RESEARCH ARTICLE OPEN ACCESS

Study & Analysis of Knuckle Joint with the Replacement of Material by Using Teflon

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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 modified system has become popular in industry as well as in research. As a result, this there are reduction in accident and safety has increased. Many systems used in industries use knuckle joint which is combination of two materials: cast iron and stainless steel. Here we are proposing the modification of one of the material that is changing cast iron into a composite polymer material. The proposed system has many advantages over other system such as making the device, simpler and having maximum safety and is ecofriendly.

The analysis of the system proves all the above features mention above. The reason for considering polymer is that property of polymer is mostly similar to the property of metal. Composite polymers are characterized by a high flexibility material. The revolutionary evolution in technologies in last year allowed reducing stress and strain.

In the present work ANSYS 13 has been used for analysis of knuckle joint with modified material and varying loads.

Keyword- Knuckle joint, FEM, ANYSIS-13, Composite material

I. INTRODUCTION

A knuckle joint is used to connect two rods which are under the action of tensile loads whereas, if the joint is guided, compressive load may be supported by rods. A knuckle joint can be easily disconnected when required. Its uses are link of a cycle chain, tie road joint for roof truss, valve rod joint with eccentric rod, pump rod joint, tension link in bridge structure and lever and rod connection of various types [7].

In knuckle join, one end of one of the rods is made into an eye and the end of the other rod is formed into a fork with an eye in each of the fork leg. The knuckle pin passes through both the eye hole and the fork holes and may be secured by means of a collar and taper pin or spilt pin. The knuckle pin may be prevented from rotating in the fork by means of a small stop, pin, peg, or snug. In order to get a better quality of joint, the sides of the fork and eye are machined, the hole is accurately drilled and pin turned. The material used for the joint may be steel or wrought iron [10].

Knuckle joints may be cast or fabricated or forged. In the knuckle joint illustrated, the rods are integral with the eye and fork. In fig 1

A knuckle joint is a pin joint used to fasten two circular rods. [3] In this joint, one end of the rod is formed into an eye and the other into a fork. For making the joint, the eye end of the rod is aligned into the fork end of the other and held in position by means of a collar and a taper pin. Once the joint is made, the rods are free to swivel about the cylindrical pin. Knuckle joints are used in suspension links, air brake arrangement of locomotives, etc.

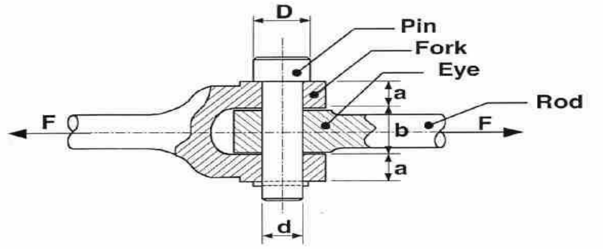

Fig 1: Knuckle joint

Knuckle joints are made up of cast iron and stainless steel. With the advancements in the field of polymers, Teflon can be used for knuckle joints also. The results obtained from simulation proves that for same loads, total deformation, stress and strain are much less in comparison to cast iron.

II. GEOMETRIC MODELING AND BOUNDARY CONDITIONS

The numerical flow simulation needs input of 2D or 3D geometry of domain under consideration. The domain is divided into small elements called mesh. Numerical methods are used for discretisation of governing equations over an element.

A. *Geometry*

The geometry of knuckle joint is modeled in CATIA V-5.

The 3D view of complete domain is shown in figure 2.

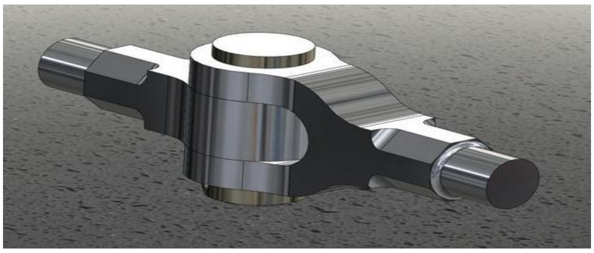

Fig 2: 3D View of knuckle joint

B. *Mesh Generation*

After completing the draw the wheel model is then import in the ANYSY 13 software. Meshing is done in ANSYS. The tetrahedral elements have been used for 3D domain. The meshing of domains has been shown in fig.3.

