Material optimization of knuckle joint using FEA

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Abstract: Knuckle joint is a key component for joining two parts allowing movement in one plane only. It is widely used in most of the automobile applications .Shear stresses and tensile stresses are developed during operation of knuckle joint. If these stresses are developed beyond ultimate limit, then there is probability of failure. Hence selection of material considering stresses & deformation becomes very important for optimization of material. Finite element Analysis using Ansys 15.0 as software tool is used now a days efficiently for optimization of materials. The aim of this work is to analyze different material configuration for knuckle joint using FEA. Comparison of stress development & deformation in knuckle joint for three materials, i.e. stainless steel, Grey Cast iron & low carbon steel grade 30C8 is done. Based on this comparison optimum material is selected considering minimum occurrence of stresses & deformation.

***Index Terms* – FEA, Knuckle Joint, Ansys 15.0**

I. INTRODUCTION

In mechanical & automobile domain the joints play very crucial role, Type of joints i.e. temporary or permanent is selected upon the application. For power transmission or motion transfer application we generally uses temporary joints like screwed joint, cotter joint, sleeve cotter joint, universal joint or knuckle joint. The Knuckle joint is a type of joint which is used in steering system in between the steering rod and pinion of the steering gear, as the line of the action axis of both the mechanical parts are intersecting and lies in different planes, so it is the only joint that we can employ here

A Knuckle joint is used to connect two rods under tensile load. It permits angular misalignment of the rods and may take compressive load if it is guided. We can find use of these joints for different types of connections i.e. tie rods, tension links in bridge structure.

Failure of knuckle joint may cause accident so it necessary to design knuckle joint to withstand under tension without failure. The effective design of mechanical device or assembly demands the predictive knowledge of its behavior in working condition. It became necessary for the designer to know the forces and stress developed during its operation.

II. COMPONENTS OF KNUCKLE JOINT

Construction of knuckle joint is simple. Major components of knuckle joint are as given below. It can be justified with diagram as given below.

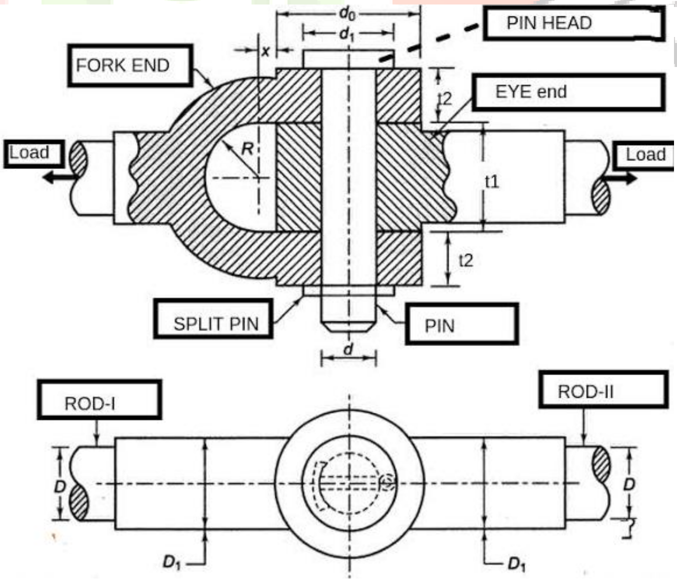

Fig. 1 Knuckle joint

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.

III. DIMENSIONS AND GEOMETRY

3D model of joint is made using Standard dimensions obtained for knuckle joint as below.
3D modeling is done using software tool solid works 2013.

