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STUDY & ANALYSIS OF UNIVERSAL JOINT WITH THE REPLACEMENT OF DEFFERENT MATERIAL

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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 universal joint which is combination of three materials: structural steel magnesium copper. 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 eco friendly. The analysis of the system proves all the above features mention above. design and analysis of universal joint should be proper enough to withstand in working condition without failure. So modelling and analysis of universal joint under a certain condition is carried out. Modelling and analysis of a universal joint was performed by using 3D software CATIA & Finite Element Analysis (FEA) respectively. 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.

Keywords: - Universal joint, FEA, ANSYS, CATIA.

I. INTRODUCTION

In mechanical & automobile domain the joints play very crucial role, depending upon the application the joints are used may be temporary or permanent. For power transmission or motion transfer application we generally uses temporary joints like screwed joint, cotter joint, sleeve cotter joint, universal joint or universal joint The Universal joint is a type of joint which is used in steering system in between the steering rod and pinion of the steering gear, as the line of the action axis of both the mechanical parts are intersecting and lies in different planes, so it is the only joint that we can employ here In order to gain the maximum productivity for the plant, the manufacturing technology must not be stiff. A Universal joint is used to connect two rods under tensile load. This joint permits angular misalignment of the rods and may take compressive load if it is guided. These joints are used for different types of connections i.e. tie rods, tension links in bridge structure. In this, one of the rods as an eye at the rod end and other end is forked with eyes at the both the legs. A pin (universal pin) is inserted through the rod-end and fork end eyes and is secured by collar and a split pin Failure of universal joint may causes accident so it necessary to design universal joint to withstand under tension without failure.

1.1 Introduction to Universal Joint:

Universal joint is a type of mechanical joint used in structures, to connect two intersecting cylindrical rods, whose axes lie on the same plane. It permits some angular movement between the cylindrical rods (in their plane). It is specially designed to withstand tensile loads. A universal joint is a positive, mechanical connection between rotating shafts, which are not parallel, but intersecting. They are used to transmit motion, power or both. The simplest and most common type is called the Yoke Joint or Hooke Joint. It is shown in Figure 1. It consists of two yokes, one on each shaft, connected by a cross-shaped intermediate member called the Spider. The angle between the two shafts is called the operating angle.The flexibility is achieved by constructing the joint with two U-shaped yokes which is joined by a cross shaped hub. One of the yoke is attached to the end of each portion of the split shaft and joined with the cross hub, with the Usections oriented at 90 degree to each other. It is commonly known for its use on automobiles and Bus, trucks etc.

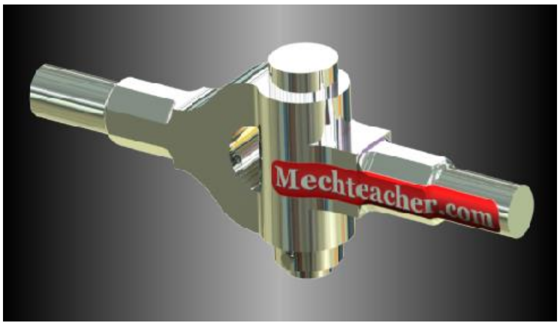

Figure:1 Universal Joint

1.2 Parts of a Universal Joint:

A typical universal joint has the following parts:

1. Fork end
2. Eye end
3. Universal pin
4. Collar
5. Taper pin

All the above parts can be visualized if you take a look at the exploded view shown below.

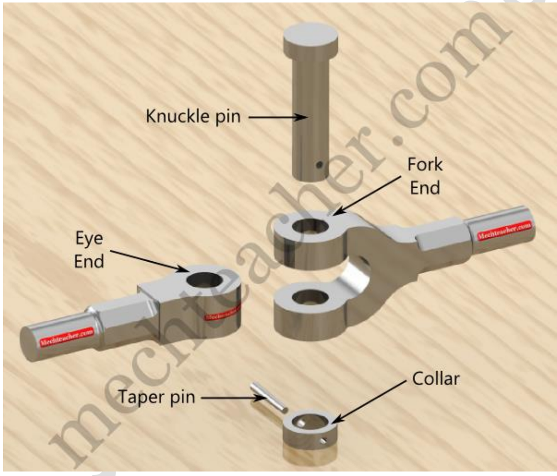

Figure:2 Exploded View of a Universal Joint

Coaxial holes are provided in the fork end, eye end and collar. The fork end and the eye end are held together in position by means of a universal pin. The universal pin is held in its position with the help of a collar and a taper pin.