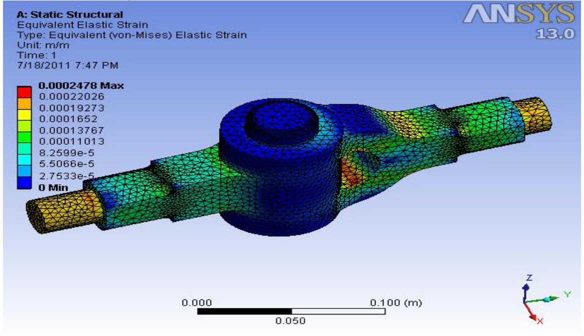

Fig 3: Mesh for knuckle joint

C. *Common Input Data*

The material properties and some common input data used for stainless steel are mentioned in Table 1. Properties used for cast iron [10] are mentioned in Table 2 and for Teflon [20] in Table 3.

TABLE 1: MATERIAL INPUT DATA FOR STAINLESS STEEL

Mechanical property	**Value**	**Unit**
Density	7850	Kg/m^3
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 2: MATERIAL INPUT DATA FOR CAST IRON

Mechanical property	**Value**	**Unit**
Density	7200	Kg/m^3
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 3: MATERIAL INPUT DATA FOR TEFLON

Mechanical property	**Value**	**Unit**
Density		
Tensile Yield Strength		
Compressive Yield Strength	1.5e+007	
Tensile Ultimate Strength	2.07e+007	
Young's Modulus	5.e+008	
Poisson's Ratio	0.46	
Bulk Modulus	2.0833e+009	
Shear Modulus	1.7123e+008	

For stainless steel and cast iron four loads are applied. Materials used for various parts are:
For eye and fork - Cast Iron.
For Taper pin, Collar and small pin - Stainless Steel.

D. *Boundary Conditions*

Four varying load has been specified at eye and fork shafts. Taper pin, Collar and small pin are fix.

III. RESULTS AND DISCUSSIONS

The simulation has been carried out for four different loads and two different materials. The simulation has provided with values of total deformation, equivalent stress and equivalent elastic strain.