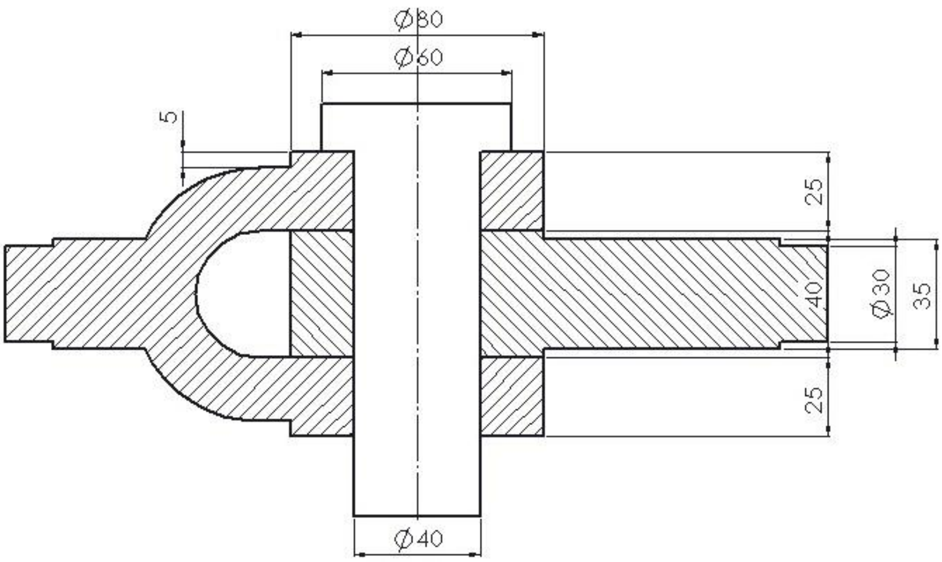

Fig. 2 dimensions of Knuckle joint

Imported model geometry meshed in Ansys 15.0 is also shown below.

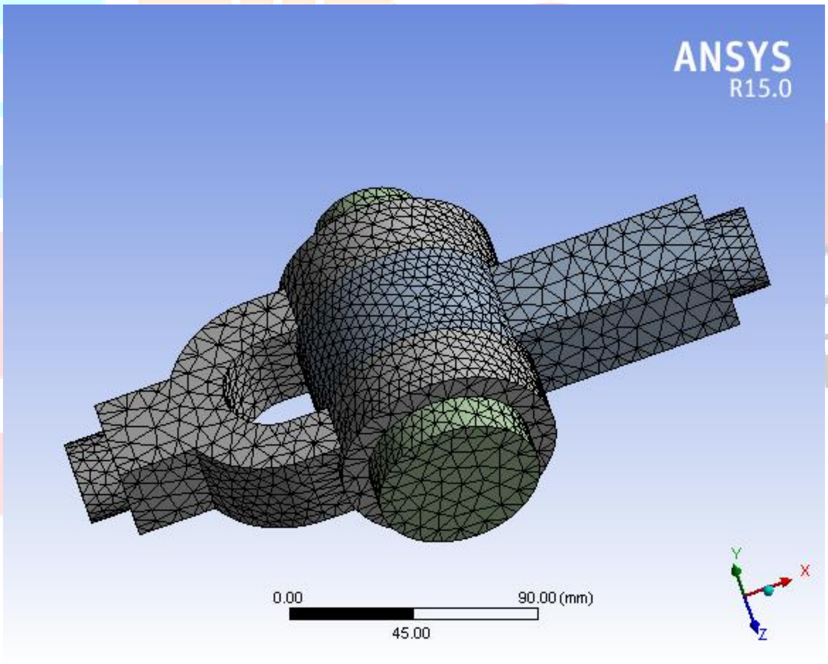

Fig. 3 3D model with meshing

IV. Materials

Material optimization is carried out by assigning three materials i.e. stainless steel, grey cast iron & low carbon steel grade 30C8. Properties of each material inputted for analysis are given below

Mechanical property	**Value**	**Unit**
Density	7850	Kg/m3
Coefficient of Thermal Expansion	1.7e-005	1/C
Specific Heat	480	J/kg/C

Thermal Conductivity	15.1	W/m/C
Resistivity	7.7e-007	ohm m
Compressive Yield Strength	2.07e+008	Pa
Tensile Yield Strength	2.07e+008	Pa
Tensile Ultimate Strength	5.86e+008	Pa
Reference Temperature	22	C
Young's Modulus	1.93e+011	Pa
Poisson's Ratio	0.31	
Bulk Modulus	1.693e+011	Pa
Shear Modulus	7.366e+010	Pa

