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Design and Analysis of Universal Coupling Joint

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Abstract:
The power produced from an engine of automobile can be transferred to the drive wheel by power transmission system. To transmit the driving torque from the engine or gear unit to the final drive by the propeller shaft, we need at least one or two universal joints. Some common reasons for the failures may be manufacturing and design faults, maintenance faults, raw material faults, material processing faults as well as the user originated faults. In this study, fracture analysis of a universal joint yoke and a drive shaft of an automobile power transmission system are carried out. Spectroscopic analyses, metallographic analyses and hardness measurements are carried out for each part. For the determination of stress conditions at the failed section, stress analysis is also carried out by the finite element method. The common failure types in automobiles and revealed that the failures in the transmission system elements cover 1/4 of all the automobile failures. The failure is analyzed in the ANASYS with FEM.

I. INTRODUCTION

A **coupling** is a device used to connect two shafts together at their ends for the purpose of transmitting power. Couplings do not normally allow disconnection of shafts during operation, however there are torque limiting couplings which can slip or disconnect when some torque limit is exceeded. The primary purpose of couplings is to join two pieces of rotating equipment while permitting some degree of misalignment or end movement or both. By careful selection, installation and maintenance of couplings, substantial savings can be made in reduced maintenance costs and downtime.

Types of couplings

1. Rigid couplings
2. Flexible Couplings

In the rigid couplings there is no chance for the transmission of power in misalignments.

In flexible couplings, is also possible for transfer of power in some angles from driving shaft to drive shaft e.g upto 18 degrees.

II. TYPES OF FLEXIBLE COUPLINGS

UNIVERSAL JOINTS

A universal joint also known as universal coupling, U-joint, Cardon joint, Hardy-Spicer joint, or Hooke's joint is a joint or coupling used to connect rotating shafts that are coplanar, but not coinciding. A universal joint is a positive, mechanical connection used to transmit motion, power or both. Each universal joint assembly consists of three major components: two yokes (flange and weld) and a cross trunnion. An automotive flange yoke has a machined flat face which may be affixed through a bolted connection to the rear differential of a vehicle. A weld yoke incorporates a machined step, and is inserted into the end of the driveshaft and welded in place. The cross trunnion is used to deliver rotation from one yoke to another using four needle pin bearings.

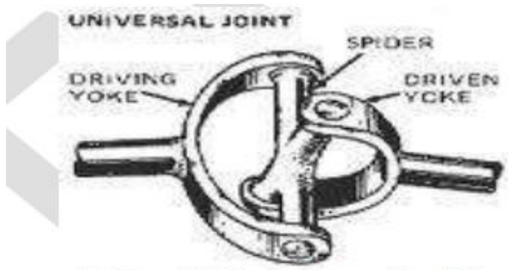


Figure 1 Universal coupling [1]

Oldham Coupling

Oldham couplings consist of three members. A floating member is trapped by 90 displaced grooves between the two outer members which connect to the drive shafts as shown in *Figure6*. Oldham couplings can accommodate lateral shaft misalignments up to 10% of nominal shaft diameters and up to 3 angular misalignments. Lubrication is a problem but can in most applications be overcome by choosing a coupling that uses a wear resistant plastic or an elastomeric in place of steel or bronze floating members.

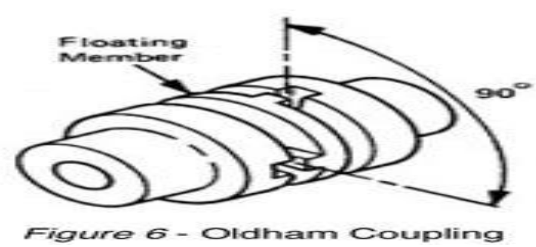


Figure.2. Oldham coupling

III. OBJECTIVES

The main aim of this project is to determine the Von-Misses stresses, element displacement, and optimization in the existing steering yoke. If the existing design shows the failure, then suggest the minimum design changes in the existing steering yoke. In this project, only the static FEA of the steering yoke and the steering shaft has been performed by the use of software. Afterword's Determine design alternatives and analyze for iterations. Then the combination of finite element technique with aspect of weight reduction is to beamed and finally Comparison of analytical results of any one variant with Experimental results for validation.