A. *Stainless steel and cast iron*

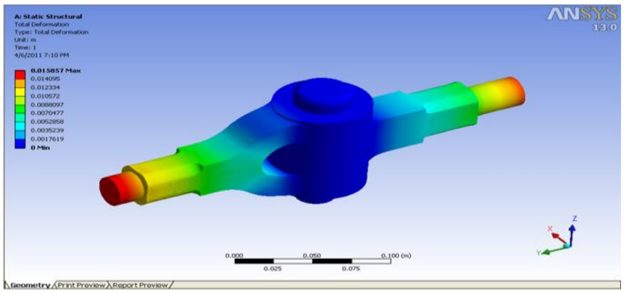

Fig.4 Analysis of Total Deformation Using Cast Iron with 100-N Load

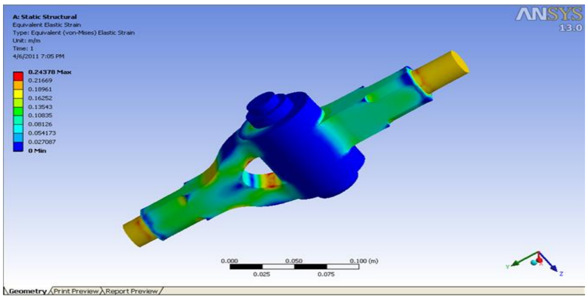

Fig.5 Analysis of Equivalent Elastic Strain Using Cast Iron with 100-N Load

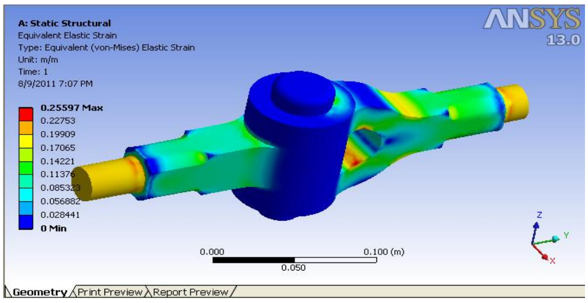

Fig.6: Analysis of Equivalent Stress Using Cast Iron with 100-N Load

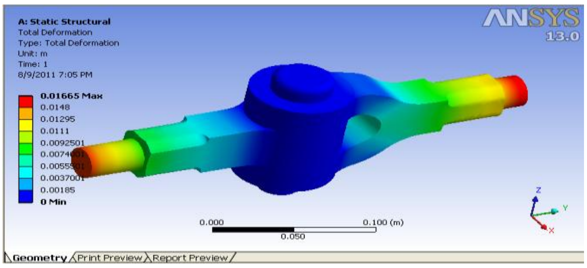

Fig.7: Analysis of Total Deformation Using Cast Iron With 105-N Load

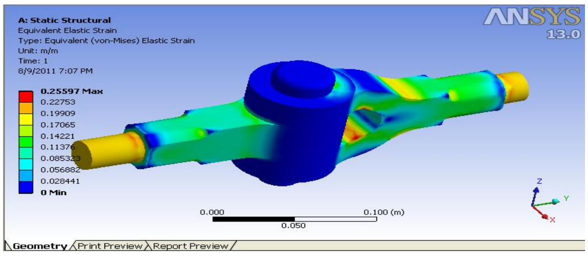

Fig.8: Analysis of Equivalent Stress Using Cast Iron With105-N Load

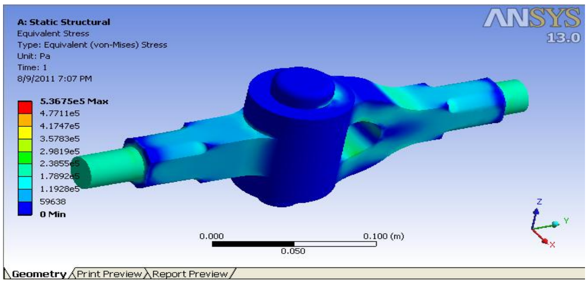

Fig.9: Analysis of Equivalent Elastic Strain Using Cast Iron With105-N Load

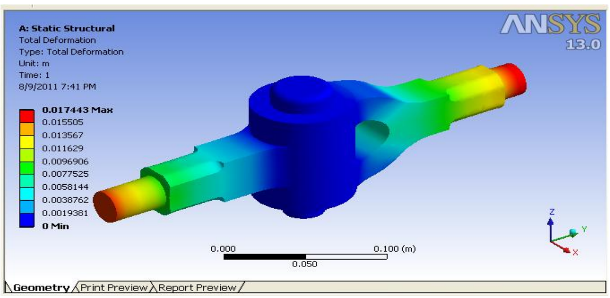

Fig.10: Analysis of Total Deformation Using Cast Iron With110-N Load