Table 1.Stainless steel material properties

Mechanical property	**Value**	**Unit**
Density	7200	Kg/m3
Coefficient of Thermal Expansion	1.7e-005	1/C
Tensile Yield Strength	190	Pa
Reference Temperature	22	C
Young's Modulus	1.e+006	Pa
Poisson's Ratio	0.23	
Bulk Modulus	6.1728e+005	Pa
Shear Modulus	4.065e+005	Pa

Table 2.Cast Iron material properties

Mechanical property	**Value**	**Unit**
Density	7800	Kg/m^3
Tensile Yield Strength	400	MPa
Tensile Yield Strength	400	MPa
Reference Temperature	22	C
Young's Modulus	$2x\ 10^{11}$	Pa
Poisson's Ratio	0.3	
Bulk Modulus	$1.6\ X\ 10^{11}$	Pa
Shear Modulus	$7.69\ X\ 10^{11}$	Pa

Table 3.30C8 material properties

V. FE ANALYSIS

Finite element method is a numerical method for solving problem of engineering and physics. It is also referred to as finite element analysis (FEA). FEA is a numerical method that offers a means to find approximation solution. It gives idea for prediction of failure in a component by giving stresses in components. FEA applied in engineering is computational tool for performing engineering. Success of FEA lies in creation of nodes, selection of proper meshing for descretization &application of correct boundary conditions to get relevant results.

There are three main steps followed in FEA. These are given as below.

5.1 Preprocessing:

It is the first step in FEA. It consists of process of importing or creating model and defining material properties. Then descritizing is done by meshing the model. Appropriate application of boundary conditions is very important in preprocessing.

Knuckle joint model is prepared in solid works 2013 and it is imported in Ansys 15.

Boundary conditions are applied as tensile force of 50KN on both sides i.e. eye end and fork end. Knuckle joint pin is fixed at middle hence fixed support is applied on knuckle pin.

Model is fine meshed with relevance 1, with span angle center as fine to get better results

5.2Processing:

This process is done by software. Software tool can be any i.e. Ansys or Abacus. It considers boundary conditions; magnitude of forces, supports applied and processes the problem itself choosing appropriate solution method.

5.3Post Processing:

In this process, results are obtained in the solution. These results can be viewed in various formats like graph, value, animation etc. By studying & analyzing these results we are leading towards conclusion.

In current work, results of two parameters for three materials are obtained and analyzed.

1) Shear stress in eye
2) Shear stress in fork
3) Equivalent stress
4) Total deformation

VI. ANSYS RESULTS

Ansys results for all four parameters are obtained by assigning three materials as given below.

6.1 Stainless Steel

Properties of stainless steel are taken from Ansys library and material assignment is made keeping meshing & boundary conditions same.

It gives results for all parameters as given below.

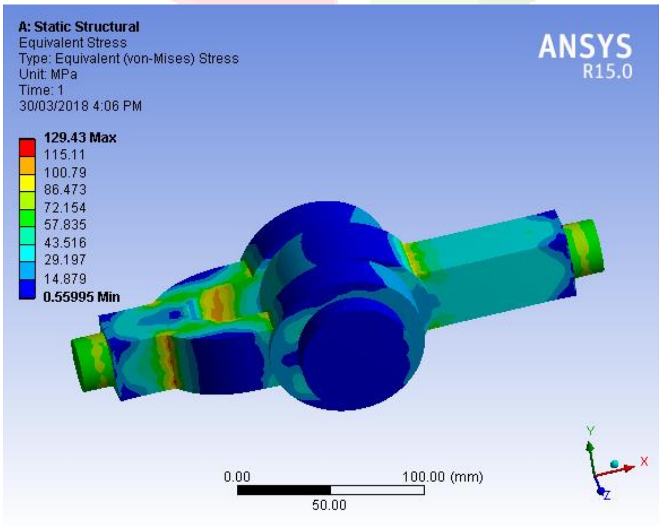

Fig. 4 Equivalent stress (SS)

