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# Optimization and Analysis of Drive Shaft Using CAE Tools

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**ABSTRACT-** Drive shaft or propeller shaft is the essential part of Automobiles. It is used to deliver torque from transmission to the differential and further to the wheel to cause the motion of the vehicle. The drive shaft is used to connect with the transmission shaft with the help of universal joint whose axis intersects and the rotation of one shaft about its own axis results in the rotation of the other shaft about its axis. In present work the model of the drive shaft has been generated in Solid works and further imported in ANSYS workbench. A finite element analysis of the drive shaft has been carried out as a case study. In the present work the static analysis of a drive shaft has been carried out with the new design changes. The results for equivalent von-Mises stress, strain and deformation have been calculated by applying boundary conditions and compared with the existing results.

**KEYWORD**– Solid Works, ANSYS Workbench, Drive Shaft

## I. INTRODUCTION

This study employs Finite Element Analysis (FEA) to analyze components, necessitating practical applications for comparison with experimental data for validation. In this study, a drive shaft, widely utilized in various vehicles, serves as the focal component. Using SolidWorks, the drive shaft model was created and subsequently imported into ANSYS Workbench for analysis. A universal joint facilitates the connection between two shafts, enabling rotation of one shaft about its axis to result in the rotation of the other. The primary objective of this investigation is to conduct FEA on the drive shaft using Computer-Aided Engineering (CAE) tools, aiming to ascertain total deformation and stress distribution within the shaft. Deformation and stress contours are plotted and analyzed to discern patterns. Finally, the obtained results are compared and validated against existing data.

Optimizing the drive shaft also leads to a reduction in the weight of the universal joint assembly, thereby lowering overall costs. A substantial body of literature on Finite Element Analysis (FEA) exists. The literature review provided here examines significant advancements in FEA implementation. G. M. E. Cooke [1] explained an introduction to the Mechanical Properties of Structural Steel at Elevated Temperatures. Cooke presents data on the elevated temperature mechanical properties of hot rolled structural steel used in buildings and explains their physical meaning. The characteristics comprise Poisson's ratio, thermal expansion, phase transformation, stress-strain correlations, and elastic modulus. Several benchmarks are provided for room temperature data. Additionally, it aims to elucidate certain inconsistencies in measurements of elastic modulus and the challenges in simplifying stress-strain data.

R. Paoluzzi, G. Rigamonti and L. G. Zarotti [2] explained the simulation studies of vehicle-transmission interactions. In the context of dynamic simulation methodologies, the paper outlines a model for vehicle movement, incorporating both the internal powertrain system and the interaction between the vehicle's wheels and the ground. Two application areas are given as examples. The first refers to hydrostatic transmission sizing. The second part addresses how the system reacts to rapid changes caused by external stimuli or loads. Dynamic simulation is gaining popularity as an additional tool available to designers to improve the characteristics of physical systems. The recognized benefits of the approach are financial (by saving one or more prototypes and by cheaper planning of experimental tests); and related to performance (better understanding of the system behaviour, study of special working conditions or faults and analysis of the system sensitivity to the design parameters). An additional benefit is less recognized (i.e. the ability of simulation to integrate contributions from different specialized fields). In actual fact, this is the case with vehicle locomotion, a complex problem which involves two main fields (i.e. soil-vehicle interaction and power transmission). It is easy to understand that they interact and influence each other, but experience shows that their developments are almost independent. Consequently, the simulation environment seems to offer a promising opportunity of synthesis and synergy.

A. M. Heyes [3] carried out the automotive component failure. The failure of vehicle components is an area which is likely to affect all of us at one stage or another. This paper explores the distribution of component failures and their underlying causes. It presents four case studies to illustrate the methodology of analyzing failures in automotive components and the valuable insights that can be derived from such analyses.

S. R. Hummel, C. Chassapis [4] presented the configuration design and optimization of universal joints. Universal joints serve to link shafts that are not in perfect alignment and intersecting. They facilitate the transmission of rotational motion from one shaft to another. The joint consists of input and output yokes and a cross trunnion. The cross stunning joint comprises a block and two pins: a large pin passing through the block, and a small pin traversing the large pin and the block. This study outlines a systematic methodology for designing and optimizing the ideal universal joint. It establishes relationships to design universal joints with the minimal required diameter to withstand a specified input torque at a given joint angle. Joints designed using this method will guarantee non-interference between different parts of the mechanism during operation.

Krishan Gopal, Ravikant and Mukesh Didwania [5] conducted a modal analysis of a drive shaft to determine its natural frequencies, vibration modes, and corresponding deformations. Through deformation analysis, critical stress points and hazardous regions of the drive shaft were identified. The relationship between frequency and vibration mode is elucidated through the modal analysis of the drive shaft.

