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Analysis of Screwed Shaft Failure using the Process Simulation of Loaded Torsion

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Abstract

The paper present the result of the study on the use of simulation software of ANSYS R15.0 version in attempt to simulate the load which is working on a screwed shaft of a shaping machine. This shaft was broken down during normal working and within limit of its life time. Therefore, the simulation aims to find out the cause of the failure by analyzing static and torsion load using von Misses criterion. In order to simulate the load, the mechanical properties and chemical composition of the shaft were used as the input for modeling. The shaft is made of medium carbon steel of S 45 C in round shape. The finite element method (FEM) was used for analyzing. The modeling was started with a 3D redrafting the real dimension of the shaft in a computer aided design (CAD) model, then imported to the ANSYS system into FEM format. The mechanical and physical properties of the material was entered as the engineering data. Meshing was made to divide the component into several small elements. A combination of static and torsion load was applied to the shaft with a fixed position. The simulation results shown that von mises stress of 4.546 MPa was achieved. While, the first principal stress of 4.518 MPa, the third principal stress of 0.538 MPa. Other result revealed that the displacement was 0.001602 mm. Simulation also indicate that failure occurs at the slot a place where the pin was inserted to lock between the shaft and the bevel gear. The result is in accordance with the real failure of the shaft. To conclude, the ANSYS with FEM modeling has succeeded to simulate the failure of the screwed shaft.

1. INTRODUCTION

Developments in the field of design and manufacturing of construction machinery have led to continuous testing of materials with various methods. Although all types of material on the market have undergone a process of testing the strength and mechanical behavior, it turns out there is still a lot of information needed by designers and technicians that have not been maximally fulfilled. One of the things that still needs to be done is research in obtaining dynamic and static material behavior in various loading conditions.

The screw shaft, as depicted in Figure 1, is one part of the engine component that is experiencing dynamic load voltage fluctuations will occur. When fluctuations that occur repeatedly as often as possible, there will be a failure, even though the maximum stress that occurs is still smaller than the static strength of the screw shaft material.

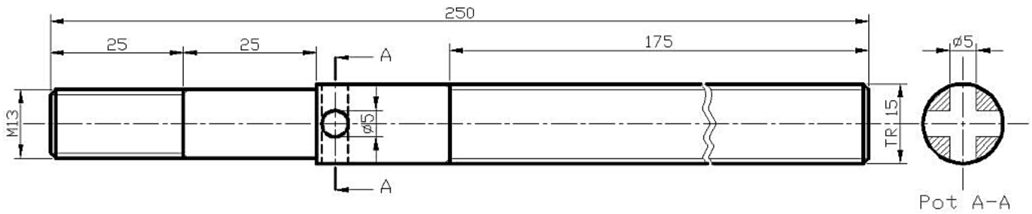


Figure 1. A Screwed Shaft

The failure of a material is inseparable from the structural characteristics it has. Screw shaft failure occurs at points where there is a stress concentration, where the source of the stress concentration in the engine element can be a notch, groove, hole, thread, peg and others as shown in Figure 2.

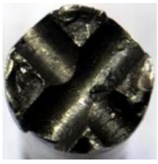


Figure 2. Screwed Shaft Failure

2. LITERATURE REVIEW

Torsionally loaded shafts are among the most commonly used structures in engineering, serves primarily to transmit torsion. These shafts are almost always hollow and circular in cross section, transmitting power from the transmission to the differential joint at which the rotation is diverted to the drive wheels [1-2]. Many shaft are manufactured from carbon steel [3] and sometimes is added with other alloy [4]. Also, the shaft goes into heat treatment to improve its prperties [5-8]. As in the case of the shaft length regulating drive shaft, it is important to note design methods for such structures are purely for inherent uses. However, we study they are here too because they illustrate the role of shear stress and strain.

Not all deformation is elongational or compressive, and we need to extend our concept of strain to include “shearing,” or “distortional,” effects. To illustrate the nature of shearing distortions, first consider a square grid inscribed on a tensile specimen as depicted in Fig. 2(a). Upon uniaxial loading, the grid would be deformed so as to increase the length of the lines in the tensile loading direction and contract the lines perpendicular to the loading direction. However, the lines remain perpendicular to one another. These are termed normal strains, since planes normal to the loading direction are moving apart.