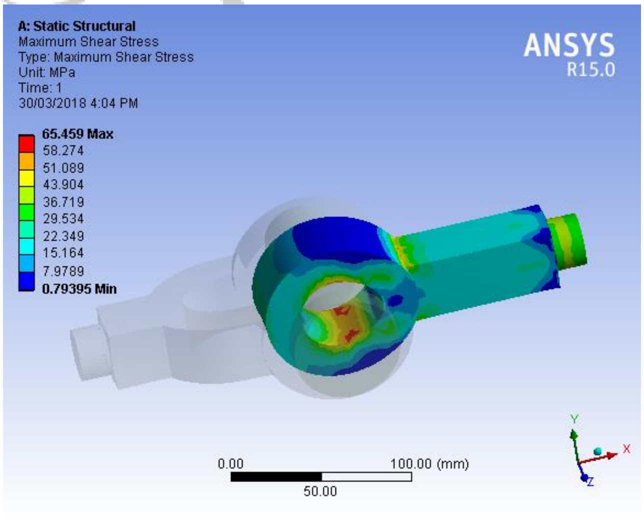

Fig.5 Max. Shear stress eye(SS)

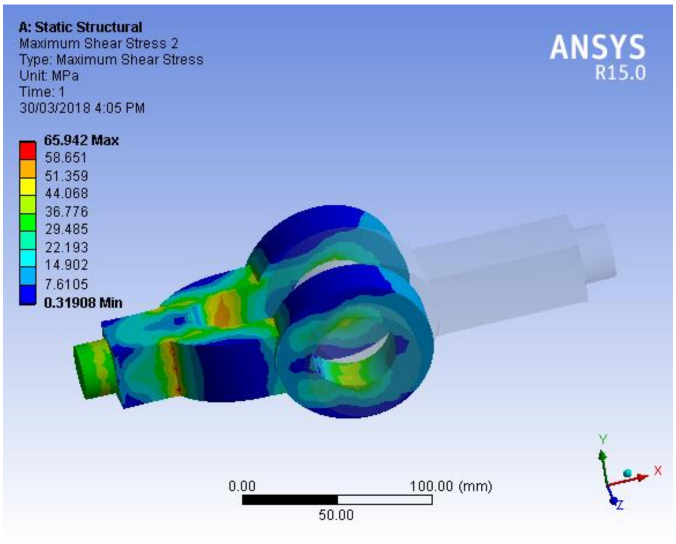

Fig.6Max. Shear stress in fork(SS)

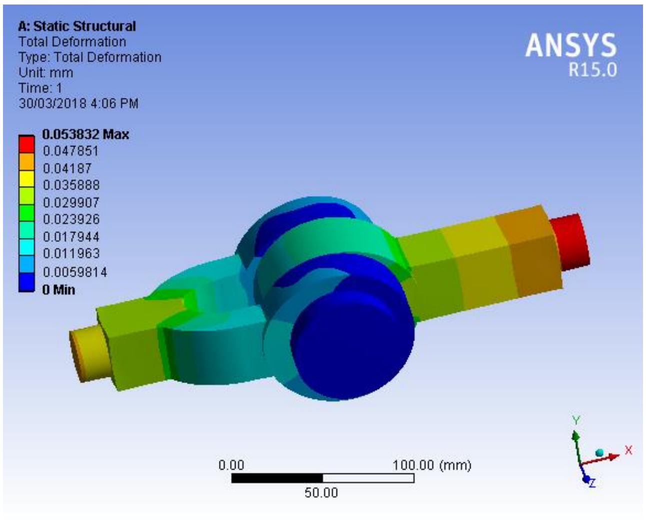

Fig.7 Total deformation(SS)

6.2 Cast Iron(CI)

Properties of grey cast iron are taken from Ansys library and material assignment is made keeping meshing & boundary conditions same.

It gives results for all parameters as given below.