INTRODUCTION TO DESIGN SOFTWARES

Computer Aided Design (CAD):

Computer Aided Design (CAD) is the use of wide range of computer based tools that assist engineering, architects and other design professionals in their design activities. It is the main geometry authoring tool within the product life cycle management process and involves both software and sometimes special purpose hardware. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design models.

INTRODUCTION TO PRO/E:

PRO/E is the industry's de facto standard 3D mechanical design suit. It is the world's leading **CAD/CAM /CAE** software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. Much of its success can be attributed to its technology which spurs its customer's to more quickly and consistently innovate a new robust, parametric, feature based model.

MODAL IS DRAWN:

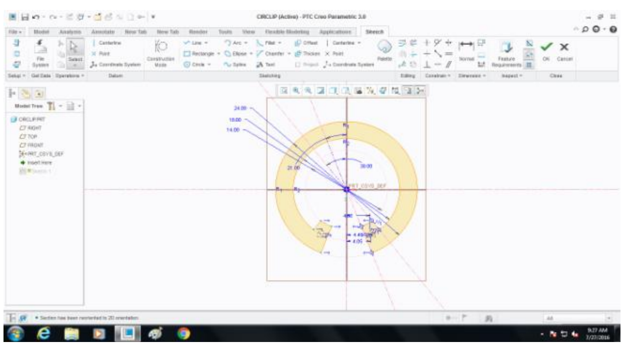


Figure.3. Sketch view

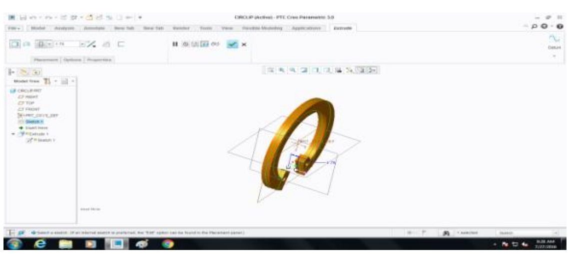


Figure.4. 3d View

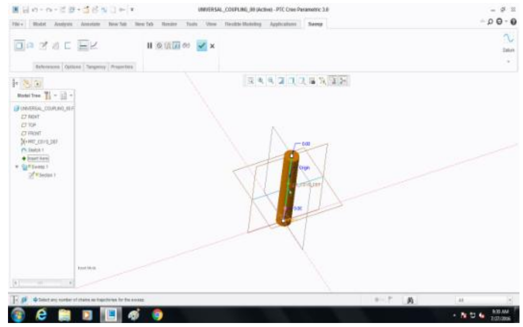


Figure.5. 1st Step of Pin joint

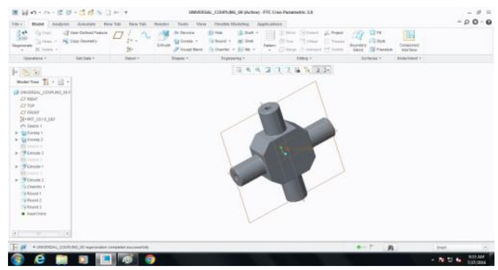


Figure.6. Final view of pin

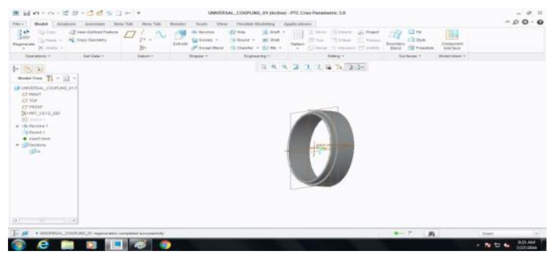


Figure.7. supporter ring

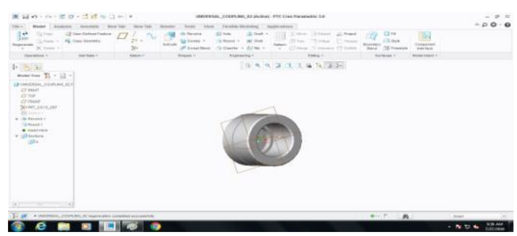


Figure.8. Bearing Cup

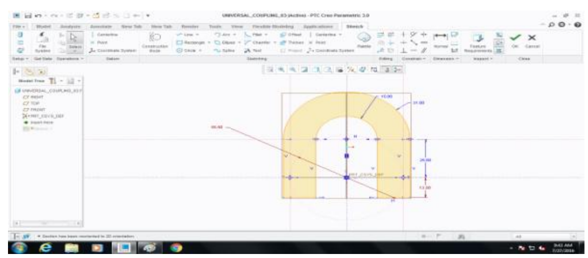


Figure.7. U shape coupling sketch

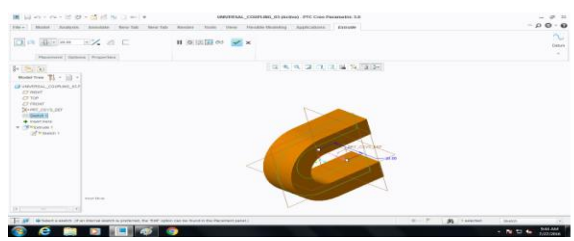


Figure.8. 3D view

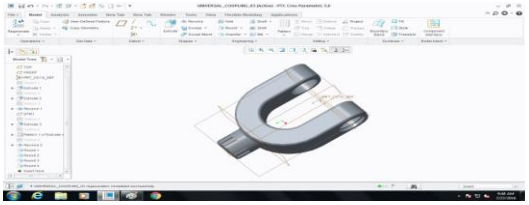


Figure.9. Final View

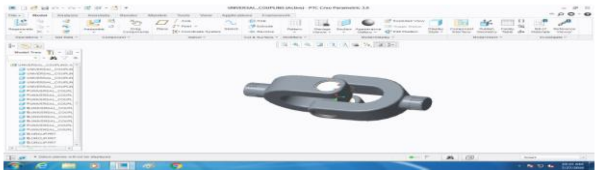


Figure.10. Assembly view of universal coupling

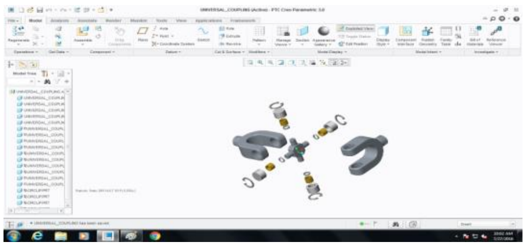


Figure.11. Explode view of final universal coupling

ANALYSIS

Introduction of FEA:

Finite Element Analysis (FEA) is a numerical method which provides solutions to problems that would otherwise be difficult to obtain. To predict the behavior of structure the designer adopts three tools such as analytical, Experimental and Numerical methods. The analytical method is used for the regular sections of known geometric entities or primitives where the component geometry is expressed mathematically. The solution obtained through analytical method is exact and takes less time. This method cannot be used for irregular sections and the shapes which required very complex mathematical equations.

Introduction of ANSYS:

ANSYS is general-purpose finite element analysis (FEA) software package. Nowadays, ANSYS package is playing an important role in all fields. The analysis capabilities of ANSYS include the ability to solve static and dynamic structural analysis, steady state and transient heat transfer problems, mode-frequency and buckling Eigen value problems and various types of field and coupled-field applications. In Workbench, the user can generate 3-dimensional and FEA models, perform analysis, and generate results of analysis and also it can be used to perform a variety of tasks ranging from Design Assessment to Finite Element Analysis to complete Product Optimization Analysis by using ANSYS Workbench.
The following is the list of analyses that can be performed by ANSYS Workbench:

1. Design Assessment
2. Fluid Flow (CFX)
3. Harmonic Response
4. Linear Buckling
5. Modal
6. Rigid Dynamics
7. Static Structural
8. Steady-State Thermal
9. Transient Structural
10. Transient Thermal

Procedural Steps Followed in ANSYS WORKBENCH:

Structural Analysis:

Importing the Model:

In this step the PRO/E model is imported into ANSYS workbench as follows:

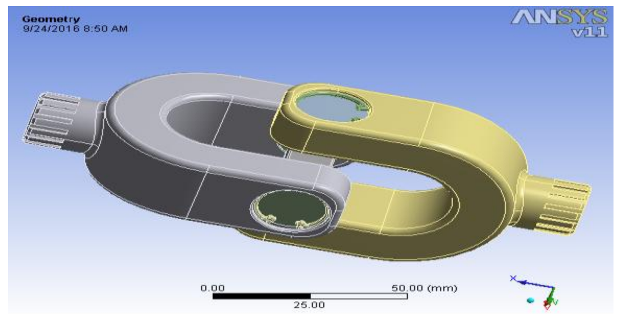


Figure.12. Imported model

Details of "Mesh"	
Defaults	
Physics Preference	Mechanical
Relevance	0
Advanced	
Relevance Center	Coarse
Element Size	Default
Shape Checking	Standard Mechanical
Solid Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Initial Size Seed	Active Assembly
Smoothing	Low
Transition	Fast
Statistics	
Nodes	213427
Elements	121442