The assembled view of a universal joint is shown in the image below. Both the fork end and the eye end are capable of rotating in their planes about the axis of the universal pin.

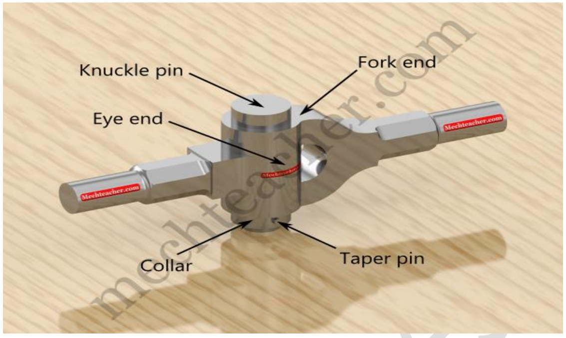

Figure:3 Assembled View of a Universal Joint

Whenever a tensile load is applied on the cylindrical rods, the fork end and eye end adjust their positions about the axis of the universal pin The universal pin remains stationary. It does not rotate about its axis.

Advantages of Universal Joint:

Advantages of Universal Joint Universal joints have always been recognized for their inherent advantage of large misalignment capabilities upward of 15° compared to a maximum of approximately 6° for typical gear-type spindles. In recent years, research and improvements in design and manufacture have contributed to substantial increases in the torque capability of universal joints. Achievement of power transmission densities that allow universal joints to meet rolling mill diameter limitations has increased their competitiveness with gear spindles. Today, U-joints are generally available with power densities equal to or greater than geared spindles, especially when operating misalignment angles exceed 1½°. The advantages of universal joints include:

1. Universal joint can withstand large tensile loads.
2. It has good mechanical rigidity.
3. It is easy to manufacture and set up.
4. It can be easily dismantled and assembled.
5. Design is simple and easy.

Operating characteristics: U-joints utilize a cross and bearings instead of engaging gear teeth for the flexing component. Gear spindle teeth are constantly sliding and wearing during their operational life, which can have significant effects

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on the life and capacity of the gear spindle. U-joint bearings roll and have minimal and relatively predictable wear during their operating life. The torque capacity of gear spindles decreases as misalignment increases because fewer teeth are in full contact to share the load. U-joint torque capacity is not significantly influenced by the misalignment angle, and reduction in bearing life is statistically predictable regardless of operating angle.

II. DESIGN OF UNIVERSAL JOINT

Universal Joint has mainly three components – eye, fork and pin as shown in Eye is formed on one of the rods and fork is formed on the other. Eye fits inside the fork and the pin is passed through both the fork and the eye. This pin is secured in its place by means of a split-pin. The ends of the rods are made octagonal to some distance for better grip and are made square for some portion before it is forged to make the eye and fork shapes.

Advantages of Universal Joint are:

- Simple to design and manufacture.
- Fewer parts – less cost more reliability.
- Simple to assemble and dismantle.

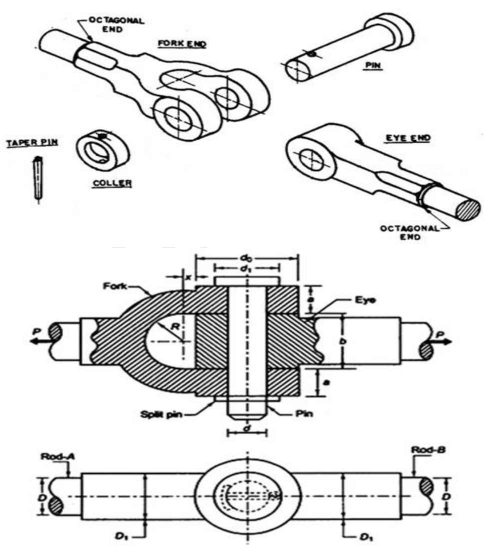

Figure:4 Design of Universal Joint

OBJECTIVES:

- To Design of universal joint done by using CATIA V5 R20 And analysis is done by Using ANYS 15.0
- To analysis of universal joint with the replacement of different materials (structural steel, magnesium, copper)

III. LITERATURE REVIEW

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. Number of investigations has been done on finite element analysis of universal joint and its components. calculated the stresses in universal joint using analytical method. It was observed that on changing the pin diameter the load carrying capacity of the pin increases performed FE analysis of universal joint pin used in tractor trailer. Analysis was performed on pin under acceleration and declaration condition using newton's second law. It was observed the intensity of von misses stress is maximum in case of deceleration performed the study and analysis of universal joint with the replacement of material by Teflon. It was observed parts made of composite materials are economical to produce and facilitate cost reduction as compared to metal parts

