stress values of Hex mesh

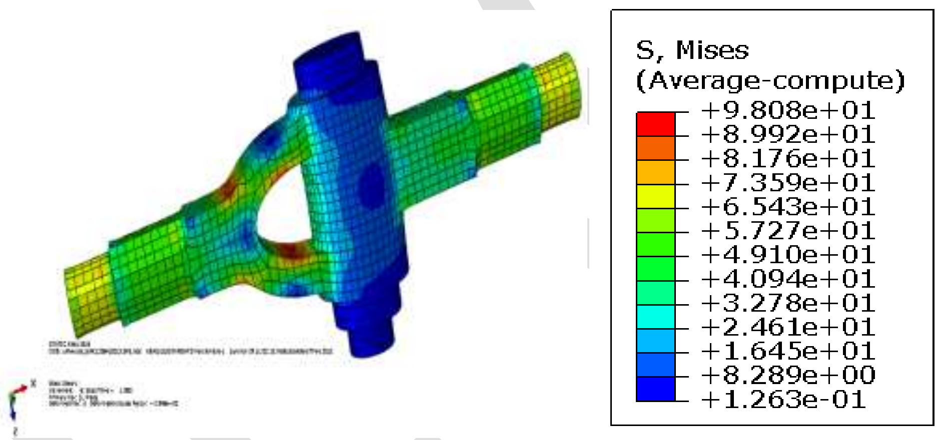


Fig 3: Stress values of hex mesh

B.Stress values for tetra mesh

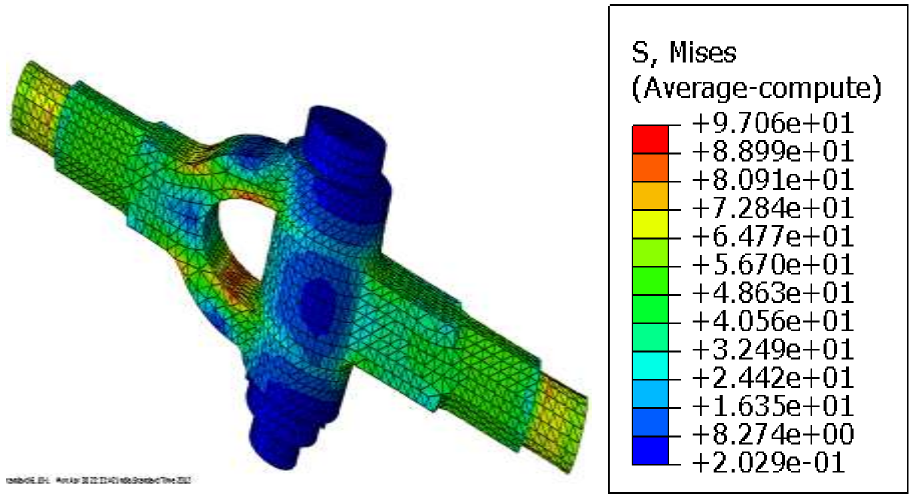


Fig 4: Stress values for tetra mesh

C.Strain values for hex mesh

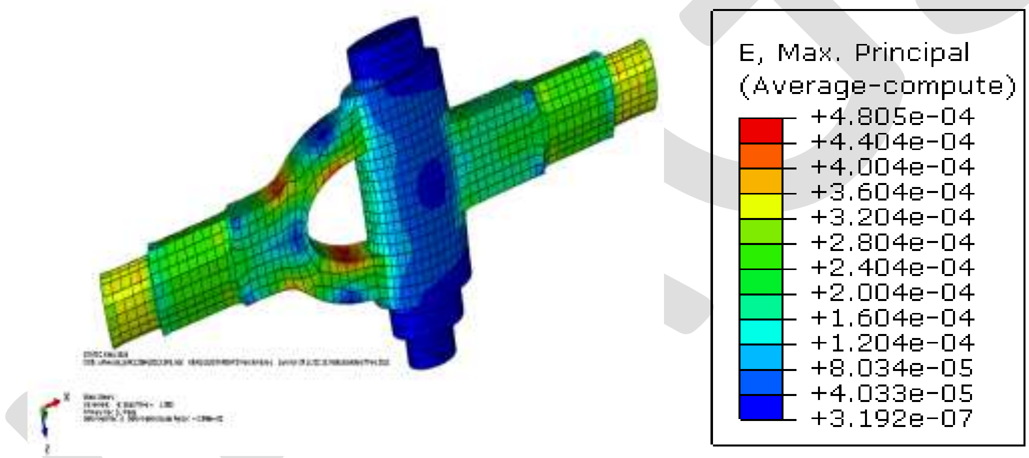


Fig 5: Strain values for hex mesh

D.Strain values for tetra mesh

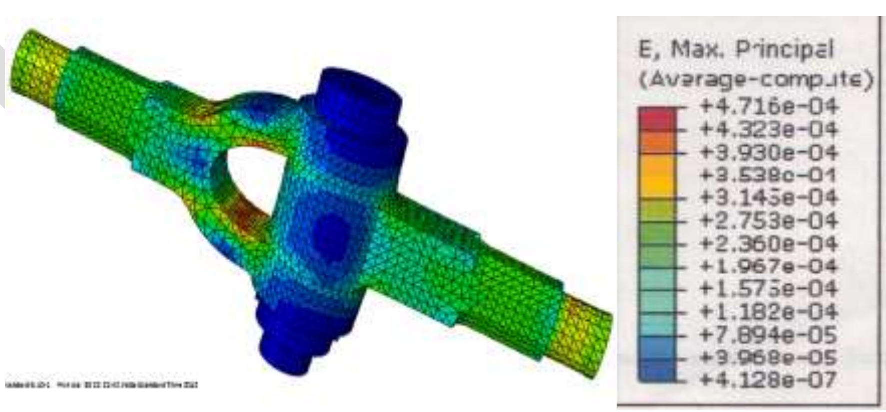


Fig 6: Strain values for tetra mesh

ANALYTICAL RESULTS

Theoretical calculation for maximum stress

Let, applied load=50kn

But the fork is considered as plate which is subjected to abrupt changes in cross sectional area therefore stress concentration factor should be required to determine max stress.

We know that,

$$K_{t=\frac{\sigma max}{\sigma nom}} \quad (1)$$

K=stress concentration factor.

$\sigma m\text{ax} = \text{maximum stress}$

$\sigma nom = nominal\ stress$

$$\sigma nom = \frac{force}{area} \quad (2)$$

Area=(w-d)× h

=(90-36)×35

=1890mm^2

Therefore $\sigma nom = \frac{50,000}{1890}$ = 26.45 N/mm^2

Also we have that, fork is subjected to abrupt changes in two major sections and hence we get

$K_t = (K1+K2)$

K1=stress concentration factor for plate with hole

i.e=2.23 for $\frac{d}{w} = \frac{36}{90}$

From DDHB V1 by Dr.LINGAIAH

K2=stress concentration factor for filleted flat bar in tension

i.e=1.6 for $\frac{r}{d} = 0.28\ and\ \frac{w}{d} = 2.5$

$$K_t = (2.23 + 1.65) = 3.88$$

$$\sigma max = K_t \times \sigma nom$$

$$= 3.88 \times 26.45$$

$$\sigma max = 102.6 N/mm^2$$

Theoretical calculation for maximum stress

Youngs modules(E) =$\frac{stress}{strain}$

μ=$\frac{\sigma}{E}$

=(102.6/210000)

Strain =4.84×10^{-4}

Table 3: Comparison of stress values as measured by theoretical in component and as predicted using the finite element analysis for hex & tetra mesh on knuckle joint

S.no	Types of mesh	The,value	Exp,value	%Error
1.	HEX	102.6N/mm^2	98.08	4.41%
2.	TETRA	102.6Nmm^2	97.06	5.39%

Table 4: Comparison of strain values as measured by theoretical in component and as predicted using the finite element analysis for hex & tetra mesh on knuckle joint

S.NO	Types of mesh	The, value	Exp, value	%Error
1.	HEX	4.88×10^{-4}	4.80×10^{-4}	1.64%