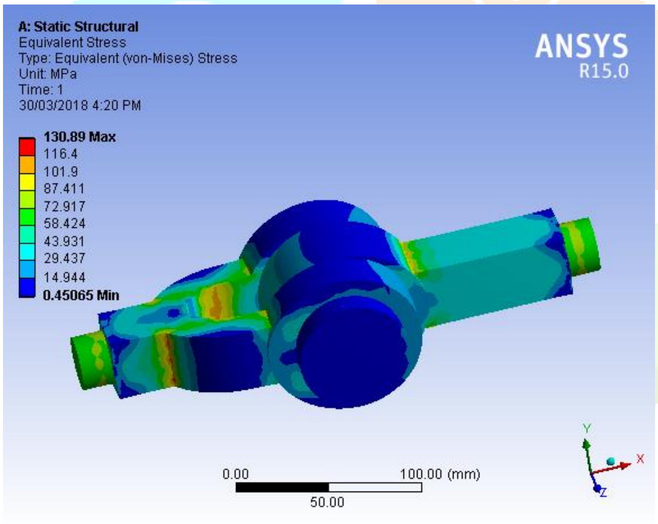

Fig. 8 Equivalent stress (CI)

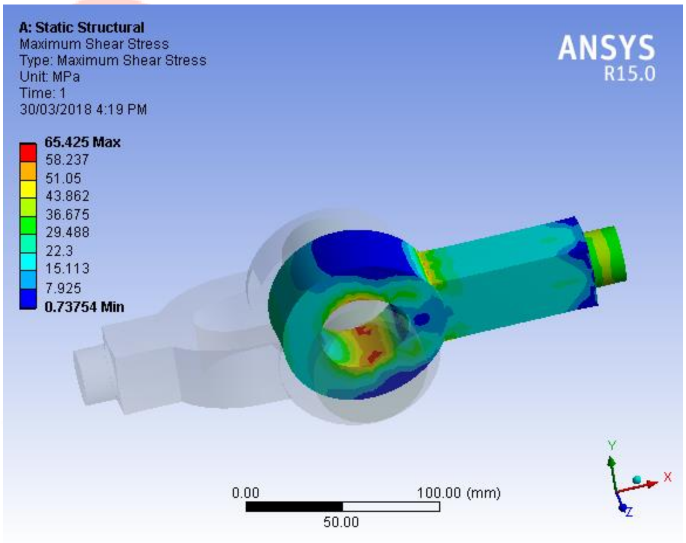

Fig.9 Max. Shear stress eye (CI)

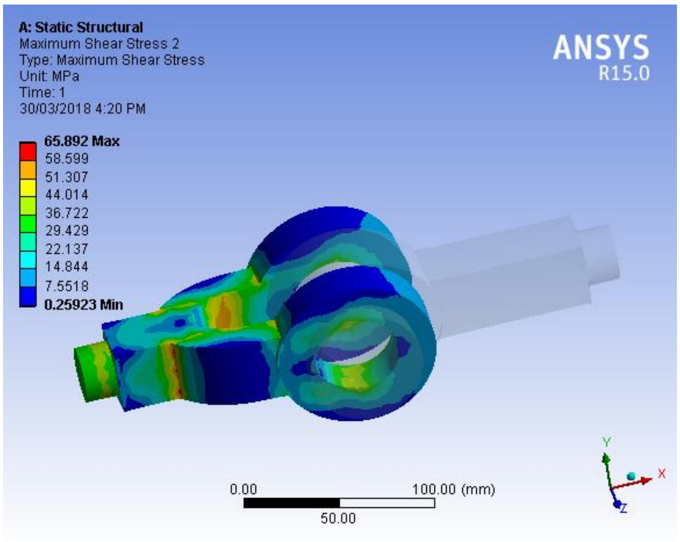

Fig.10Max. Shear stress in fork (CI)

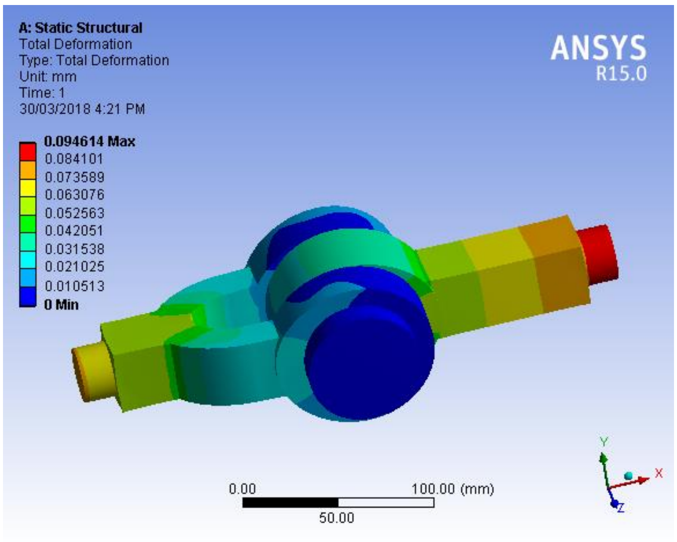

Fig.11 Total deformation (CI)

