Enhancement of Structural Performance of Knuckle Joint with Composite Material using Ansys Structural

Mukesh Kumar[1], Ranjeet Kumar[2]
[1]*M.tech Student, Mechanical Engineering Department, VIST BHOPAL, MP, INDIA, 462021*
[2]*Assistant Professor, Mechanical Engineering department, VIST BHOPAL, MP, INDIA, 462021*

Abstract- **In this research article we have performed a comparative analysis of structural performance of knuckle joint by using different materials. The 3d modeling of knuckle joint was done using Catia V5. Thereafter we used this geometry for structural performance analysis using Ansys 14.0. the conventional material of knuckle joint i.e. grey cast iron(eye and fork) and structural steel (collar, collar pin and cylindrical pin) was replaced by carbon fibre and alumina (Saffil) for numerical analysis. The results show lower total deformation with carbon fibre and alumina Saffil with comparison to conventional material of knuckle joint. The stresses and strains were also found to be optimum which leads to increase of structural strength of knuckle joint.**

Index Terms- **knuckle joint, composite materials, structural analysis, Ansys.**

1. INTRODUCTION

There are so many of connecting joints available for connecting two mechanical rods, linkages, shafts. Knuckle joint is one of the important mechanical joining mechanism which is used to connect two rods when the stress concentration is so high such is a of tractor trailer and other automobile applications. 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 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.

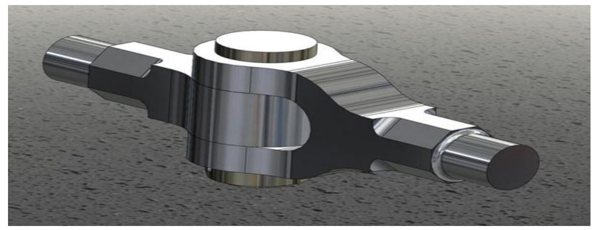

Fig.1.1) knuckle joint

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 [1].

2. GEOMETRY

The figure shown below is a 3d model of knuckle joint made with -

- Case1) Grey cast iron (eye and fork) and structural steel (collar, collar pin and cylindrical pin).
- Case2) Carbon Fibre (all parts)
- Case3) Alumina Saffil (all parts)

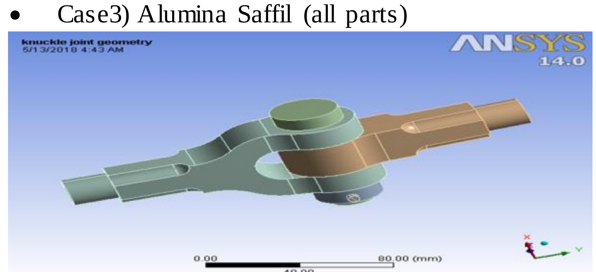

Fig.2.1) 3D Geometry of knuckle joint

3. MESHING

- Case1) Grey cast iron (eye and fork) and structural steel (collar, collar pin and cylindrical pin).
- Case2) Carbon fibre (all parts)
- Case3) Alumina Saffil (all parts)

The figure shown below shows the meshing of knuckle joint geometry made with

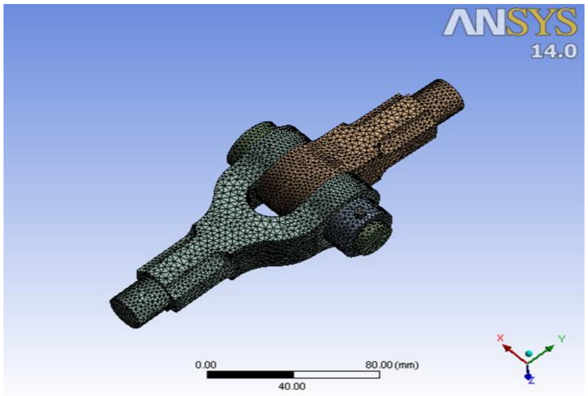

Fig.3.1) Meshing of knuckle joint made

4. SOLVER SETUP

The following figures show the setup for solution in the Ansys 14.0.

- Case1) Grey cast iron (eye and fork) and structural steel (collar, collar pin and cylindrical pin).
- Case2) Carbon fibre (all parts)
- Case3) Alumina Saffil (all parts)

The figure shown below shows the fixed support applied at fork end.