[1] Li and Melkote (1999) modelled the work piece as elastic in the contact region and rigid elsewhere. The fixture is assumed to be completely rigid. The locators are modelled as displacement constraints that prevent work piece translation in the normal direction. They modelled the clamping force as uniformly distributed force acting over the work piece-clamp contact area and work piece is considered as 3D. Static analysis is conducted to predict the elastic deformation by ignoring machining force. proposed a model for analysing the reaction forces and moments for machining fixtures with large contact areas and it has been developed using a contact mechanics approach where the work piece is assumed to be elastic in the contact region and the fixture element is treated as rigid. The model has also been used to determine the minimum clamping force necessary to keep the work piece in static equilibrium during machining.

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IV. METHODOLOGY

A universal joint or Hooke's joint is a joint or coupling in a rigid rod that allows the rod to bend in any direction, and is commonly used in shafts that transmit rotary motion. It generally consists of two hinges located close together, oriented at 900 to each other, connected by a cross shaft. It is widely used in industrial applications and vehicle drivelines to connect misaligned shafts. A major problem with the use of a Hooke's joint is that it transforms a constant input speed to a periodically fluctuating one. The kinematical consequences of this property of this joint can be remedied, as long as rigid body rotations are concerned, by using two converse Hooke's joint. But if torsional vibrations of the propeller shaft are concerned, there is no way of removing the dynamical consequences of an introduced Hooke's joint in a rear wheel drive vehicle. In a widely used single piece drive shaft, two universal joints are used

UNIVERSAL JOINTS:

A universal joint also known as universal coupling, U-joint, Cordon 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 grunion is used to deliver rotation from one yoke to another using four needle pin bearings.

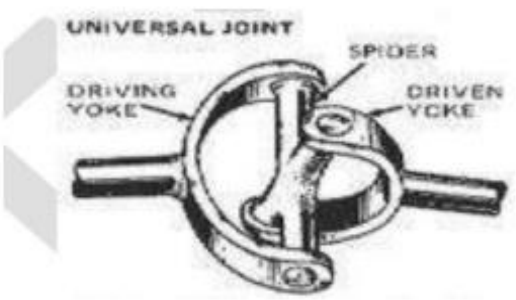

Figure: 5 Universal coupling

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

V. MATERIAL PROPERTIES:

STRUCTURAL STEEL:

There are different categories of steel structures which can be used in the construction of steel buildings. Typical stress strain curves for various classes of structural steel, which are derived from steel tensile test,

The initial part of the curve represents steel elastic limit. In this range, steel structure deformation is not permanent, and the steel regain its original shape upon the removal of the load As far as poisons ratio is concerned, it is the ratio of transverse strain to axial strain and it is about 0.30 and 0.50 in elastic and plastic range, respectively.

Regarding cold working of structural steel, it is the process in which different shapes of steel structure are produced at room temperature.
Consequently, steel structure ductility is increased but its ductility is reduced. Residual stress is a stress that stays in steel element after it has been fabricated.
It is necessary to consider strain rate while tensile test is conducted because it modifies steel tensile properties.
If steel structure is used for dynamic loads, then high strain rate would be considered. However, normal strain rate is adopted for steel used in the construction of structure designed for static loads.

Magnesium properties:

The ability of steel structure to accommodate energy is called steel toughness. Chemical element, metallic, symbol Mg, situated in group IIa in the periodic table, atomic number: 12, atomic weight: 24,312. Magnesium is silvery white and very light. Its relative density is 1,74 and it's density 1740 kg/m3 (0.063 lb/in3 or 108.6 lb/ft3). Magnesium is known for a long time as the lighter structural metal in the industry, due to it's low weight and to it's capability of forming mechanically resistant alloys. Magnesium is very chemically active, it takes the place of hydrogen in boiling water and a great number of metals can be produced by thermic reduction of its salts and oxidized forms with magnesium. It joins together with most non-metals and almost every acid. Magnesium reacts only slightly or not at all with most of the alkalis and many organic substances, like hydrocarbons, aldehydes, alcohols, phenols, amines, esters and most of the oils. Used as a catalyst, magnesium promotes organic reactions of condensation, reduction, addition and deha logenization. It was used for a long time for synthesizing special and complex organic components by the well-known Grignard reaction. The main ingredients of the alloys are: aluminum, manganese, zircon, zinc, rare-earth metals and thorium

PRE – PROCESSOR:

Pre processor has been developed so that the same program is available on micro, mini, super-mini and mainframe computer system. This slows easy transfer of models one system to other.