6.3 Low Carbon steel (30C8)

Properties of low carbon steel grade 30C8 are inputted in Ansys 15.0 library and material assignment is made keeping meshing & boundary conditions same.

It gives results for all parameters as given below.

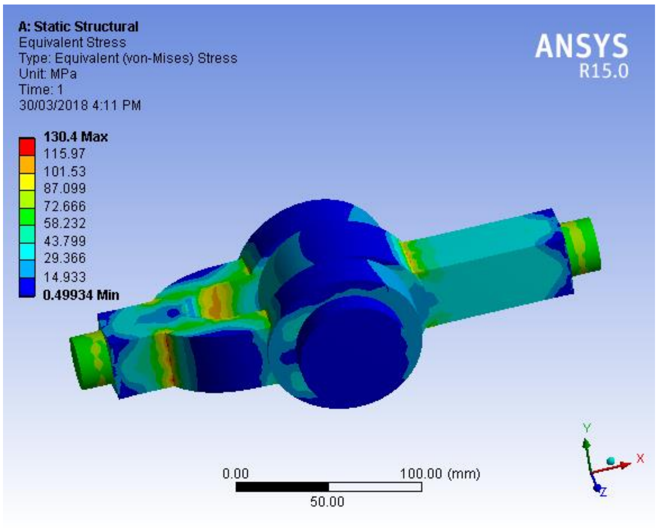

Fig. 12 Equivalent stress (30C8)

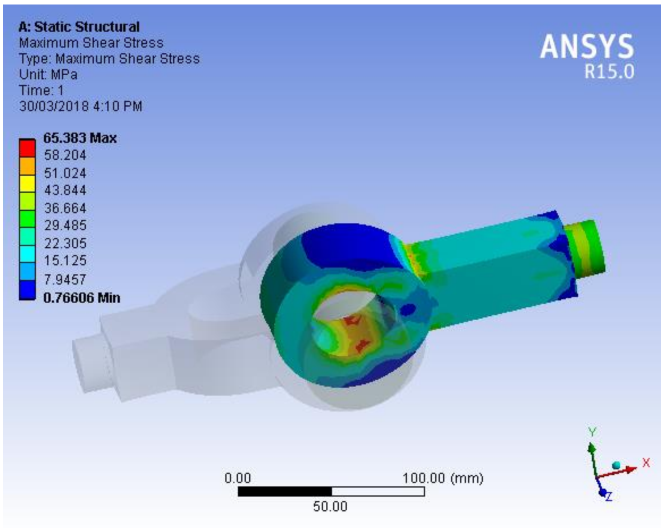

Fig.13 Max. Shear stress eye(30C8)

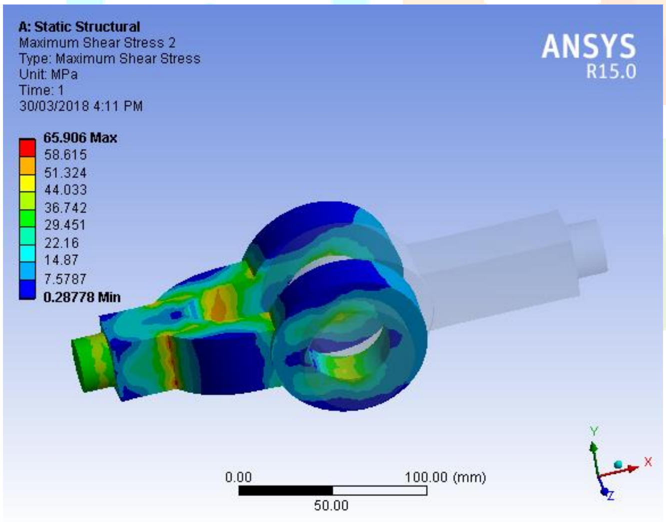

Fig.14Max. Shear stress in fork(30C8)

