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Analysis and Development of a Universal Joint

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ABSTRACT

Universal joint is a type of joint which allows angular moments in any direction, and is commonly used in shafts that transmit rotary motion. It generally consists of two hinges located close together, oriented at 90° to each other, connected by a cross shaft. It is widely used in industrial applications and vehicle drivelines to connect misaligned shaft. Automobile industries are exploring composite material in order to obtained reduction of weight without significant decrease in vehicle quantity and reliability. This is due to the fact that the reduction of weight of vehicle directly proportional to the fuel consumption.

In this project, it is proposed to design and analyse the Universal joint for the selected load condition. The failure of Universal joint occurs when the induced stresses exceed the permissible limit of the material, so it is necessary that design and analyse of Universal joint to withstand the working condition without failure. The modelling and Static analysis of the Universal joint will be done using PRO-E Creo 4.0 software. The same analysis is replicated for Steel, Cast Iron and Carbon reinforced epoxy composite. Based on the FEM analysis the best material will be recommended for the Universal joint.

1. INTRODUCTION

A joint 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.

Universal Joint

A Universal joint is more commonly known as U-Joint. Besides, it can also be known as Universal coupling, Cardan joint, Hooke’s joint etc. It is a mechanical connection between the rotating shafts which are generally not in parallel but intersecting. It can allow positive transmission of rotating power at a much larger angle than is permissible with a flexible coupling. And it can transmit torque and motion.

Universal joints can be widely used in all types of power transmission systems. They have a variety of applications. They can be used in food processing equipment’s, replacement for expensive gear boxes, and drives, etc. Besides, they are also commonly applied in connecting power take off drive shafts in off highway tractors that operate drawn machinery such as rotary grass mowers and feed grinders. Cardan joint or Hooke’s joint is the oldest and most common type of U-joint. This is quite popular in automobile applications. It can transmit relatively high torque with minimal radial loads.

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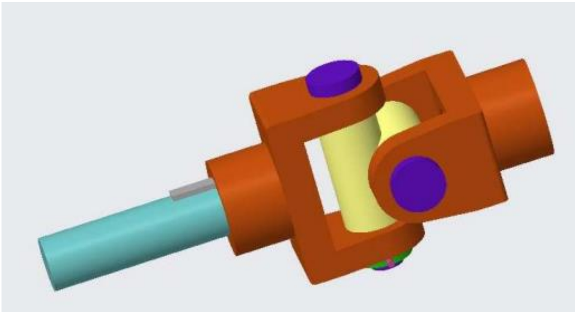
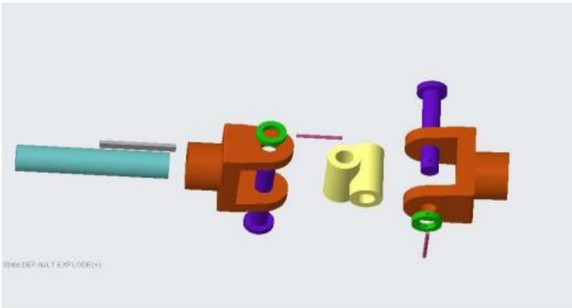
However, it also has some disadvantages. For example, by the design of these U-joints have difficulty compensating for parallel offset and axial misalignment. Besides, due to its design, even a lubricated Cardan u-joint will require periodic maintenance, and may leak lubricant.



Universal Coupling



Exploded view of Universal Coupling

2. LITERATURE REVIEW

Rahul Arora [2017], In this paper limited component investigation of the part is done to discover the stress and deformation of the last item. For demonstrating of the segment Solidworks CAD software is utilized. Pre- handling work like cross section and examination work is done in ANSYS CAE software. Utilizing FEA investigation, we can recognize the nature and qualities of stresses following up on the Yoke and evaluate the impact of the load/mass geometry/boundary limit conditions over the yoke.

Maram Venkata Sunil Reddy et.al [2016], had done an Investigation on 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.