Figure.13. Details of Mesh

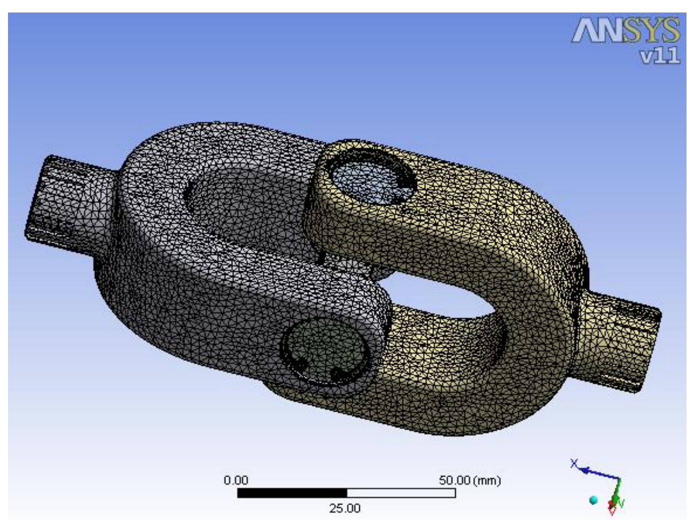


Figure.14. Meshing model

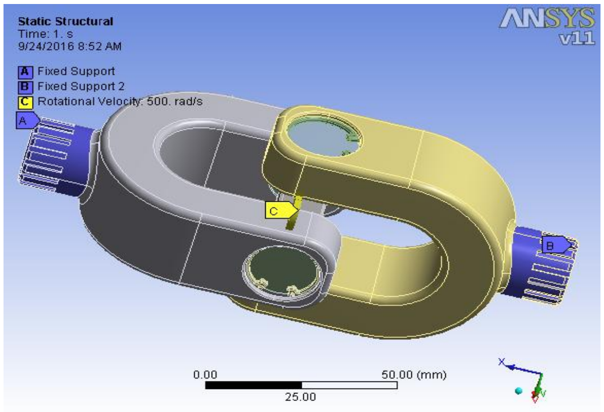


Figure.15. Fixed support& Rotational velocity

Structural Steel

Structural	Add/Remove Properties
Young's Modulus	2.e+005 MPa
Poisson's Ratio	0.3
Density	7.85e-006 kg/
Thermal Expansion	1.2e-005 1/°C
Alternating Stress	
Strain-Life Parameters	
Tensile Yield Strength	250. MPa
Compressive Yield Strength	250. MPa
Tensile Ultimate Strength	460. MPa
Compressive Ultimate Strength	0. MPa
Thermal	Add/Remove Properties
Thermal Conductivity	6.05e-002 W/mm·°C
Specific Heat	434. J/kg·°C
Electromagnetics	Add/Remove Properties
Relative Permeability	10000
Resistivity	1.7e-004 Ohm·mm