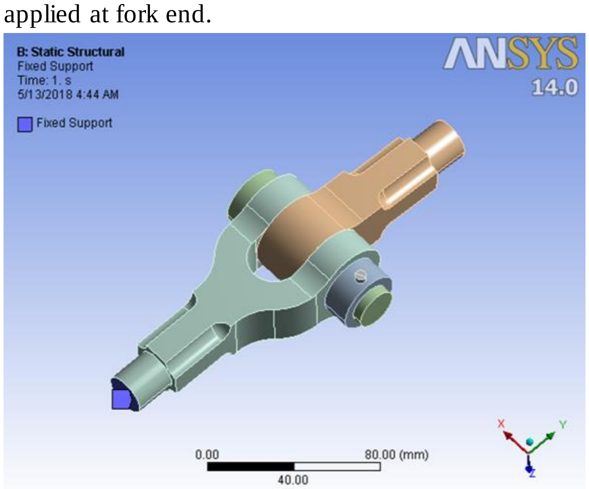

Fig.4.1) Fixed support at fork end

The figure shown below shows the application of 20000N tensile force at the eye end

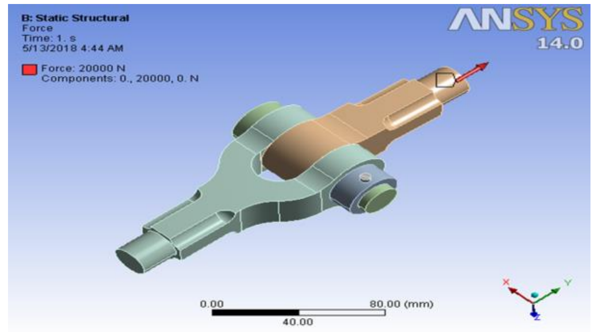

Fig.4.2) Tensile force at Eye end

Table 4.1) Details of Material Properties

properties material name	Density (g/cm^3)	Modulus of Elasticity (GPa)	Poisson ratio	Tensile Strength(MPa)
Grey Cast Iron	7.2	110	0.28	250
Structural Steel	7.85	200	0.3	460
Carbon Fibre	1.8	230	0.3	4900
Alumina (Saffil)	3.3	300	0.2	1500

Table 4.2) details of loads and supports

Object Name	*Fixed Support*	*Force*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	1 Face	
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Components
Coordinate System		Global Coordinate System
X Component		0. N (ramped)
Y Component		20000 N (ramped)
Z Component		0. N (ramped)

5. RESULTS

The figures shown below are the contour graph of results of analysis for equivalent stress (Von -Mises) and total deformation

- Case1) Grey cast iron (eye and fork) and structural steel (collar, collar pin and cylindrical pin).

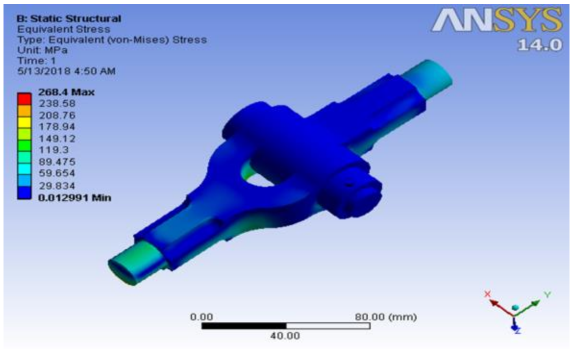

Fig.5.1) Equivalent stress for grey cast iron and structural steel

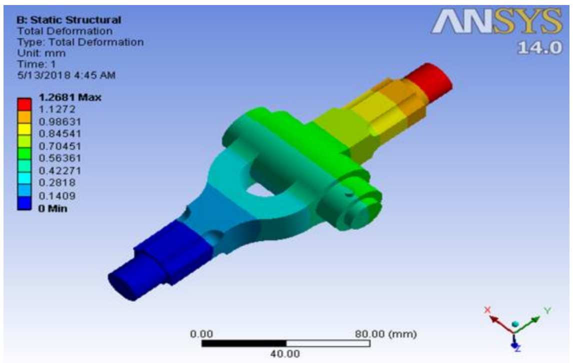

Fig.5.2) Total Deformation for grey cast iron and structural steel

• Case2) Carbon fibre (all parts)