## II. MATERIAL PROPERTIES

In present work, structural steel material is selected because of its favorable properties. Structural steel posses' good tensile strength and is isotropic in nature. Table.1 shows all material properties of structural steel like young's modulus, Poisson's ratio, tensile strength, compressive strength, yield strength and density.

Table 1: Properties of Structural Steel

| **Material selected** | **Structural steel** |
|---|---|
| Young's Modulus,(E) | $2.0 * 10^5$ MPa |
| Poisson's Ratio | 0.30 |
| Tensile Ultimate strength | 460MPa |
| Tensile Yield strength | 250 MPa |
| Compressive yield strength | 250MPa |
| Density | 7850kg/m3 |
| Behavior | isotropic |

## III. CAD MODEL

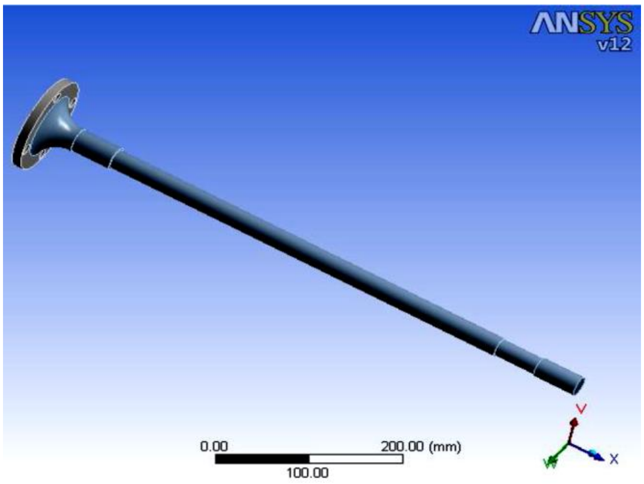


Figure 1: CAD model of drive shaft

3D CAD model of the drive shaft is shown in the above figure 1 which is generated in solid works and further imported in ANSYS.

## IV. MESHED MODEL

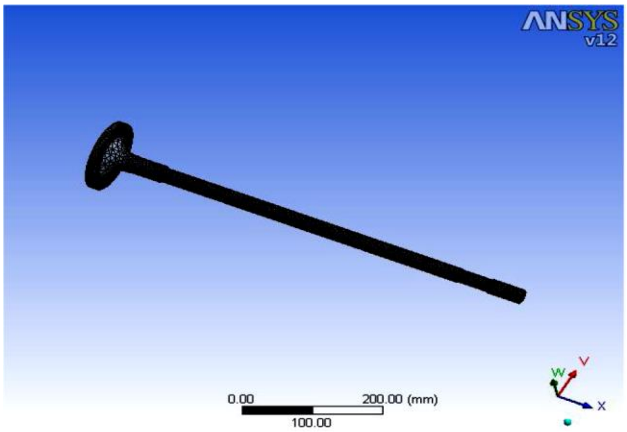


Figure 2: meshed model of drive shaft

In the above figure 2 represents the von mises stress model of the shaft. For efficient results we perform the von mises stress test. The meshed model of drive shaft is shown in figure 2. The number of elements is equal to 29484and number of nodes equal to 11069.

## V. LOADING CONDITIONS

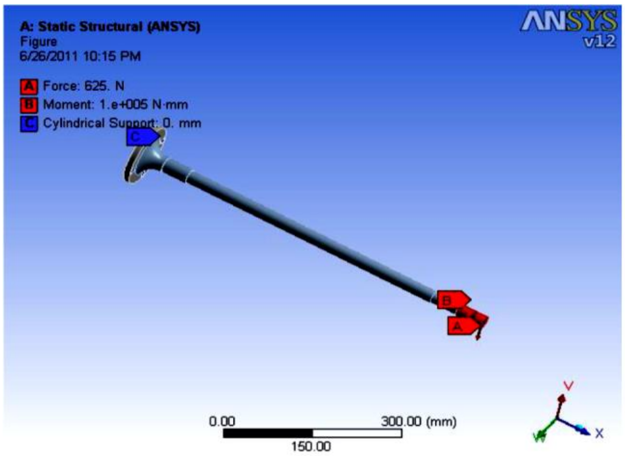


Figure 3: Boundary conditions

In the above figure 3, it shows the boundary conditions applied on the drive shaft. Boundary conditions are actual loading conditions in which the part perform. One end is provided with the moment and other end with a force.

## VI. RESULTS AND DISCUSSION

The FEA results for drive shaft for different parameters is shown in table 2. A variation of 11.18% has been found in between existing results and the computational results. The computational results are better than the existing results.

