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Review of the Universal Joint of Steering Column in Passenger Vehicle

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Abstract - *The steering column in a steering system is a very important part to attain stability and steady movement of the vehicle. A vehicle steering column assembly consists of components for transmitting steering movement from a steering wheel of a vehicle steering system. The assembly includes an integrated shaft bearing that connects to the steering wheel at one end, a tube assembly interconnected with the integrated shaft bearing at its other end, a yoke assembly having a shaft and being adapted to be interconnected with a lower steering component of the steering system, and a bearing assembly disposed within the tube assembly and around the shaft to support the shaft in axial sliding movement within the tube assembly.*

Key Words: *Steering rod, Cardan joint, Abaqus, Universal joint, CAE, ANASYS, HyperMesh, etc.*

1. INTRODUCTION

Universal joint is a joint in a rigid rod that permits the rod to move up and down while spinning in order to transmit power by changing the angle between the transmission output shaft and the drive shaft. A simple universal joint consists of two Y shaped yokes, one on the driving shaft and other on the driven shaft and the cross piece called the spider as shown in figure 1.1

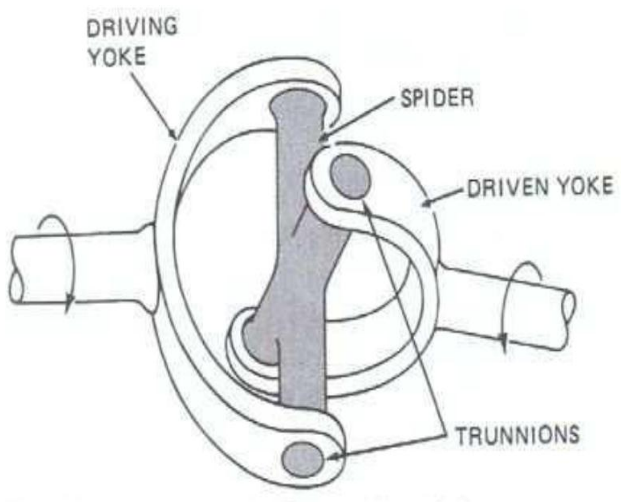

Figure 1.1 universal joints (Cardan joint)

A failure of this mechanism during operation of the vehicle could lead to fatal circumstances to the driver who is at the expense of a car without control and with high velocity. As we have seen along the history, a lot of the most serious accidents have been caused due to a failure on the steering system with different fates for the drivers.

A spider hinges these two yokes together. Since the arms of the spider are at right angles, there will be four extreme positions during each revolution when the entire angular movement is being taken by only one half of the joint. This means that the spider arm rocks backwards and forwards between these extremes. Friction due to rubbing between the spider and the yoke bores is minimized by incorporating needle-roller bearings between the hardened spider journals and hardened bearing caps pressed into the yoke bores.

The universal joint is used to carry drive from one shaft to another where the two shafts are not perfectly in line and particularly where they can move relative to each other. It is used in propeller shafts at both the transmission output and the differential input ends, in steering swivels on part-time four wheel drive vehicles, in some steering columns.

General specification of steering yoke:

1) Material used: Forged/Rolled Generic Steel or suitable.

2) Material: Forged Carbon Steel C1021 or suitable.

3) Heat treatment: Annealed.

2. LITERATURE SURVEY

Mr.P.G.Tathe [1] has developed a methodology, where the A universal joint is a positive, mechanical connection between rotating shafts, which are usually not parallel, but intersecting. They are used to transmit motion, power, or both. The simplest and most common type is called the Yoke joint, Cardan joint or Hooke joint. 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. In this study, failure analysis of a universal joint yoke of an automobile power transmission would be carried out. For the determination of stress conditions at the failed section, stress analyses can also carried out by the finite element method.

M.D.Shende and M.K.Bhavsar [2] have said that, the subassembly of steering yoke associated with this project work consists of two forged-steel yokes or forks joined to the two shafts being coupled and situated at right angles to each other. Although, the single component named `Yoke‟ would be the topic of interest for this case-study. A spider hinges these two yokes together. Since the arms of the spider are at right angle. The most common type of U-joint used in the automobile industry is Hooke or Cardan joint. Friction due to rubbing between the spider and the yoke bores is minimized by incorporating needle-roller bearings between the hardened spider journals and hardened bearing caps pressed into the yoke bores.