2.	TETRA	4.88×10^{-4}	4.71×10^{-4}	3.48%

CONCLUSIONS

Fork is analyzed for stress for the tensile load 50kn for the both mesh viz hex and tetra mesh and compared with theoretical value.

1. The conclusion is drawn from work are as follows:

2. The results show that the fork takes higher stress and eye takes less stress under loading condition.

3. The induced stress in the fork is higher than allowable stress hence the design is out of safe for that diameter of rod of knuckle joint needed to be varied.

4. The error between theoretical value and hex meshed analyzed value has less than that of between theoretical and tetra meshed analyzed value and hence hex mesh is better than the tetra mesh.

REFERENCES:

[1] Dominick Rosato and Donald Rosato, Plastics Engineered Product Design, ELSEVIER

[2] R.J. Crawford, BSc, PhD, DSC, FEng, FIMechE, FIM_Butterworth Heinemann. PLASTICS ENGINEERING_ Third Edition_

[3] K.l.Narayan, P, kannaiah, K.Venkata reddy, Machine drawing

[4] H. Gradin Jr. Macmillan, New York, Xvi + 528pp, 1986, Fundamental of FEM,

[5] Irvin L. Rubin (1990).Dry-as Molded/Moisturized, Adapted from: Handbook of Plastic Materials and Technology

[6] SAE J328 Revised 1994: knuckle joint of car and truck performance requirements and test procedures.

[7] Khurmi R.S., (2007), Machine design, S Chand Publishers, Delhi.

[8] Stuart B. H.: Tribological studies of composite material. Tribology International, 31, 647-651(1998).

[9] Yijun Liiu., Introduction to the finite element method.

[10] Mechanical and structural properties of Ductile Cast Iron- M.A.Kenaawy, A.M. Abdel Fattah, N. Okasha and M.EL-Gazery, Egypt. Sol, vol. (24), No. (2), 2001

[11] Rajeev Sakunthala Rajendran, Subash Sudalaimuthu and Mohamed Sixth “Knuckle Development Process with the Help of Optimization Techniques” Altair Technology Conference, India,2013

[12] S. Kilian, U. Zander, F.E. Talke “Suspension modeling and optimization using finite element analysis” Tribology International 36 (2003) 317–324

[13] Sonia Calvel and Marcel Mongeau “Black-box structural optimization of a mechanical component “Computers & Industrial Engineering 53 (2007) 514–530.