Abhishek Mandal et.al [2016], the purpose of this paper is an investigation about the static and structural analysis of the universal joint using advanced computer aided engineering software and study the various stresses and strains developed in the joint.

Dhananjay S Kolekar et.al [2015], had done an investigation on the universal joint based on the design review could look into aspects dealing with the material properties and/or the geometry of the part/s. For this work no radical change is sought in design and the existing design shall be reviewed for feasible alternatives calling for minimal changes in the development or production further.

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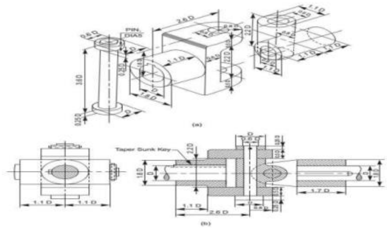
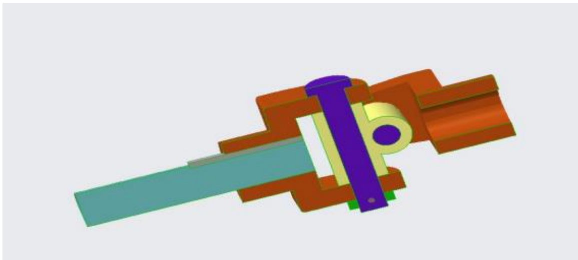
RITESH P. NEVE et.al [2015], the purpose of this paper is an Investigation Thus in this paper the aim is to replace universal joint by composite material. The following material can be chosen are carbon/epoxy composite, Kevlar/epoxy composite. Analysis and experimentation is being performed on universal joint yoke.
Avinash C Vasekar, Ranjitsinha R gidde [2015], In this study, failure analysis and weight optimization of a universal joint yoke of an automobile power transmission system are carried out.
Naik Shashank Giridhar et.al [2013], the main objective of this paper is to make certain modifications are made in the existing geometry and analysed for the identical loading and boundary conditions as in the reference paper from which the problem has been taken.

SOFTWARE USED
PRO-E
Modelling is done in Pro-e software
Entering Part Directly from Creo Parametric.
Select the NEW FILE icon from the ribbon at the top of the screen. Save as >File>New. When the New file window opens, select Part as the type, then enter a valid filename without the extension.
Pick OK.

Modelling of Universal joint



2-D,3-D Model of universal joint



Sectional view of Universal joint

Meshing
Create a mesh, by clicking on the refine model tab in the ribbon and select mesh and select the component that is going to be meshed, select the elements needed for the mesh and the size of the element, and click on the auto gem ion and it will take several minutes.

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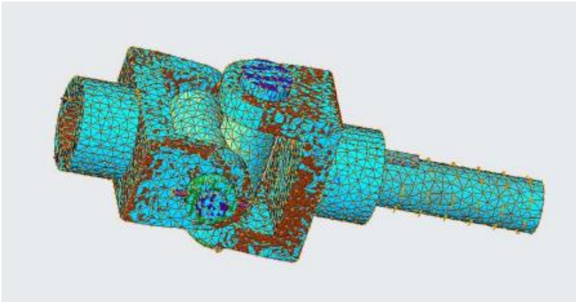
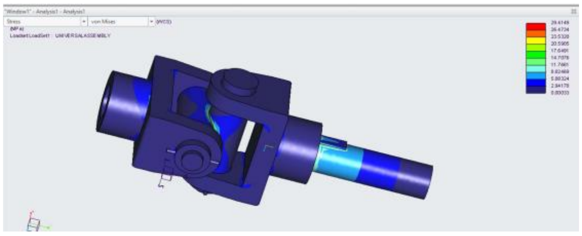