Figure.16. Structural steel details

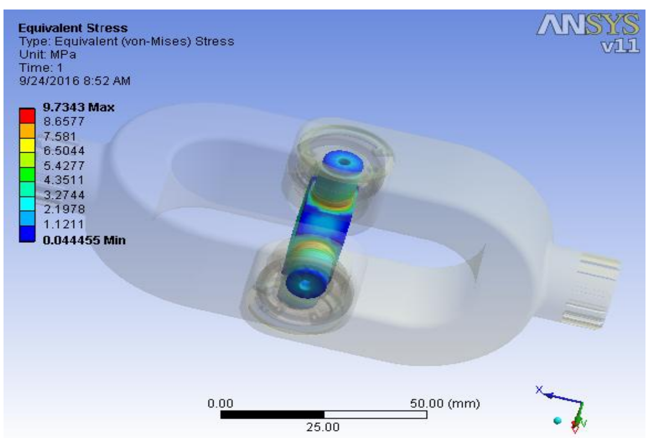


Figure.17. Stress

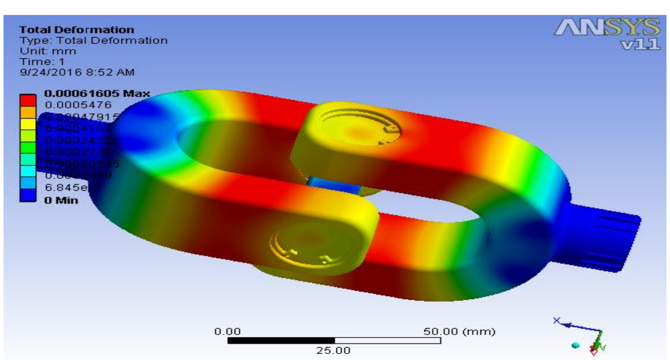
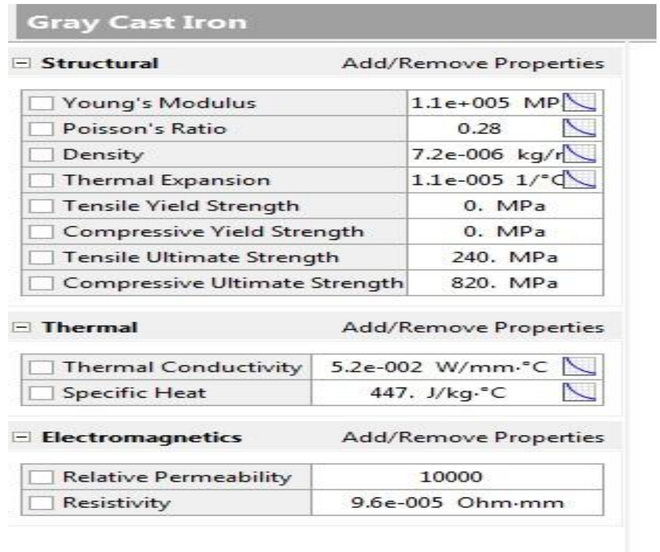


Figure.18. Total Deformation



Gray Cast Iron

Structural	Add/Remove Properties
Young's Modulus	1.1e+005 MP
Poisson's Ratio	0.28
Density	7.2e-006 kg/r
Thermal Expansion	1.1e-005 1/°C
Tensile Yield Strength	0. MPa
Compressive Yield Strength	0. MPa
Tensile Ultimate Strength	240. MPa
Compressive Ultimate Strength	820. MPa
Thermal	Add/Remove Properties
Thermal Conductivity	5.2e-002 W/mm·°C
Specific Heat	447. J/kg·°C
Electromagnetics	Add/Remove Properties
Relative Permeability	10000
Resistivity	9.6e-005 Ohm·mm

