MANIPAL INSTITUTE OF TECHNOLOGY
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FINITE ELEMENT METHOD LAB (MME 3271)

MINI-PROJECT

on

FEM Analysis of Universal Coupling

Submitted by

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1. Introduction

A Universal joint is a mechanical tool that can connect two shafts that rotate at different angles, allowing motion and power transmission. This device is used in various industries such as appliances, electronics, textiles, and vehicles, among others. The joint performs several functions, including connecting two shafts that intersect at an angle, allowing them to rotate around their axes while transmitting power at various angles. [6]

The most commonly used type of universal joint is the Cardan or Hooke's joint, which consists of two yokes connected by a cross-shaped member called the spider. It is typically used in buses, trucks, and automobiles. Universal joints can also be used to connect two rods under tensile load, allowing angular misalignment of the rods while potentially taking compressive loads if guided correctly.[7]

Universal joints can be made of either steel or thermoplastics. Steel joints have a higher load-carrying capacity for a given size, while thermoplastic joints are self-lubricating, lightweight, and corrosion-resistant, making them suitable for light industrial applications.

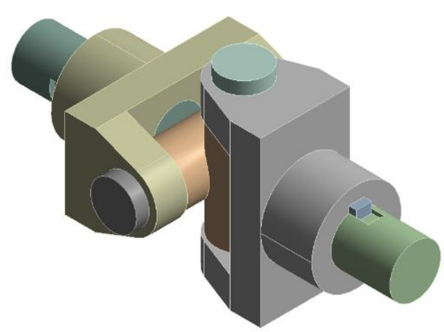

Figure 1-1 ***Model of Universal Coupling***

There are three main types of universal joints:

- cross-type or spider and two-yoke joint,
- ball and trunnion type joint, and
- constant velocity type joint.

Universal joints have several advantages, including high torque transmission efficiency, elasticity, and the ability to transmit torque between shafts with angular misalignment. They also allow for angular displacement, which is not possible with other joint types.

However, there are also some disadvantages to using universal joints. If not lubricated correctly, they may wear out quickly and require frequent maintenance. They may also cause unstable motion and cannot support axial misalignment, which is a disadvantage in certain applications. [7]

2. Literature Review

Several research papers were reviewed on the FEM analysis of universal coupling.

Mandal A. et al [2] conducted an analysis of a universal coupling using Finite Element Modelling and Static Structural Analysis. The focus was on studying and analysing the CAD model of the coupling to identify the causes of frequent failures, such as wearing out of the fork pin and resulting vibrations and noise.

The study concluded that the fork pin experiences the maximum compressive stresses and strains, leading to premature wearing out and failure of the transmission system.

Sagar Yanda et al [3] carried out finite element analysis on the individual modules of the joint in ANSYS Structural. They designed a new UV joint to address the limitations of conventional universal joints, particularly in All-Terrain Vehicles (ATVs) that require taller suspension set up and better articulation angle while maintaining strength and reducing weight.

Using these simulations, the researchers optimized the individual modules for stress, deformation, and FOS. Simulation was conducted for both steel and aluminium joints.

Giridhar NS et al [4] conducted the finite element analysis of a universal joint and propeller shaft assembly. A simulation was conducted using ANSYS software to evaluate the strength and durability of the assembly under various loading conditions.

It was found that the maximum stress and deformation occurred at the bearing location, and the angle between the two yokes had a significant effect on the stress distribution. It was also concluded that the use of non-uniform cross-sections in the yokes could improve the strength of the assembly.

Yaghoubi M. et al [5] presented another system which is intended for the transmission of power between two crossing shafts. They worked out that the system comprises of one drive body and one driven body: six aide arms and three associating arms. The converging edge between the info body and the yield body that are coupled to information and yield shafts, can be changed up to 100 degrees while the speed proportion between the two shafts stays steady. Their assembly additionally incorporated a kinematic analysis and a recreation utilizing Visual NASTRAN, Autodesk Inventor Dynamic and COSMOS Motion. The software demonstrated that this instrument could transmit consistent speed proportions at all points between two shafts. By contrasting the graphs of explanatory investigation and simulation analysis, legitimacy of conditions was demonstrated.