Meshing

3. RESULTS AND DISCUSSIONS

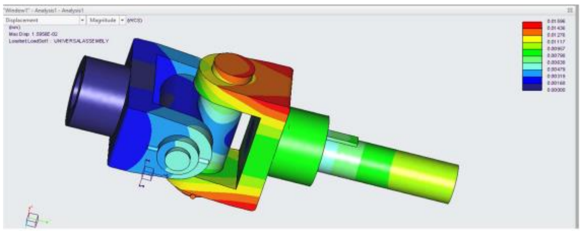
Solution of malleable cast iron
Von misses stress



Von misses stress of malleable cast iron

One side of the Universal joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum stresses developed in the key and the joint of the centre block i:e 29.4149 MPa, The minimum stress are developed in the fork and some parts of centre block i:e 0.00033 MPa.

Displacement



Displacement of malleable cast iron

One side of the Universal Joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum displacement developed in the Fork on the side of the force applied i:e 0.01596 mm. The minimum displacement developed in the fixed end side of the fork i:e 0.000 mm

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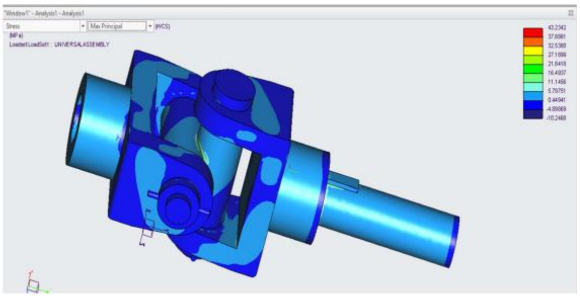
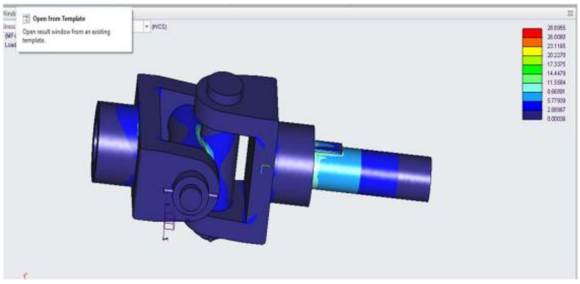
Principle stress



Principle stress of malleable cast iron

One side of the Universal Joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum stresses developed in the some parts of the Universal Joint i:e 43.2342 MPa. The minimum stresses developed in the some parts of the universal joint i:e -10.2468 MPa.

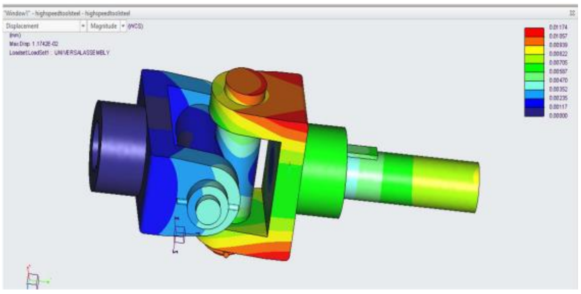
Solution of High speed tool steel
von misses stress



Von misses stress of High speed tool steel

One side of the Universal joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum stresses developed in the key and the joint of the centre block i:e 28.8955 MPa, The minimum stress are developed in the fork and some parts of centre block i:e 0.00036 MPa.

Displacement



Displacement of High speed tool steel

One side of the Universal Joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum displacement developed in the Fork on the side of the force applied i:e 0.01174 mm. The minimum displacement developed in the fixed end side of the fork i:e 0.000 mm.