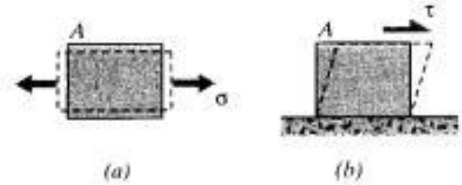


Figure 3. (a) Normal and (b) shearing deformations

Now consider the case illustrated in Fig. 3 (b), in which the load P is applied transversely to the specimen. Here the horizontal lines tend to slide relative to one another, with line lengths of the originally square grid remaining unchanged. The vertical lines tilt to accommodate this motion, so the originally right angles between the lines are distorted. Such a loading is termed direct shear. Analogously to our definition of normal stress as force per unit area, or σ = P/A, we write the shear stress τ as

$$\tau = P/A \qquad (1)$$

This expression is identical to the expression for normal stress, but the different symbol τ reminds us that the loading is transverse rather than extensional.

3. METHODOLOGY AND ANALYSIS

The computer simulation was executed using ANSYS software based on Finite Element Analysis. The geometry of shaft was given in Figure 1, and the material and its properties was given in the following. Screwed shaft with the type of steel construction machinery, the symbol S 30 C with the following specifications: Tensile strength 48 kg / mm2, elongation limit 29 kg / mm2, Hardness (Hs) 137-197 kg / mm2, Chemical Elements (%): C = 0.27-0.33, Si = 0.15-0.35, Mn = 0.60-0.90, P = 0.030, S = 0.035. The material is assumed as billinear isotropic hardening.

Research Steps:
1. Study the application of case study
2. Generate 3D CAD model using autodesk inventor 2018 software (Figure5)
3. To do the meshing of component
4. To do static analysis using ANSYS
5. Modify the material or geometry and conduct the analysis on same
6. Recommend Solution
7. Conclusion

The research steps was given in Figure 4 as follows:

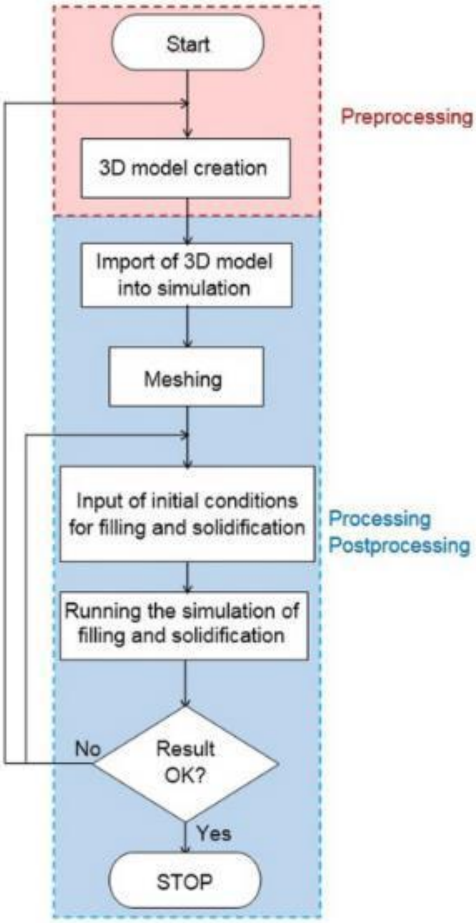


Figure 4. Flowchart

4. Results and Discussion

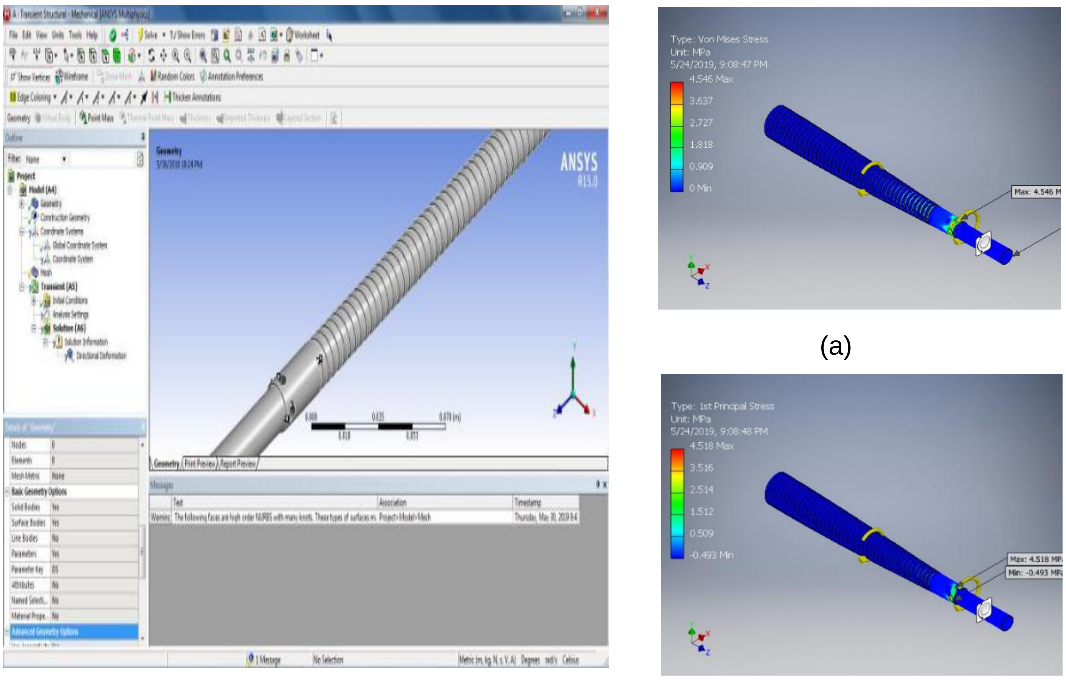
From the computer simulation, it can be obtained that the stress analysis report of physical and material of screwed shaft failure of the current model are appeared in table below:

Table 1. Physical

Material	Steel, Mild
Density	0.283599 lb mass/in^3
Mass	0.650741 lb mass
Area	15354.6 mm^2
Volume	37601.4 mm^3
Center of Gravity	x=-0.00339388 mm y=0.00352927 z=122.08 mm

Table 2. Material

Name	Steel, Mild	
General	Mass Density	0.283599 lbmass/in^3
	Yield Strength	30022.8 psi
	Ultimate Tensile Strength	50038 psi
Stress	Young's Modulus	31908.3 ksi
	Poisson's Ratio	0.275 ul
	Shear Modulus	12513.1 ksi



(a)

(b)

Figure 5. Modelling

The ANSYS examination demonstrates that von Mises stress of 4.546 MPa was achieved as given in Figure 5a. While, the first principal stress of 4.518 MPa, the third principal stress of 0.538 MPa as shown in Figure 5b. Other result revealed that the displacement was 0.001602 mm. All principal stress located near the pen hole so that caution must be given to the area during its service life.

5. Conclusions

From the simulation, it can be summarized that for screwed shaft, the failure may occur because of maximum stress zones were located near the pen hole and overlap the crack origins caused by high torque of the shaft. This conditions may leads to fatigue fracture of screwed shaft.

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References

1. Kapadia BM. In: Doane DV, Kirkaldy JS, editors. Hardenability concepts with applications to steels. Metallurgical Society of AIME; 1978. p. 448.
2. Kapadia BM, Broun RM, Murphy WJ. The influence of nitrogen, titanium and zirconium on the boron hardenability effect in constructional steels. Trans AIME 1968; Z4Z:1698.
3. Krauss G. Steels, heat treating and processing principles. American Society for Metals; 1990.
4. Morral JE, Cameron TB. Met Trans 1977; 8A:1817.
5. Levitin VV. Phys Met Metallogr 1960; 10:130.
6. Borisove VT et al. Phys Met Metallogr 1964; 17:80.
7. Mavropoulos LT, Jonas JJ. Can Metall Quart 1988; 27:235.
8. Watanabe S, Otani H, Kunitake T. Trans ISIJ 1983; 23:31.