3. Part Models with Dimensional Details

(All dimensions are in mm)

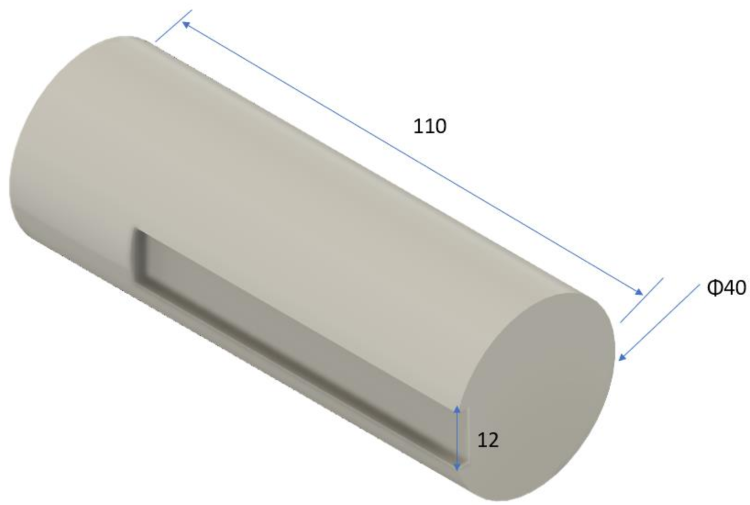

Figure 3-1 ***SHAFT***

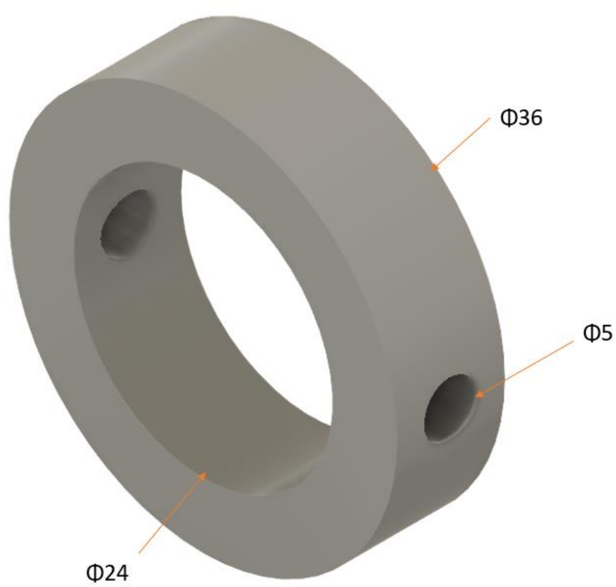

Figure 3-2 ***COLLAR***

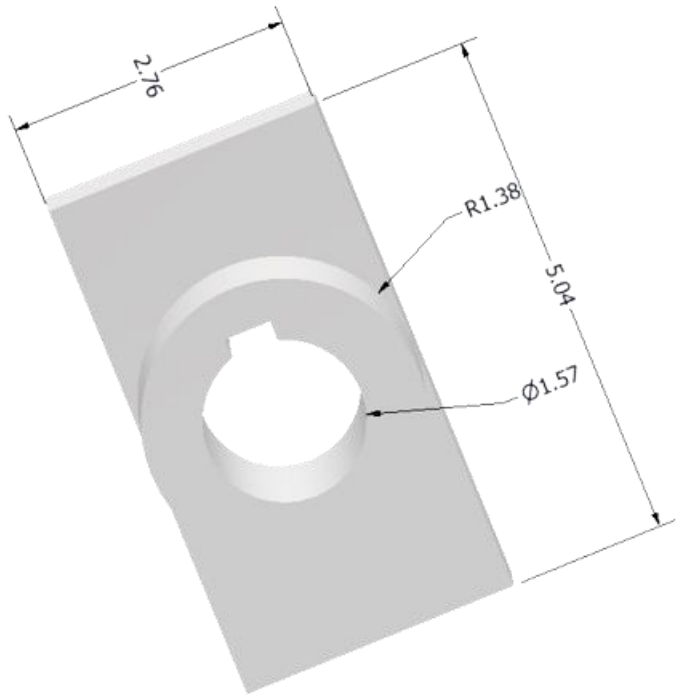

Figure 3-3 ***FORK***

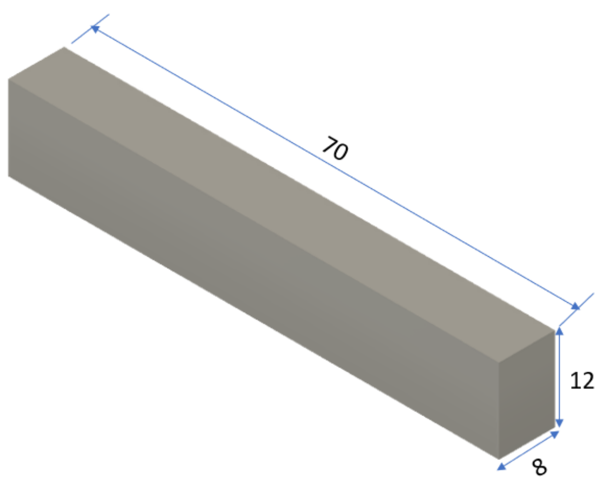

Figure 3-4 ***KEY***

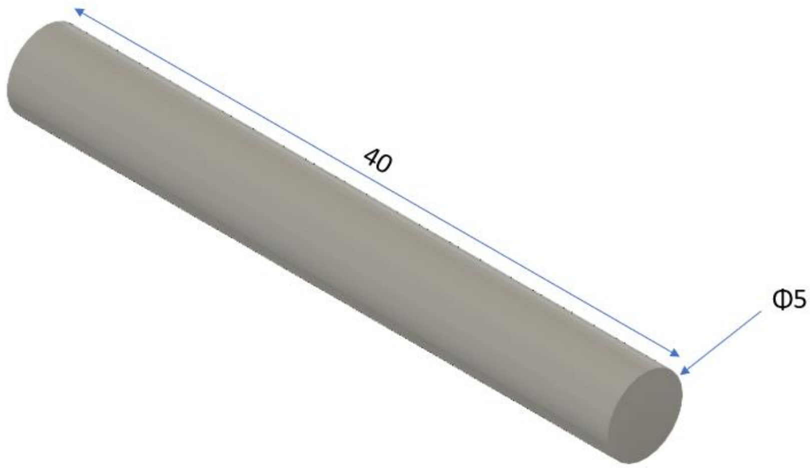

Figure 3-5 ***TAPER PIN***