Figure.19. Gray Cast Iron details

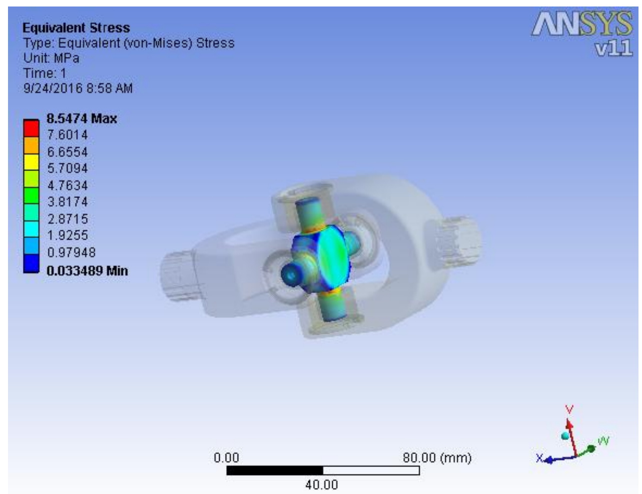


Figure.20. Stress

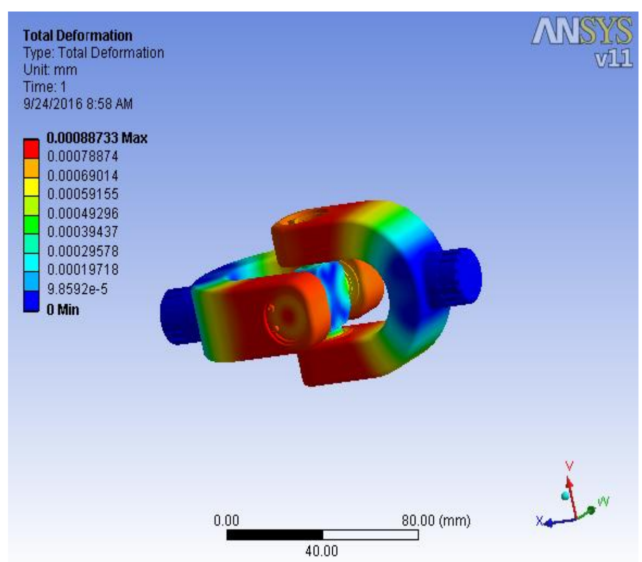


Figure.21. Total deformation

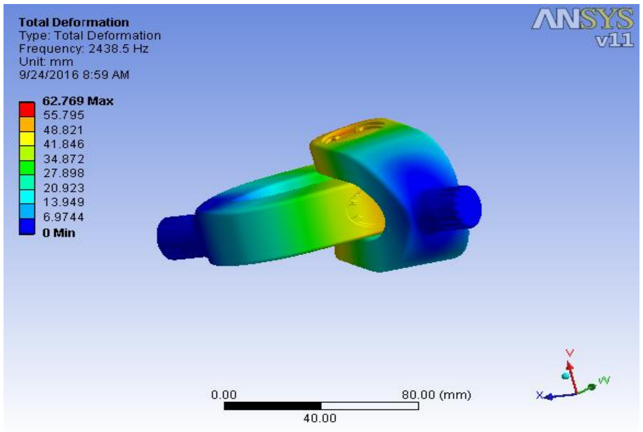


Figure.22. Model-1

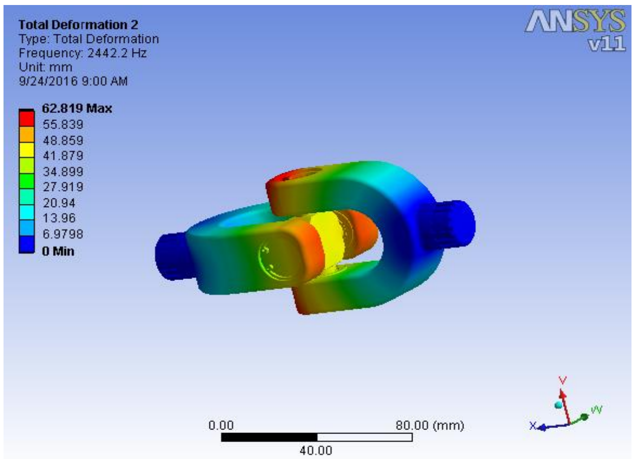


Figure.23. Model-2

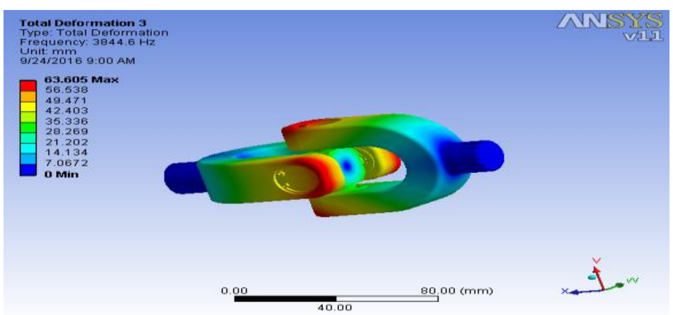


Figure.24. Model-3

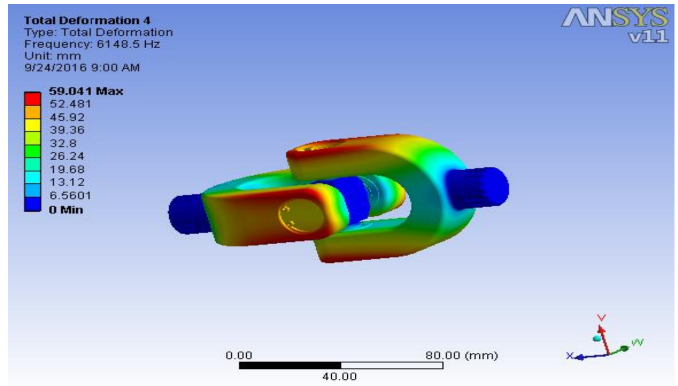


Figure.25. Model-4

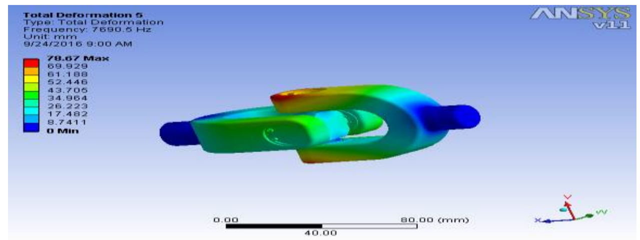


Figure.26. Model-5

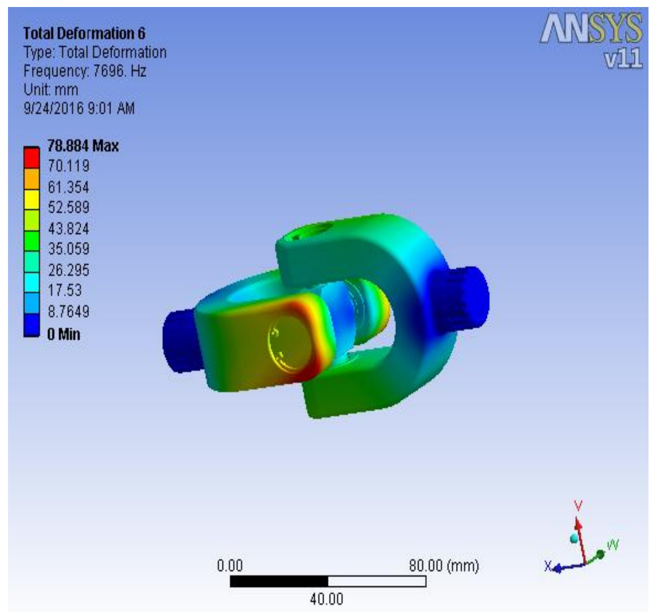


Figure.27.Model-6

Table.1. Stress vs. Total Deformation Table

Material	Equivalent stress (Mpa)		Total Deformation	
	Minimum	Maximum	Minimum	Maximum
Child Cast iron	*0.037395*	*8.6844*	*0*	*0.00083653*
Gray Cast Iron	*0.033489*	*8.5474*	*0*	*0.00088733*
Stainless Steel	*0.044455*	*9.7343*	*0*	*0.00061605*
Cast iron	*0.043256*	*8.6791*	*0*	*0.00098729*

Table.2. Total deformation Model Table

Material	Structural Steel	Gray Cast Iron	CSI	Cast Iron
Model-1	60.71	62.76	62.62	60.93
Model-2	60.76	62.81	62.67	60.99
Mode-3	62.02	63.60	63.47	62.08
Mode-4	56.89	59.04	58.52	57.05
Mode-5	76.20	78.67	78.41	77.30
Mode-6	76.41	78.88	78.62	77.54

IV. RESULTS AND CONCLUSION

RESULTS

The software results obtained from existing universal coupling with different materials like child cast iron, gray cast iron and stainless steel. By comparing these results the stress levels observed from above three materials, the equivalent stress value of gray cast iron is satisfactory by comparing with remaining three materials.The results from analysis can be replaced the universal coupling. The universal coupling is analyzed by the FEA with four materials like **stainless steel, cast iron, child cast iron** and **gray cast iron**. Analysis parameters of universal coupling are from the above table I concluded that, the material gray cast iron is preferable one, by comparing to child cast iron, stainless steel and cast iron. From static structural and modal analysis, the material **gray cast iron** is preferable one, because the material gray cast iron is got less deformation as 0.00088733 mm and stress 8.5474 MPa from static structural analysis.

V. CONCLUSION

Finite Element Analysis of the universal joint has been done using ANSYS Workbench. From the results obtained from FE Analysis, many discussions have been made. The results obtained are well in agreement with the available existing results. The model presented here, is well safe and under permissible limit of stresses.

1. On the basis of the current work, it is concluded that the design parameters of the universal coupling with modification give sufficient improvement in the existing results.

2. The weight of the universal coupling is also reduced by 9.64 %, thereby reducing the cost of the material.

3. The stress is found maximum near the sharp edges.

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