S G Solank [3] have adopted, An increased demand for greater performance of universal joint of steering column of passenger car has prompted the development of joints capable of long life at high torque, high angles and high loads. This can be easily achieved by investigating or evaluating the torsion loading and its effect over yoke by FEM. New variations of Universal joint have shown the ability to increase universal joint performance. As Yoke generally subjected to torsional and bending stresses due to wt of components also susceptible fatigue by nature of functioning. Prof. D.S. Bajaj [4] has advocated, Yoke assembly is one of the most important parts in propeller shaft. In this study, failure analysis of a universal joint yoke of an automobile power transmission system is carried out. First step in this study to find prime mode of failure by using Failure Mode and Effects Analysis technique. Continues variable torque (Torsion) loading & shearing are important mode failure having high risk priority number. Scope of the study is linear static structural stress analysis is carried out by using the following software tools: HyperMesh, ANSYS, Abaqus, or any compatible CAE software in the `Structural' domain.

Maram Venkata and Sunil Reddy [5] has developed, 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.

B Gagan Deep, Lohitesh Jagakumar [6] has defined as the, A car may utilize a longitudinal shaft to convey control from a Motor/transmission to the opposite end of the vehicle before it goes to the wheels. A couple of short drive shafts is usually used to send control from a focal differential, transmission, or transaxle to the wheels. Drive shaft (Propeller shaft) is a mechanical piece of transmission framework which is utilized to exchange the power from motor to the wheel. The development of vehicles can be given by exchanging the torque created by motors to wheels after some change. The exchange and alteration arrangement of vehicles is called as power transmission framework and have diverse productive highlights as per the vehicle's driving write. Most cars today utilize unbending driveshaft to convey control from a transmission to the wheels.

3. PROCESSING AND ANALYTICAL METHOD

The CAE software usually has an intuitive graphical user interface with direct access to CAD geometry, advanced tools for meshing and integration with other compatible software for solving. It is optimized for large scale systems, assemblies, dynamics and NVH simulations. Typically, the CAE interface design to handle structural problems as the case study concerned here is adept to linear static analysis with a post-processing interface to view results.

Steps for the work:-

- Generate the Geometry of Yoke.
- Doing the meshing of that geometry.
- Giving the nature of load and values of loading.
- Solving the meshed model.
- Identify the stressed areas.
- Viewing the results.
- Modify the geometry/mass/boundary conditions.
- Solving the meshed model again in iteration/iterations.
- Comparison of the result.
- Recommendation.

Since ductile materials usually fail by yielding i.e. when permanent deformations occur in the material and brittle materials fail by fracture, therefore the limiting strength for these two classes of materials is normally measured by different mechanical properties. For ductile materials, the limiting strength is the stress at yield point as determined from simple tension test and it is, assumed to be equal in tension or compression. For brittle materials, the limiting strength is the ultimate stress in tension or compression.

Certain steps in formulating a finite element analysis of a problem are common to all such analyses, whether structural, heat transfer, fluid flow, or some other problem. These steps are embodied in commercial finite element software packages. Figure 3.1 shows the general procedure for finite element method. These steps are described below

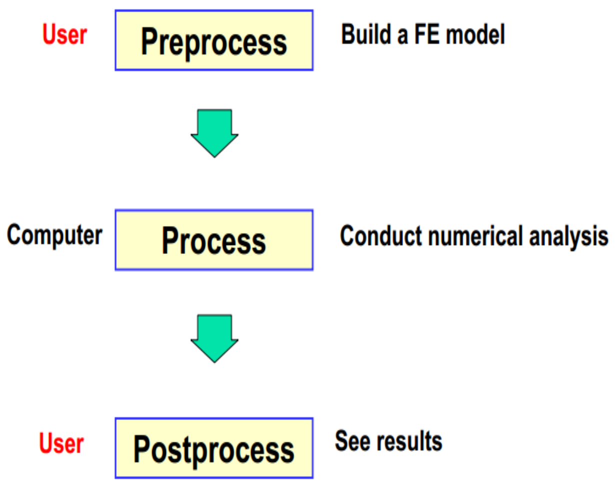

Figure 3.1 General procedures for finite element method

Preprocessing:-

The preprocessing step is critical and quite generally, described as defining the model and includes,

- Define the geometric domain of the problem.

- Define the element type(s) to be used.

- Define the material properties of the elements (modulus of elasticity, density, poison ratio and the like)

- Define the geometric properties of the elements (length, area, and the like).

- Define the element connectivity's (mesh the model).

- Define the physical constraints (boundary conditions).

- Define the loadings.

Processing:-

During the solution phase, finite element software assembles the governing algebraic equations in matrix form and computes the unknown values of the primary field variable(s). The computed values are then used by back substitution to compute additional, derived variables, such as reaction forces, element stresses, and heat flow.