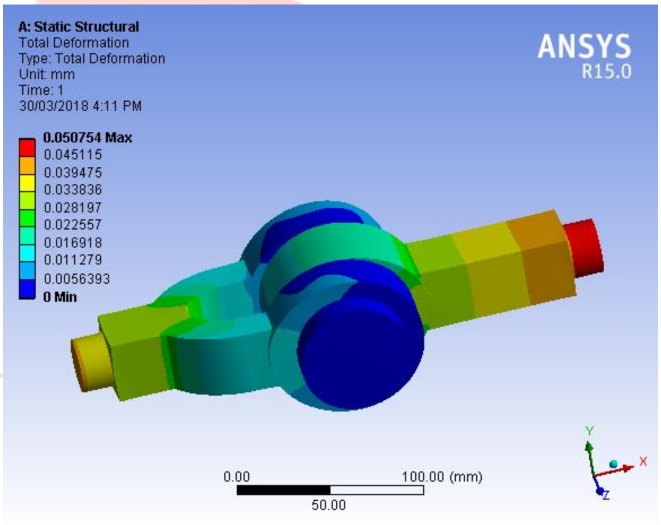

Fig.15 Total deformation(30C8)

6.4Tabulated results:

From above analysis obtained, results can be tabulated for comparative study as given below.

Material Assigned	Equivalent stress (MPa)	Max. shear stress(eye) (MPa)	Max. shear stress(fork) (MPa)	Total deformation (mm)
Stainless Steel(SS)	129.43	65.459	65.942	0.053832
Grey Cast Iron(CI)	130.89	65.425	65.892	0.09416
Low carbon steel(30C8)	130.4	65.383	65.906	0.050754

VII. CONCLUSION

From analysis, it is observed that Intensity of shear stress is more on inner side of both fork and eye. Total deformation is more at both ends i.e. eye end and fork end.

From tabulated results, it is observed that Equivalent stress (130.4MPa), Max. Shear stress in eye (65.383MPa) & total deformation(0.050754mm) obtained for low carbon steel(30C8) material.

As All these three values are lesser than that of other two materials i.e. grey Cast iron & stainless steel, it is concluded that there is less stress development & deformation in 30C8 material, hence it is best suited material for designing knuckle joint.

VIII. Acknowledgement

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IX. References:

[1]V.B. Bhandari, Design of machine Elements, Page No. 100-101, Macgraw Hill publications

[2]Suraj Yadav, Sanket Benade, Sushil Angchekar, Vaibhav Dhokle, Prof. Rakesh Kolhapure, Design And Analysis Of Knuckle Joint By Using FEA, IJCESR, Volume-4, Issue-6, 2017

[3] Sourav das, Vishwendra Pataria,Prashant Pandey, Analysis of knuckle joint of 30C8 for automobile application, IJERT, Vol.3,Issue 1, Jan. 2014

[4]Harishankar Vanka, Shaikh John Bhasha, Modeling & analysis of knuckle joint, IJMETMR, Vol. 2, November 2015, Issue 11

[5] Sangamesh B. Herakal, Ranganath Avadhani, Dr.S.Chakradhar Goud, Structural Static Analysis Of Knuckle Joint, International Journal of Engineering Research and General Science, Volume 4, Issue 2, March-April, 2016

[6] Nishant Vibhav Saxena ,Dr. Rohit Rajvaidya ,Study & Analysis of Knuckle Joint with the Replacement of Material by Using Teflon, Int. Journal of Engineering Research and Applications, Vol. 5, Issue 3, (Part -4) March 2015

[7] Prof. Swati Datey, Amit Rangari, Adarsh Dongre, Kunal Parskar, Analysis Of Knuckle Joint in Mahindra 575 DL,IJERIIE, Vol. 3, Issue 2,2017