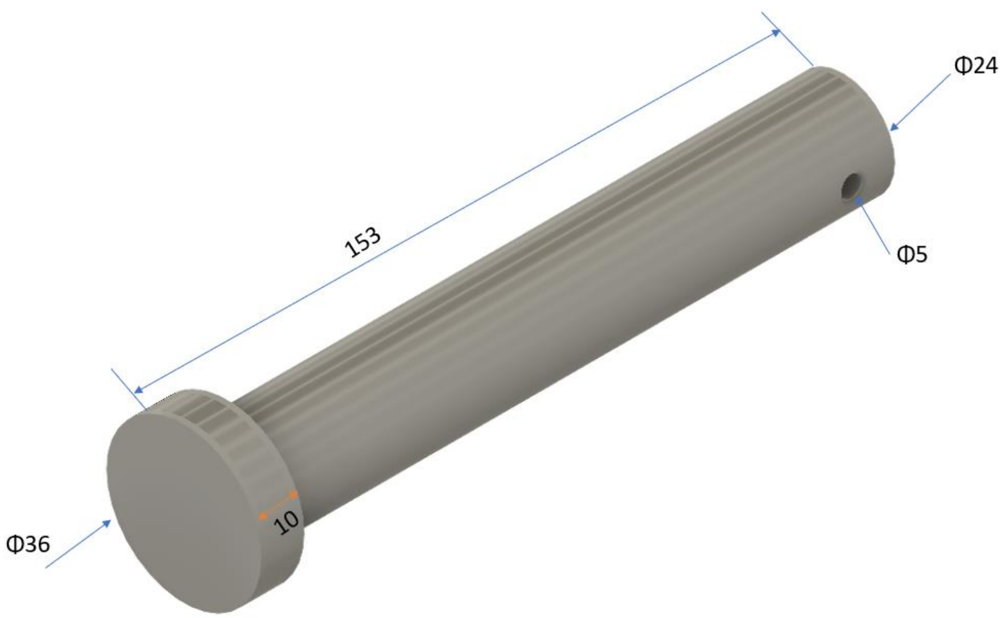

Figure 3-6 ***PIN***

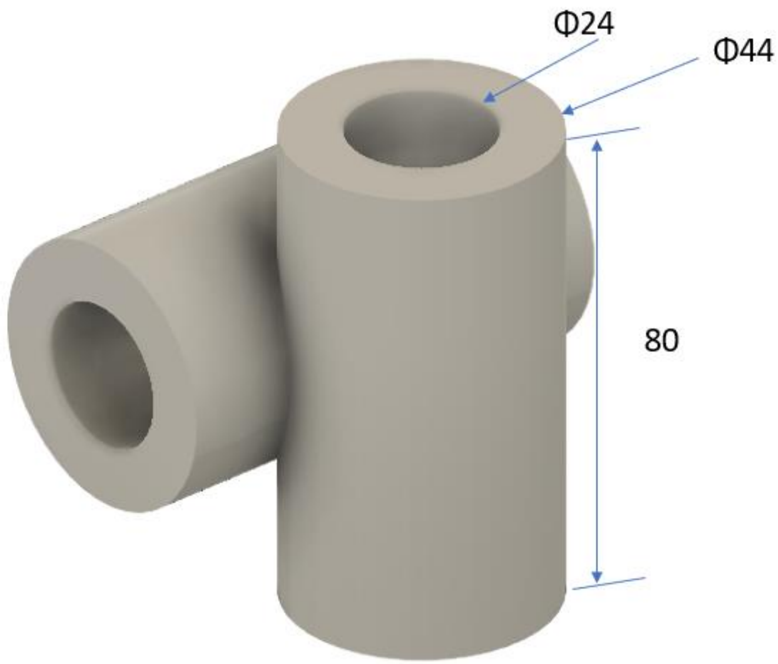

Figure 3-7 ***CENTRE BLOCK***

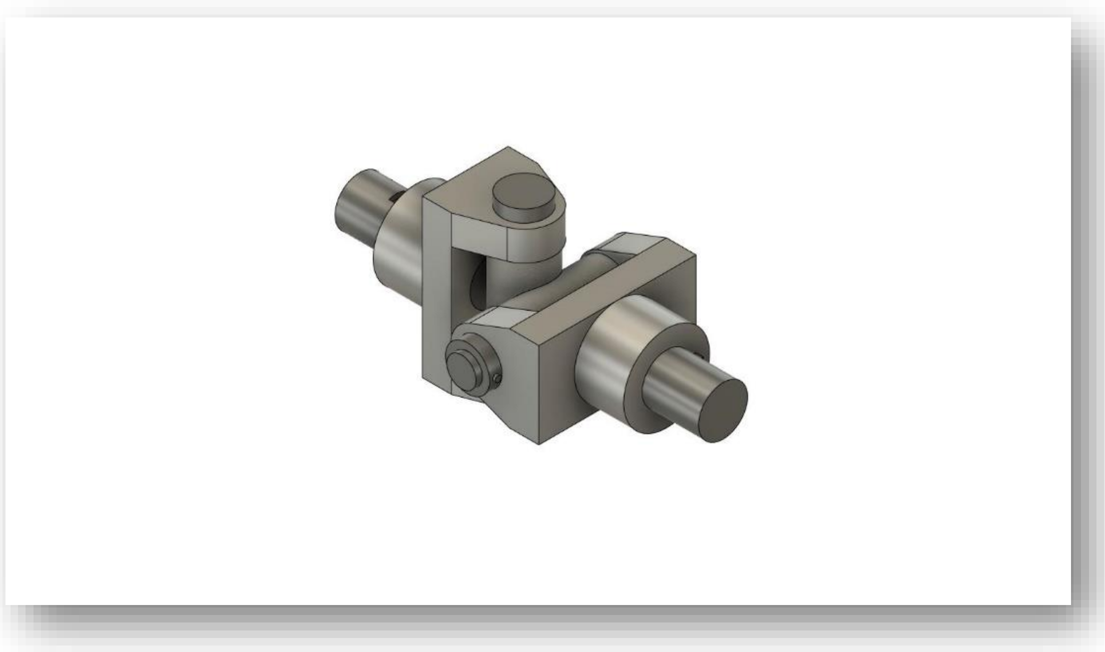

Figure 3-8 ***Assembled Model of Universal Coupling***

4. FEM Analysis

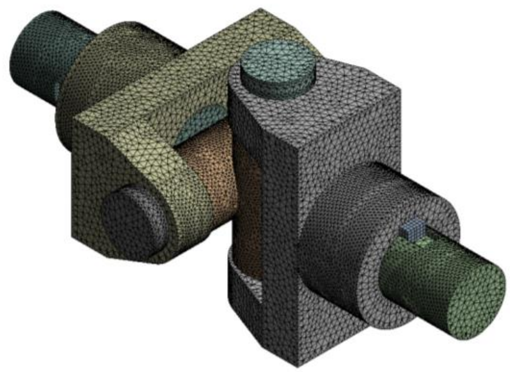

Figure 4-1 ***MESHED MODEL***

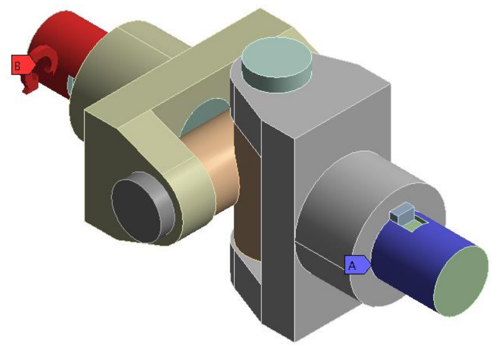

Figure 4-2 ***Boundary Conditions***

4.1 Meshing & Boundary Conditions:

- Fig. 4-1shows a meshed model of Universal Coupling in the static stuctural analysis using Ansys Workbench.
- To analyse, the FEM triangular type of mesh is used for the coupling in ANSYS environment. This is because triangular elements are more accurate in giving the correct values for the desired problem.
- The number of elements used in this mesh is 228901 and the number of nodes is 419277. In this process regular type of meshing is done to analyse the process.
- Fig.4-2 shows the boundary conditions that have been applied to the coupling. A fixed support has been applied at the location A and a moment of 300 Nm has been applied at location B.
- Using the working conditions of the coupling a relative rotating movement between the shafts comes into the picture.