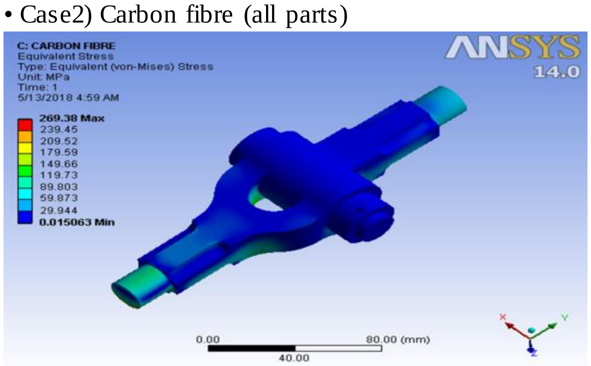

Fig.5.3) Equivalent stress for Carbon fibre

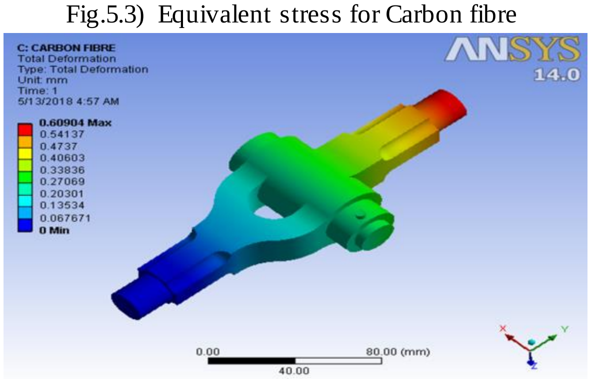

Fig.5.4) Total Deformation for Carbon fibre

• Case3) Alumina Saffil (all parts)

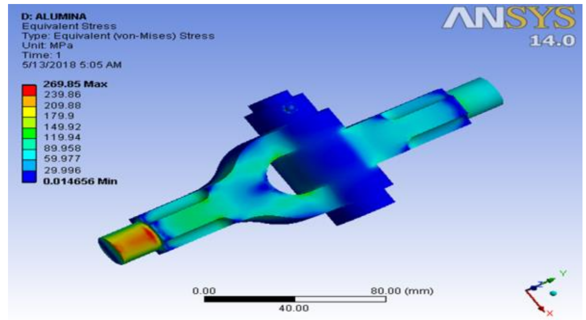

Fig.5.5) Equivalent stress for Alumina (Saffil)

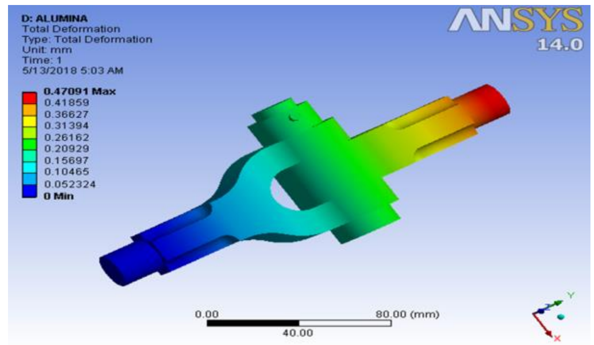

Fig.5.6) Total Deformation for Alumina (Saffil)

Table 5.1) solution results of all the materials for equivalent stress von mises and total deformation

Name of material solution	Grey cast iron(fork and eye) and structural steel(collar, collar pin, cylindrical pin)	Carbon fibre (all parts)	Alumina (Saffil) (all parts)
Equivalent stress (MPa)	268.4	269.38	269.85
Total deformation(mm)	1.2681	0.60904	0.47091

6. CONCLUSION

In this research article we have modeled a 3d geometry of knuckle joint in Catia V5 and performed structural analysis on Ansys 14.0. we found out by solution of the analysis that composite materials such as carbon fibre and alumina(Saffil) are suitable for manufacturing of knuckle joint since we got less total deformation for carbon fibre and alumina (Saffil) when compared with the conventional material of knuckle joint i.e. grey cast iron (eye and fork) and structural steel (collar , collar pin and) . The values of stresses and strains were found to be optimum as well. These all contributed to increase the structural performance of Knuckle Joint.

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