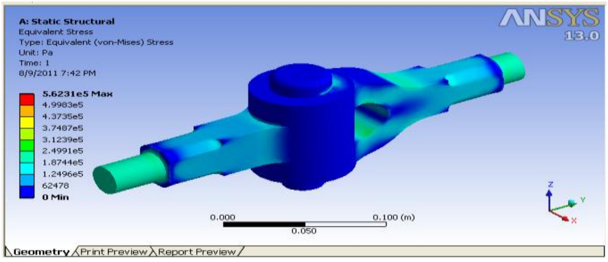

Fig.11: Analysis of Equivalent Stress Using Cast Iron With110-N Load

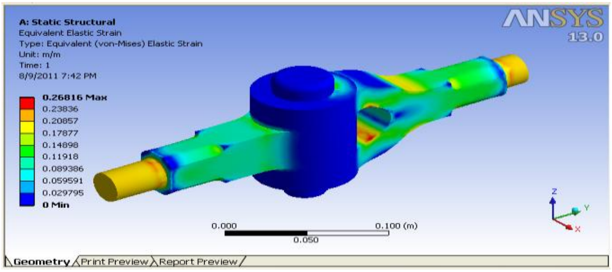

Fig.12: Analysis of Equivalent Elastic Strain Using Cast Iron With110-N Load

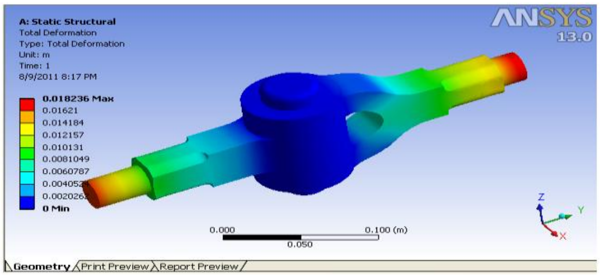

Fig.13: Analysis of Total Deformation Using Cast Iron With115-N Load

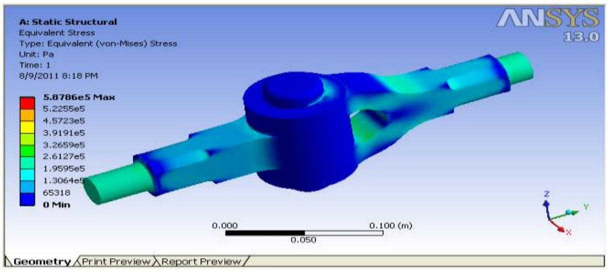

Fig.14: Analysis of Equivalent Stress Using Cast Iron With115-N Load

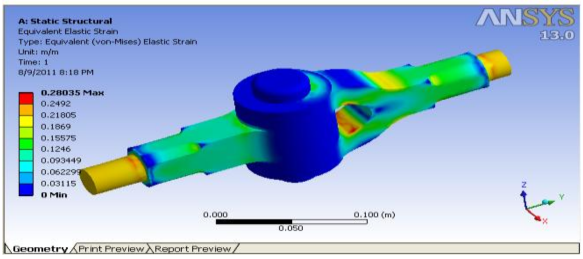

Fig.15: Analysis of Equivalent Elastic Strain Using Cast Iron With115-N Load

B. *Stainless steel and Teflon*

Under same Maximum Tensile force on knuckle joint, cast iron was replaced with Teflon. After defining the mechanical property of Teflon material on knuckle joint, if joint does not deform, then we can easily replace cast iron shaft with Teflon shaft