Pre processor is an interactive model builder to prepare the FE (finite element) model and input data. The solution phase utilizes the input data developed by the pre processor, and prepares the solution according to the problem definition. It creates input files to the temperature etc., on the screen in the form of contours.

Geometrical definitions:

There are four different geometric entities in pre processor namely key points, lines, areas and volumes. These entities can be used to obtain the geometric representation of the structure. All the entities are independent of other and have unique identification labels.

Model generations:

Two different methods are used to generate a model:

- **Direct generation.**
- **Solid modeling**

With solid modeling we can describe we can describe the geometric boundaries of the model, establish controls over the size and desired shape of the elements and then instruct ANSYS program to generate all the nodes and elements automatically. By contrast, with the direct generation method, we determine the location of every node and size, shape and connectivity of every element prior to defining these entities in the ANSYS model. Although, some automatic data generation is possible (by using commands such as FILL, NGEN, EGEN etc) the direct generation method essentially a hands on numerical method that requires us to keep track of all the node numbers as we develop the finite element mesh. This detailed book keeping can become difficult for large models, giving scope for modeling errors. Solid modeling is usually more powerful and versatile than direct generation and is commonly preferred method of generating a model.

Mesh generation:

In the finite element analysis the basic concept is to analyze the structure, which is an assemblage of discrete pieces called elements, which are connected, together at a finite number of points called Nodes. Loading boundary conditions are then applied to these elements and nodes. A network of these elements is known as Mesh.

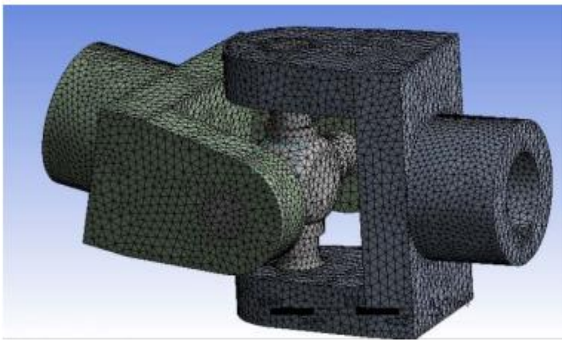

Figure:6 Mashed model

Finite element generation:

The maximum amount of time in a finite element analysis is spent on generating elements and nodal data. Pre processor allows the user to generate nodes and elements automatically at the same time allowing control over size and number of elements. There are various types of elements that can be mapped or generated on various geometric entities.

The elements developed by various automatic element generation capabilities of pre processor can be checked element characteristics that may need to be verified before the finite element analysis for connectivity, distortion-index, etc.

Generally, automatic mesh generating capabilities of pre processor are used rather than defining the nodes individually. If required, nodes can be defined easily by defining the allocations or by translating the existing nodes. Also one can plot, delete, or search nodes.

Boundary conditions and loading:

After completion of the finite element model it has to constrain and load has to be applied to the model. User can define constraints and loads in various ways. All constraints and loads are assigned set 1D. This helps the user to keep track of load cases.

Model display:

During the construction and verification stages of the model it may be necessary to view it from different angles. It is useful to rotate the model with respect to the global system and view it from different angles. Pre processor offers this capability. By windowing feature pre processor allows the user to enlarge a specific area of the model for clarity and details. Pre processor also provides features like smoothness, scaling, regions, active set, etc for efficient model viewing and editing.

Material definitions:

All elements are defined by nodes, which have only their location defined. In the case of plate and shell elements there is no indication of thickness. This thickness can be given as element property. Property tables for a particular property set 1-D have to be input. Different types of elements have different properties for e.g.

Beams : Cross sectional area, moment of inertia etc

Shells : Thickness

Springs : Stiffness

Solids : None

The user also needs to define material properties of the elements. For linear static analysis, modules of elasticity and Poisson's ratio need to be provided. For heat transfer, coefficient of thermal expansion, densities etc are required. They can be given to the elements by the material property set to 1-D.

Solution:

The solution phase deals with the solution of the problem according to the problem definitions. All the tedious work of formulating and assembling of matrices are done by the computer and finally displacements are stress values are given as output. Some of the capabilities of the ANSYS are linear static analysis, non-linear static analysis, transient dynamic analysis, etc

Post – Processor:

It is a powerful user-friendly post-processing program using interactive colour graphics. It has extensive plotting features for displaying the results obtained from the finite element analysis. One picture of the analysis results (i.e. the results in a visual form) can often reveal in seconds what would take an engineer hour to asses from a numerical output, say in tabular form. The engineer may also see the important aspects of the results that could be easily missed in a stack of numerical data.