Table 1: FEA Results of Drive Shaft

| Sr. No. | Parameters | Existing results | FEA Results | variation |
|---|---|---|---|---|
| 1. | Equivalent von-Misses stress | 296 MPa | 262.90 MPa | 11.18% |
| 2. | Shear stress | - | 25.232 MPa | - |
| 3. | Elastic strain | - | 0.0013149 mm/mm | - |
| 4. | Total deformation | - | 15.742mm | - |

The maximum stress was found to be maximum near the head of the drive shaft and minimum at the other end. The red colour shows the maximum stress, deformation and strain and blue colour shows the minimum value. Figure 4 shows the maximum stress point. Figure 5 represents the total deformation in the object under loading conditions and figure 6 represents the shear stress induced in the shaft and the strain produced is shown in Figure 7.

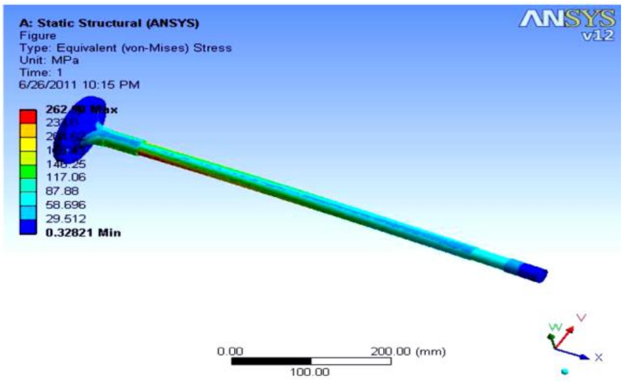


Figure 4: Equivalent von-mises stresses in drive shaft

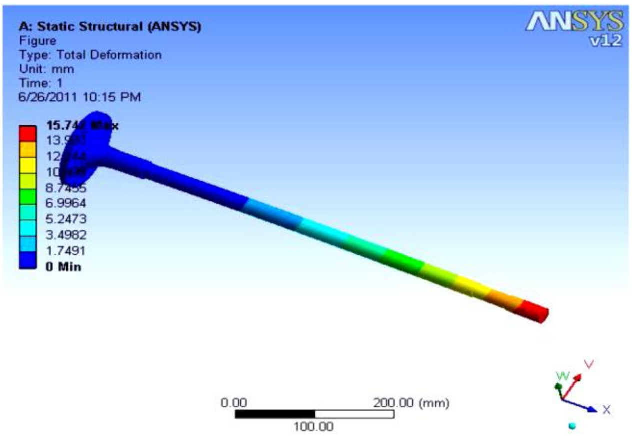


Figure 5: Total deformation

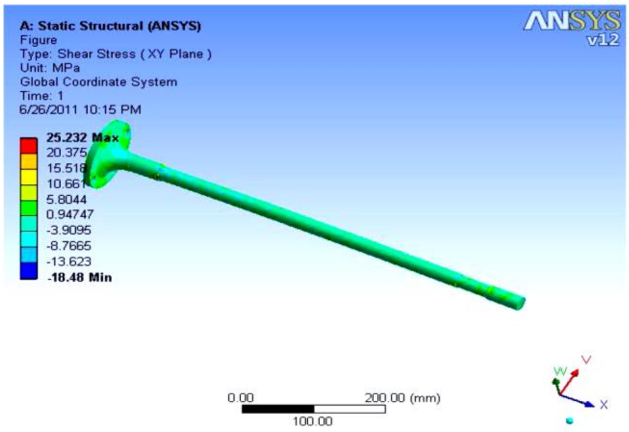


Figure 6: Shear stresses in drive shaft

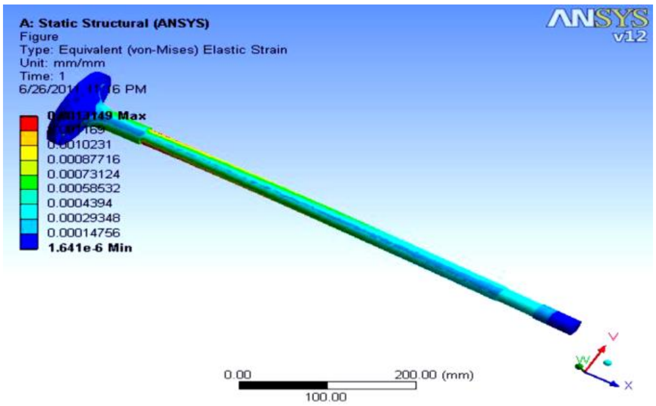


Figure 7: Equivalent von mises strain

## VII. CONCLUSION

Finite Element Analysis (FEA) was conducted on the drive shaft of the TATA 407 using the ANSYS Workbench tool. The obtained results closely align with existing data, affirming the accuracy of the model. The presented model demonstrates safety within permissible stress limits. Furthermore, assessments of shear stress, total deformation, and strain corroborate the excellence of the stress analysis results.

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