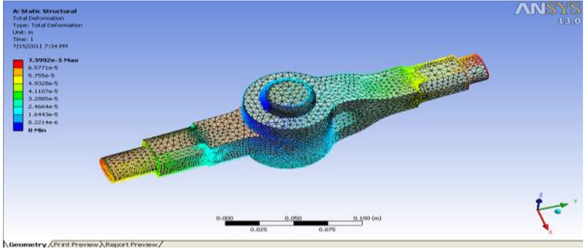

Fig.16: Analysis of Total Deformation Using TEFLON With100-N Load

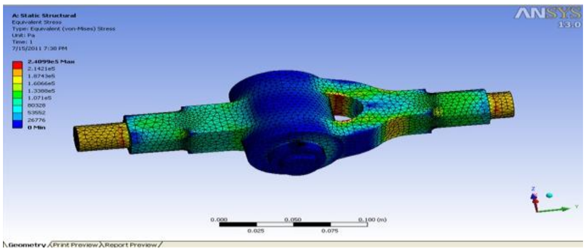

Fig.17: Analysis of Equivalent Stress Using TEFLON With100-N Load

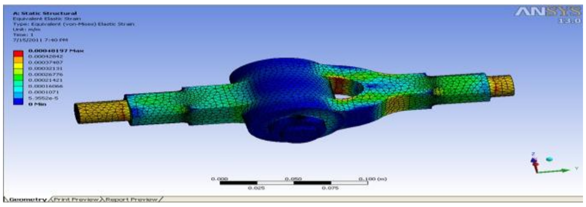

Fig.18: Analysis of Equivalent Elastic Strain Using TEFLON With100-N Load

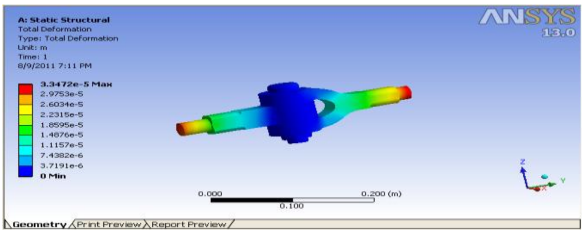

Fig.19: Analysis of Total Deformation Using TEFLON With105-N Load

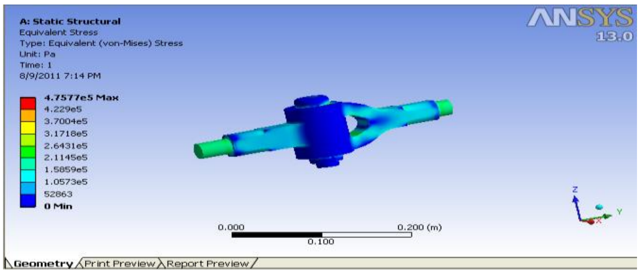

Fig.20:Analysis of Equivalent Stress Using TEFLON With105-N Load

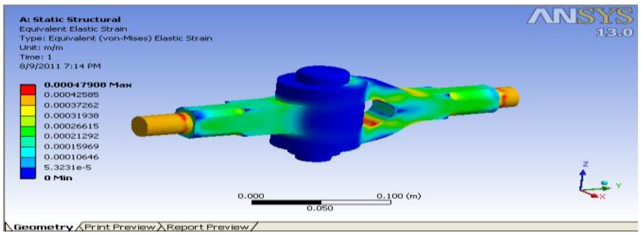

Fig.21 Analysis of Equivalent Elastic Strain Using TEFLON With105-N Load

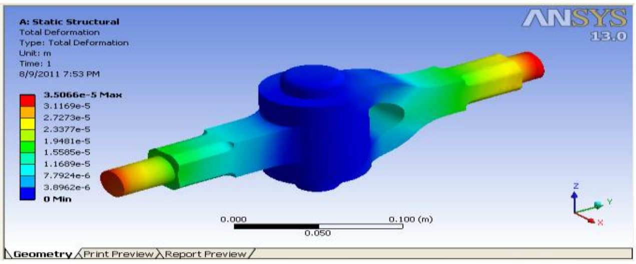

Fig.22 Analysis of Total Deformation Using TEFLON With 110-N Load

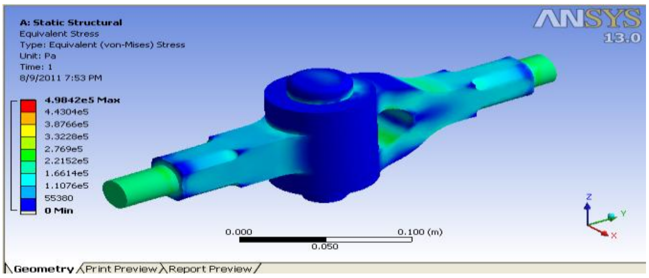

Fig.23 Analysis Result of Equivalent Stress Using TEFLON With 110-N Load

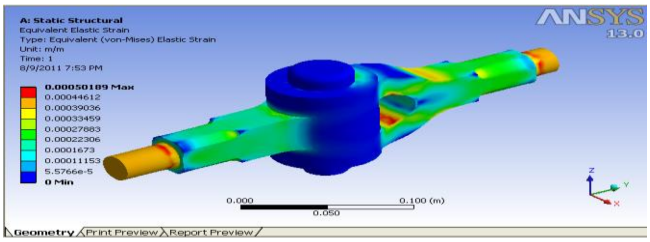

Fig.24 Analysis of Equivalent Elastic Strain Using TEFLON With 110-N Load

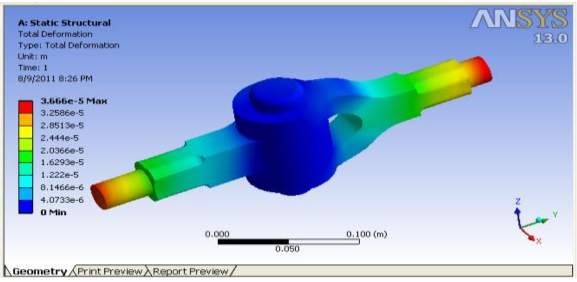

Fig.25: Analysis of Total Deformation Using TEFLON With115-N Load

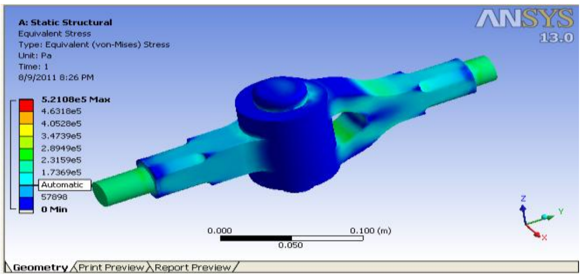

Fig.26 Analysis of Equivalent Stress Using TEFLON With115-N Load