As it is not uncommon for a finite element model to be represented by tens of thousands of equations, special solution techniques are used to reduce data storage requirements and computation time. For static, linear problems, a wave front solver, based on Gauss elimination.

Post processing:-

Analysis and evaluation of the solution results is referred to as post processing. Postprocessor software contains sophisticated routines used for sorting, printing and plotting selected results from a finite element solution. Examples of operations that can be accomplished include,

- Element stresses in order of magnitude.

- Check equilibrium.

- Calculate factors of safety.

- Plot deformed structural shape.

- Animate dynamic model behavior.

- Produce color-coded temperature plots.

While solution data can be manipulated many ways in post processing, the most important objective is to apply sound engineering judgment in determining whether the solution results are physically reasonable.

4. CONCLUSION

The results obtained are quite favorable which was expected. Finite element analysis is effectively utilized for addressing the conceptualization and formulation for the design stages. The stresses derived during the analysis phase normally indicate the potential solution. The iterations are carried out in the analysis phase which yields the suitable values for design parameter. To improve performance, geometry has been modified using topology & free size optimization which enables to reduce stress levels marginally well below yield limit. Less process time will required to melt the material of modified component as the weight of component is reduced.

REFERENCES

[1] Mr. P.G.Tathe, Prof. D.S.Bajaj: Failure Analysis of yoke assembly of a transmission drive shaft subjected to Torsion and Shear, ISSN: 2278-0181 Vol. 2 Issue 10, October – 2013

[2] S.K.Chandole, M.D.Shende, M.K.Bhavsar: Structural Analysis of Steering Yoke of an Automobile for Withstanding Torsion/ Shear Loads, eISSN: 2319-1163 | pISSN: 2321-7308 Volume: 03 Issue: 03 | Mar-2014.

[3] S G Solanke, A S Bharule: An Investigation On Stress Distribution For Optimization Of Yoke In Universal Joint Under Variable Torque Condition: A Review, ISSN 2278 – 0149 Vol. 3, No. 2, April 2014

[4] Prof. D.S. Bajaj, Mr.P.G.Tathe, Swapnil S. Kulkarni: Failure Analysis and Optimization in Yoke Assembly Subjected by Torsion and Shear, Int. J. Adv. Engg. Res. Studies/III/IV/July- Sept.,2014/13-1

[5] Maram Venkata Sunil Reddy, C. Raghunatha Reddy: Design and Analysis of Universal Coupling Joint, Volume 6 Issue No. 12, Dec-2016

[6] B Gagan Deep, Lohitesh Jagakumar: Study the Static Stiffness of a Propeller Shaft of a Car for a Maximum Torque Load to Evaluate the Shear Stress. Volume 3, Issue 7, July – 2018, ISSN No:-2456-2165.

[7] Avinash Chandrashekhar Vasekar, R.R.Gidde, Swapnil S. Kulkarni: Assessment Of The Yoke At The Transmission Drive Shaft For Evaluating Structural Performance Under Torsion Loading, IJAER Studies/III/IV/July-Sept., 2014/25- 27 E-ISSN2249–8974, 690-694.

[8] V.Jose Ananth Vino, Dr. J. Hameed Hussain: Design and Analysis of Propeller Shaft DOI:10.15680/IJIRSET.2015.0408259 page no.- 7311-7319.

[9] Nick Cristello, and Il Yong Kim: Design Optimization Of An Automotive Universal Joint Considering Manufacturing Cost, Procedia engineering 40 May24-26(2006) Montreal, QC, Canada.

[10] Dongchan Lee, Chilho Yang: An analytical approach for design and performance evaluation of torsion beam rear suspension, Finite element in analysis and design 63 (2013) 98-106.

[11] Siraj MohammadAli Sheikh: Analysis of Universal Coupling under Different Torque Condition , IJESAT Volume-2, Issue-3, 690 – 694

[12] J. Melcher and M. Karmazínová: On problems of torsion analysis of steel members with open cross section, ELSEVIER Procedia Engineering 40 (2012) 262 – 267.

[13] Shinde Dinesh S., Solanki Pradeep M. and Chaudhari J. R.: Wear Analysis Of U- Joint Needle Bearing, International Journal of Science, Environment and Technology, Vol. 2, No 2, 2013, 162 – 167.

[14] Onesmus Muvengei a,*, John Kihiu a, Bernard Iku: Numerical study of parametric effects on the dynamic response of planar multi-body systems with differently located frictionless revolute clearance joints, O. Muvengei et al. / Mechanism and Machine Theory 53 (2012) 30 –49.

[15] J. Eddie Baker: On instantaneous translation in the couplers of spatial linkages, Mechanism and Machine Theory 35 (2000) 771+784.