Employing state of art image enhancement techniques, facilities viewing of:

- Contours of stresses, displacements, temperatures, etc.
- Deform geometric plots
- Animated deformed shapes
- Time-history plots
- Solid sectioning

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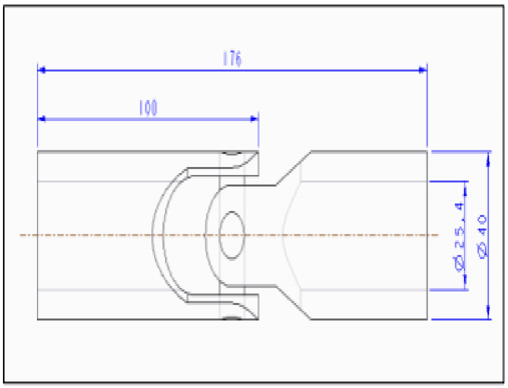

Figure:7 Geometric view

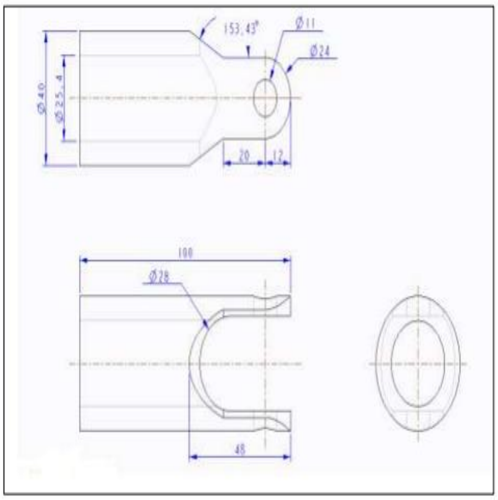

Figure:8 Detailed of the drawing

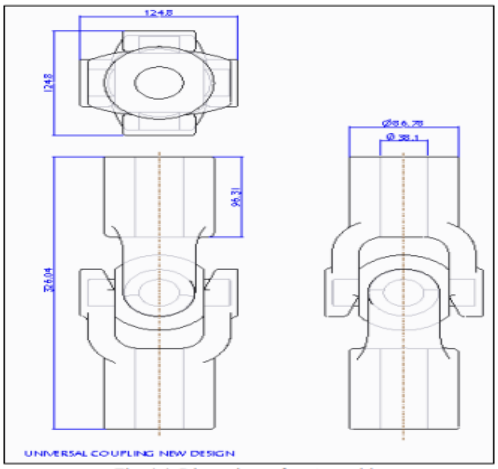

Figure:9 Dimensions of an Assembly

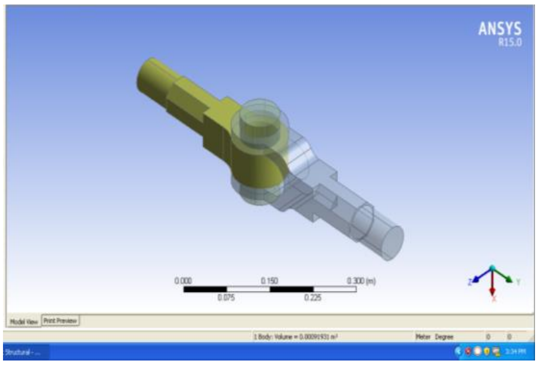

Figure:10 universal joint

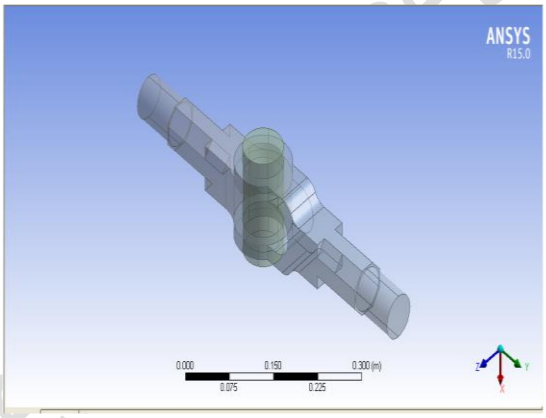

Figure:11 universal joint 3D View

Meshing:

- The Figure shown is the meshed model of rigid flange coupling in the ANSYS analysis
- for the static structural process. To analyse, the FEM triangular type of mesh is used for the rigid flange coupling in the ANSYS environment.
- The number of elements used in this meshing is 71441and the number of nodes is 122228.In this process regular type of meshing is done to analyse the process.
- Using the working condition of the coupling a relative rotational movement between the shafts comes into picture consequently.
- The determination of the shear stress along the contact region is essential. So, the model
- is meshed and then analysed to get the detail and authentic result of the stresses of the contact region.