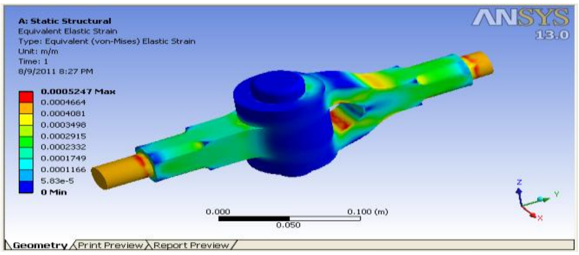

Fig.27: Analysis of Equivalent Elastic Strain Using TEFLON With115-N Load

TABLE 4
COMPARISON OF RESULTS

Results For CAST IRON				
S.No	Load(N)	Total Deformation (m)	Equivalent Stress (Pa)	Equivalent Elastic Strain
1	100 N	1.586e-002	5.1119e+005	0.24378
2	105 N	1.665e-002	5.3675e+005	0.25597
3	110 N	1.744e-002	5.6231e+005	0.26816
4	115 N	1.824e-002	5.8786e+005	0.28035

Results For TEFLON				
S.No	Load (N)	Total Deformation (m)	Equivalent Stress (Pa)	Equivalent Elastic Strain
1	100 N	3.0519e-005	1.613e+005	4.8148e-04
2	105 N	3.3472e-005	4.7577e+005	4.7908e-04
3	110 N	3.5066e-005	4.9842e+005	5.0189e-04
4	115 N	3.666e-005	5.2108e+005	5.247e-04

IV. CONCLUSIONS

Parts made out of composite materials are economical to produce, and facilitate overall systems cost reductions by eliminating secondary operations for parts, such as machining, as well as facilitating reduction in part count when compared with metal parts.

NOMENCLATURE

FEA:	Finite element analysis
FEP:	Fluorinated ethylene propylene
FEM:	Finite element method
J kg:	Joule kilo gram
Kg:	Kilo gram
M:	Meter
N:	Newton
Pa:	Pascal
PFOA:	Per fluorooctanoate
PTFE:	PolyTetraFluoroEthylene

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