5. Results and Discussions

5.1Results

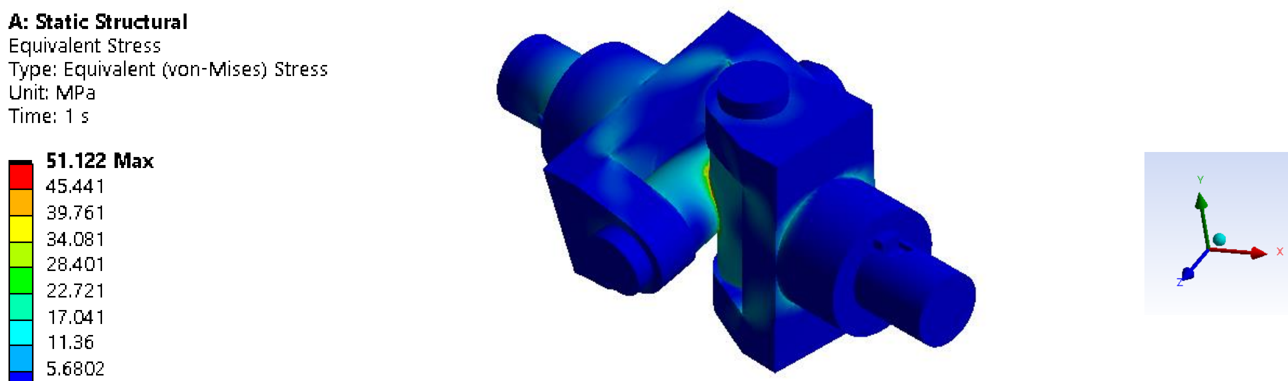

Figure 5-1 ***Equivalent Stress***

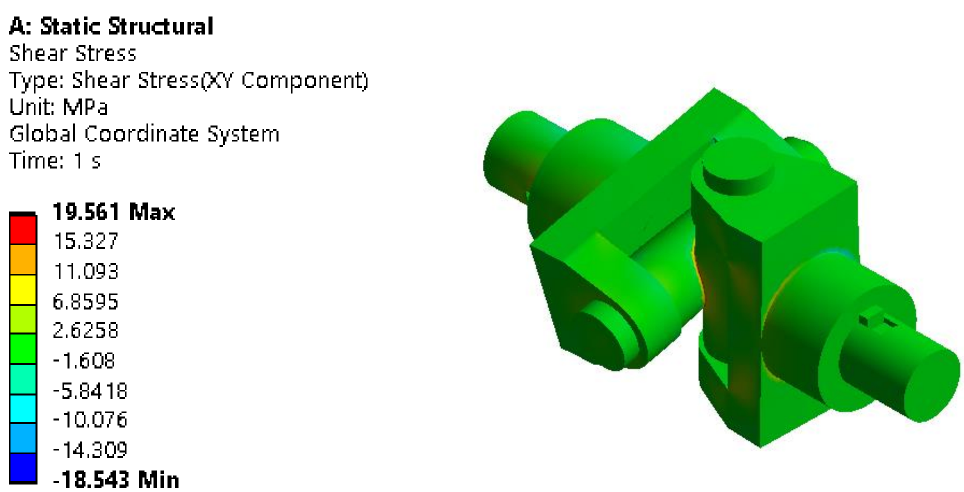

Figure 5-2 ***Shear Stress***

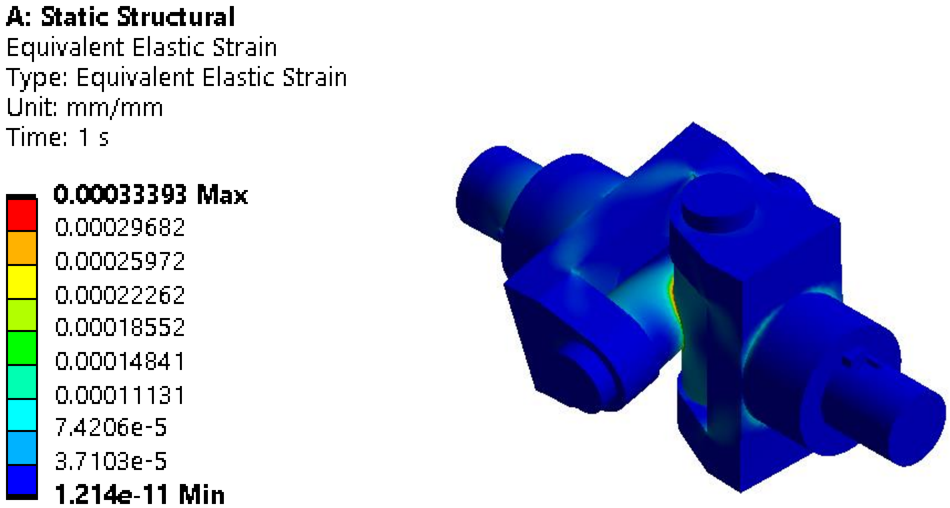

Figure 5-3 ***Elastic Strain***

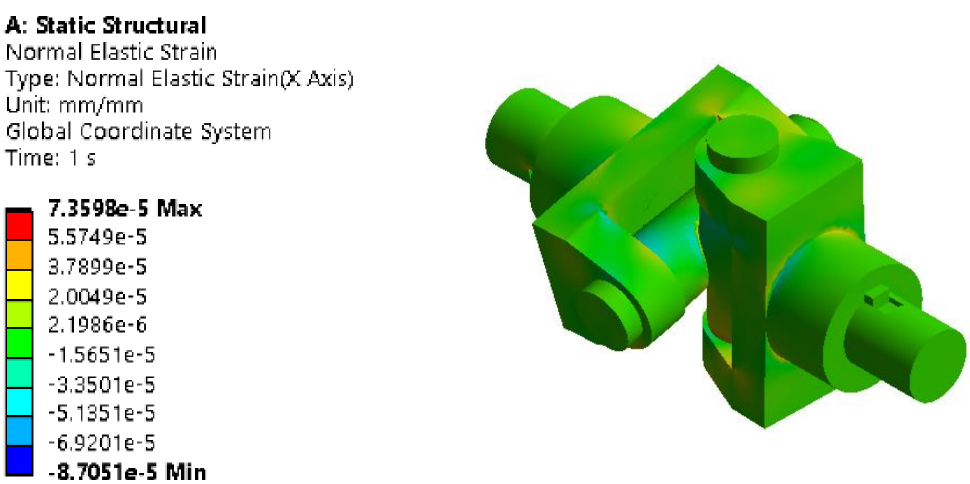

Figure 5-4 ***Normal Elastic Strain***

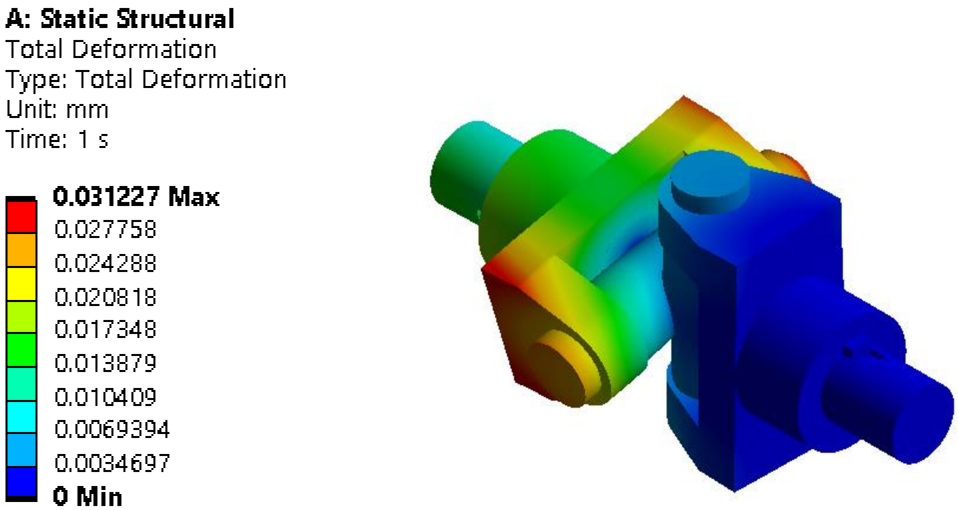

Figure 5-5 ***Total Deformation***

Table 1- Results from the FEM analysis

Parameters	Maximum	Minimum
Total Deformation(m)	3.1227e-5	0
Equivalent Stress (Pa)	5.1122e7	1.125e-6
Factor of Safety	15	4.8903

5.2 Discussions

Based on the results, the following conclusions can be drawn:

1. The maximum total deformation observed in the universal coupling is 3.1227e-5m, which is within acceptable limits. The minimum deformation observed is zero, indicating that there is no deformation in some parts of the coupling.
2. The maximum equivalent stress observed in the universal coupling is 5.1122e7 Pa, while the minimum is 1.125 Pa. This shows that the coupling can withstand high stress levels without experiencing failure.
3. The factor of safety for the universal coupling ranges from a minimum of 4.8903 to a maximum of 15. This indicates that the coupling is designed to handle loads beyond the expected operational conditions and is therefore safe to use.

Overall, the results of the structural analysis indicate that the universal coupling is structurally sound and can withstand the loads and stresses it is expected to encounter during operation.

6. References

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