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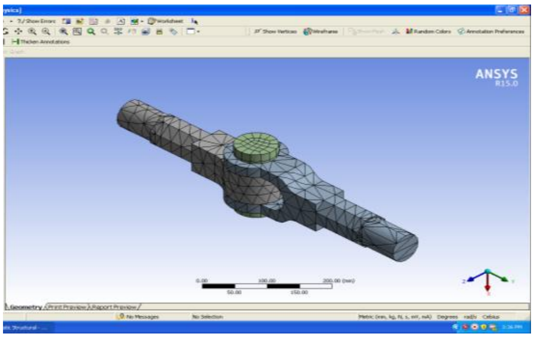

Figure:12 meshing model of universal joint

VI. RESULTS

The simple definition of stress is that is force divided by area. 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. If the force is parallel to area to cause sliding of one area over other the stress is shearing. If two bodies are in contact and pressed against each other the stress is bearing. The magnitude of bearing stress will be the compressing force divided by contact area between two bodies. The bearing stress is compressive in nature and is also called crushing stress

STRUCTURAL STEEL OF UNIVERSAL JOINT:

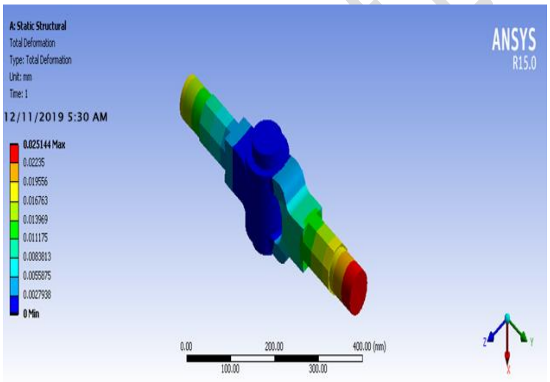

Figure 13.Total deformation universal joint

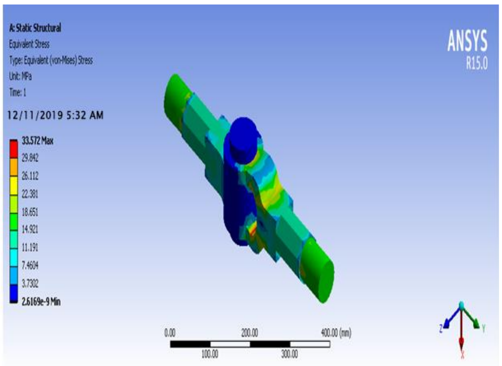

Figure 14..Equivalent stress universal joint

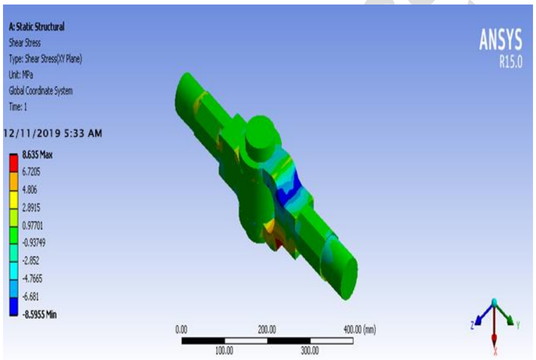

Figure:15. shear stress universal joint

UNIVERSAL JOINT MAGNESIUM ALLOY:

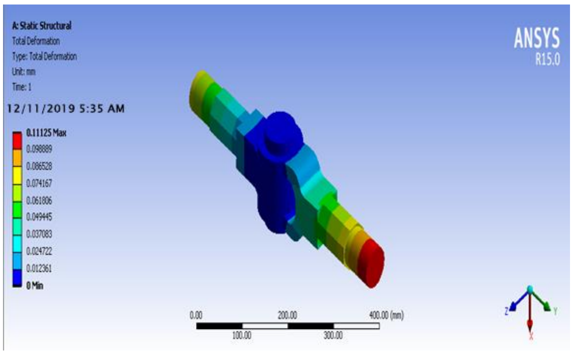

Figure: 16.Total deformation universal joint

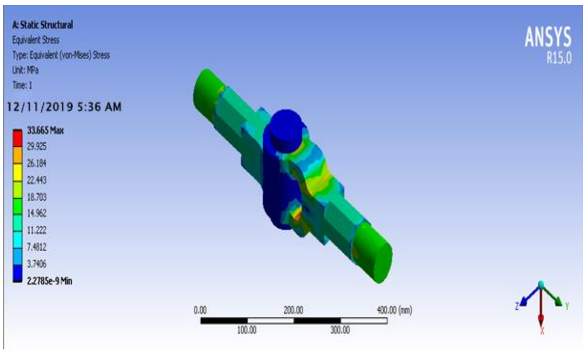

Figure .17. equivalent stress universal joint

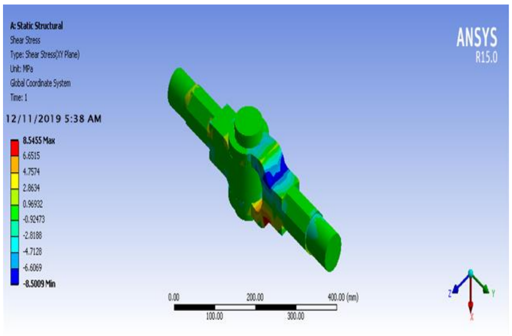

Figure:18. Shear stress universal joint

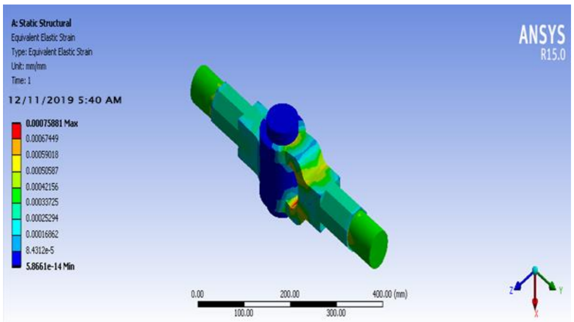

Figure:19.Equivalent elastic strain universal joint

UNIVERSAL JOINT COPPER ALLOY:

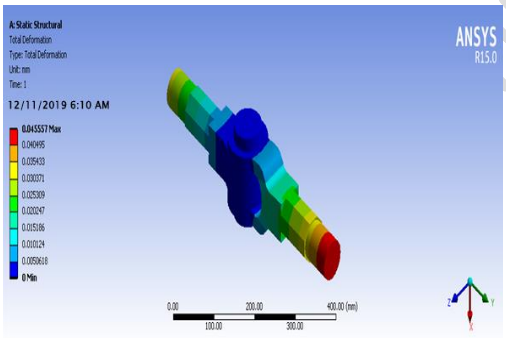

Figure: 20. total deformation universal joint

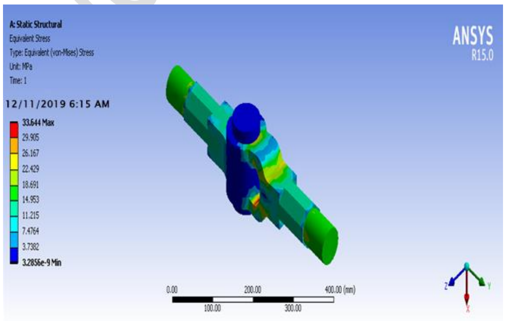

Figure.21. Equivalent stress universal joint

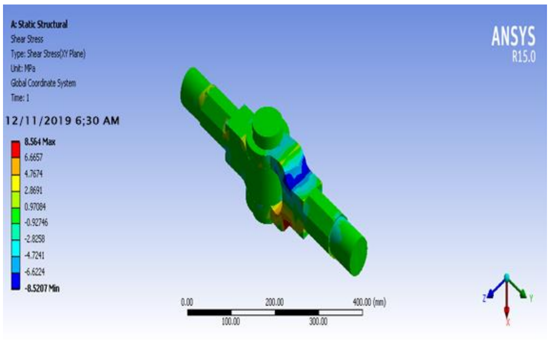

Figure:22. shear stress universal joint

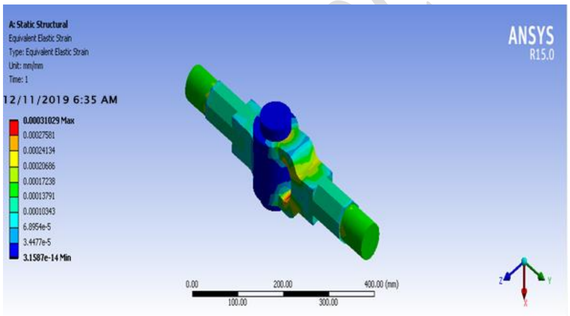

Figure:23.Equivalent elastic strain universal joint

Above figure and table represents spiral thickness comparison between ANSYS generated and neural network generated values to obtain the optimized value of spiral thickness. Above all figure and table represents force comparison between ANSYS generated and neural network generated values to obtain the optimized value of force. The Values thereby generated helps to choose an appropriate and optimized set of design parameters as well as force input which is being depicted in the table