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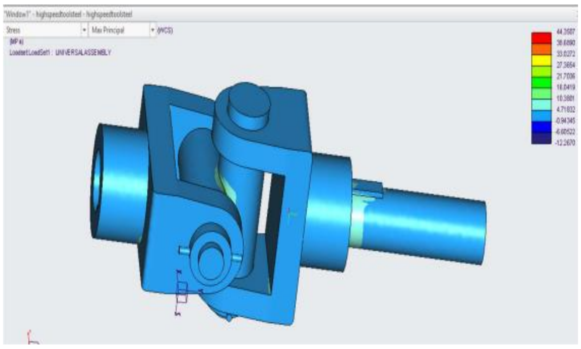
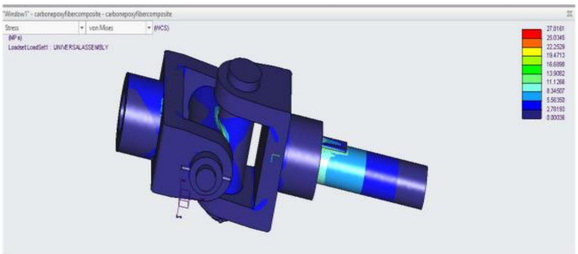
Principle stress



Principle stress of High speed tool steel

One side of the Universal Joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum stresses developed in the some parts of the Universal Joint i:e 44.3507 MPa. The minimum stresses developed in the some parts of the universal joint i:e -12.2670 MPa.

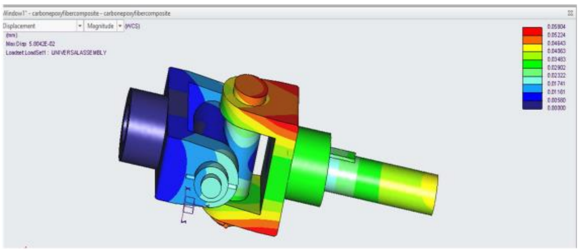
Solution for the epoxy carbon fibre composite
Von misses stress



Von misses stress of Carbon epoxy fibre composite

One side of the Universal joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum stresses developed in the key and the joint of the centre block i:e 27.8161 MPa, The minimum stress are developed in the fork and some parts of centre block i:e 0.00036 MPa.

Displacement



Displacement of Carbon epoxy fibre composite

One side of the Universal Joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum displacement developed in the Fork on the side of the

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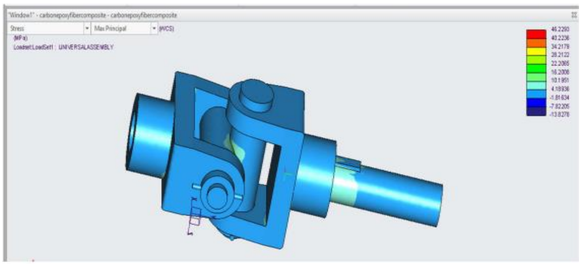
force applied i:e 0.05804 mm. The minimum displacement developed in the fixed end side of the fork i:e 0.000 mm.

Principle stress



Principle stress of Carbon epoxy fibre composite

One side of the Universal Joint is fixed and the Load is applied on the Shaft of the Universal joint i:e 100KN-m and the maximum stresses developed in the some parts of the Universal Joint i:e 46.2293 MPa. The minimum stresses developed in the some parts of the universal joint i:e -13.8278 MPa.

Name of the material	Von misses stress(MPA)	Displacement (mm)	Principal stress(MPA)
Malleable cast iron	29.4149	0.01596	43.2342
High speed tool steel	29.8955	0.01174	44.3507
Carbon epoxy fibre composite	27.8161	0.05804	46.2293

Name of the material	Von misses stress (MPA)	Ultimate stress (MPa)	Factor of Safety
Malleable cast iron	29.4149	586	19.92
High speed tool steel	29.8955	1696	56.73
Carbon epoxy fibre composite	27.8161	901	32.39

The software results obtained from existing universal coupling with different materials like malleable cast iron, High speed tool steel and carbon epoxy fibre composite. By comparing these results, High speed tool steel material has the maximum acquirable factor of safety and it is the best material in terms maximum designable factor of safety.

4. CONCLUSIONS

Finite Element Analysis of the universal joint has been done using Creo 4.0. 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.

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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 slightly increased by 10.5 %, and cost of the material is decreased.
3. The stress is found maximum near the sharp edges.

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