TABLE:1 STRUCTURAL STEEL OF UNIVERSAL JOINT

Parameters	Maximum	Minimum
Total deformation	0.025144	0
equivalent stress	33.572	2.6169e-9
shear stress	8.635	8.5955

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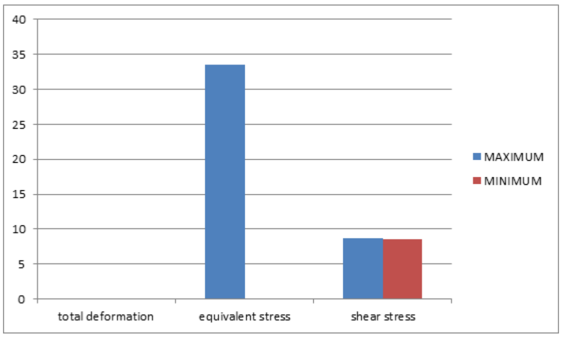
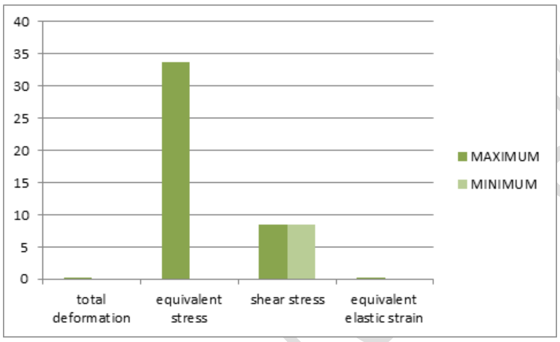


GRAPH .1. STRUCTURAL STEEL PARAMETERS DIFFERENT VARIATIONS

TABLE 2. MEGNESIUM OF UNIVERSAL JOINT

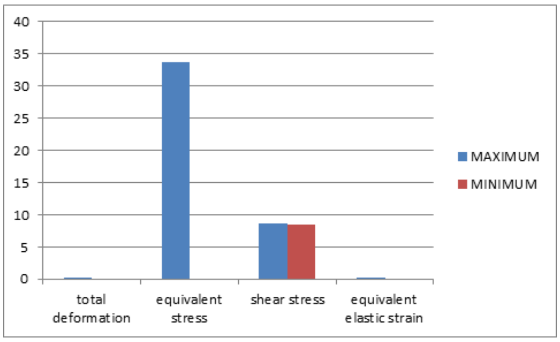
PARAMETERS	MAXIMUM	MINIMUM
total deformation	0.11125	0
equivalent stress	33.665	2.2785e-9
shear stress	8.5455	8.5005
equivalent elastic strain	0.00075881	5.8661e-14



GRAPH.2. MEGNESIUM PARAMETERS DIFFERENT VARIATIONS

TABLE. 3 UNIVERSAL JOINT COPPER ALLOYS

PARAMETERS	MAXIMUM	MINIMUM
total deformation	0.045557	0
equivalent stress	33.644	3.2856e-9
shear stress	8.564	8.5207
equivalent elastic strain	0.0031029	3.1587e-14



GRAPH . 3. COPPER ALLOYS PARAMETERS DIFFERENT VARIATIONS

VII. 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. The results generated for spiral pin with 4 number of set of input parameters can be further analyzed to obtain the optimum value of diameter and thickness of pin with the tool. After remodelling of the universal joint using the predicted optimized parameters obtained by neural network the model is used to generate the value of stress which is compared with the neural network result in order to prove that optimized model is better as compared to the previously selected four models. The optimization process includes the generation of diameter of pin at a given pin thickness and force applied to the universal joint mechanism. This finally concludes the objective of the study being conducted.

Future Scope:

- The optimization of the universal joint can be done considering the other lighter materials also. Hence a new material can be proposed for the universal joint.
- Further mass reduction can be done from the non-sensitive area of the universal joint that is yokes.

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