Biomedical and Mechanical Engineering Journal (BIOMEJ)
e-ISSN: 2776-1983, p-ISSN: 2829-5242
Vol. 2, No.2, October 2022, pp 36-40

Torque Load Analysis on Rear Axle Shaft Material AISI 4340 Normalized

F A Nurmansyah[1] L Edahwati[1] R D Issafira[1] W Saputro[1] A K Faizin[1] T P Sari[1] W D Lestari[1] N Adyono[1]

[1] Department of Mechanical Engineering, Faculty of Engineering, University of Pembangunan Nasional Veteran Jawa Timur, 60294, Indonesia

Corresponding e-mail: 20036010012@student.upnjatim.ac.id

Abstract. The choice of rear axle shaft material on the car needs to be considered because this component affects the performance of the car. This component material is also very necessary, the selection of components used is AISI 4340 Steel Normalized, where this material contains Nickel, Chrom, and Molybden with the characteristics of the AISI 4340 Steel Normalized material is a steel material that has high hardness properties, can accept great pressure and force and not easy to deform. The method used is the Finite Element Method (FEM), this method uses a meshing size of 5 mm, to get more accurate results. Simulation results from rear axle shaft AISI 4340 Steel Normalized to determine the value of stress, strain, and safety factor from load variations of 1200 Nm, 1400 Nm, 1600 Nm, and 2000. The highest maximum stress value occurs at 2000 Nm torque load of 5.586×10^{8} Nm. The highest maximum strain value occurs at a torque load of 2000 Nm of 5.034×10^{3}. The safest value of the safety factor is 2.1 at a torque load of 1200 Nm. The torque load value is directly proportional to the stress and strain values obtained, because the greater the torque load value, the greater the stress and strain values obtained.

Keywords: Rear axle shaft, AISI 4340 Steel Normalized, torsion load, safety factor

1. Introduction

Rear axle shaft is a very important component in the automotive sector, especially in vehicles. Which is one of the general criteria that underlies the automotive design industry. The mechanical properties of a construction material are related to the resistance of the material to the magnitude of the intensity of the distribution of external forces during the vehicle. Therefore, characterization of the material on the rear axle shaft for the rear axle shaft is carried out which will later become input for domestic industries, especially the automotive industry [1].

Damage to the rear axle shaft often occurs in the area of the shaft, the tooth area, the fillet and wheel mount or the center area of the shaft. The load experienced by the rear axle shaft is obtained from the torque load and the load that comes from the weight of the vehicle and its load. This is done to get more profit, even though it has an impact on the life of the vehicle components being shorter. Therefore, characterization of the material on the axle shaft is carried out for the axle shaft which will later become input for industries.

In this study, AISI 4340 Normalized material is used which is a type of material commonly used in the industrial world. This material is composed of Ni, Cr, and Mo. This material undergoes a heating process to the austtenite phase, so that it gets the austenite microstructure. This type of material is widely

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used as vehicle components and engine components. This material is very tough [2]. The characteristics of AISI 4340 Normalized Steel are listed in table 1

Table 1. Characteristics of AISI 4340 Normalized Steel

Property	Value	Units
Elastic Modulus	2.05e+11	N/m^2
Poisson's Ratio	0.32	N/A
Shear Modulus	8e+10	N/m^2
Mass Density	7850	kg/m^3
Tensile Strength	1110000000	N/m^2
Yield Strength	710000000	N/m^2
Thermal Expansion Coefficient	1,23x10-5	K-1
Thermal Conductivity	44,5	W/(m·K)
Specific Heat	475	J/(kg·K)

This study uses a torque load of 1200 Nm, 1400 Nm, 1600 Nm, 1800 Nm, and 2000 Nm. With the aim of getting the maximum stress, maximum strain, and safety factors according to the given torque load. Torque load is the measured ability of the engine to produce work. Torque is the product of the tangential force and the arm in units of Nm [3]. If the load is added continuously, the shaft power will decrease, while the torque on the engine can increase, so that at certain placements it will reach maximum torque [4] [5].

2. Methodology

The material used in the rear axle shaft modeling for simulation design and testing as well as element analysis based on Solidworks 2020 is AISI 4340 Normalized. Figure 1. shows the flow of the research implementation method. The method used in this activity is the finite element method (FEM) used to estimate stress and strain on the rear axle shaft.

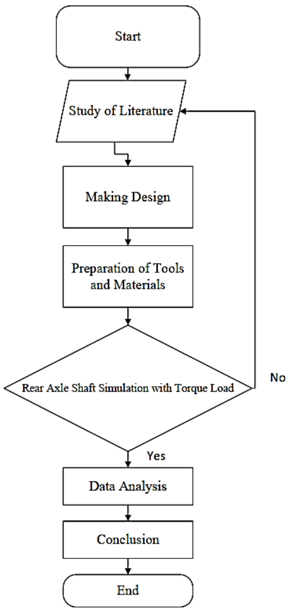

Figure 1. Research Method Flowchart

Limited element analysis provides a way to conduct research easily and efficiently on a wide range of parameters used under easy-to-evaluate design and manufacturing conditions. Meshing used is 5 mm. Meshing is a step to identify transform objects into small structures that facilitate analysis [6].

The next step is the simulation of boundary conditions including the load position and a fixed position used to provide a torsion load at the end of the axle shaft. The location of the hard constraint is the location of the component that is made to be static and cannot be moved during the simulation process. Fixed restraints are positioned in the area of the bolt holes connecting to the wheels. Stress and strain simulation stage with load variations of 1200 Nm, 1400 Nm, 1600 Nm, 1800 Nm, and 2000 Nm. The research procedure is described in the form of a flowchart **figure 1.**

3. Result and Discussion

Analysis of the simulation results of rear axle shaft AISI 4340 Normalized with variations in torque load of 1200 Nm, 1400 Nm, 1600 Nm, 1800 Nm, and 2000 Nm to get the stress and strain values.

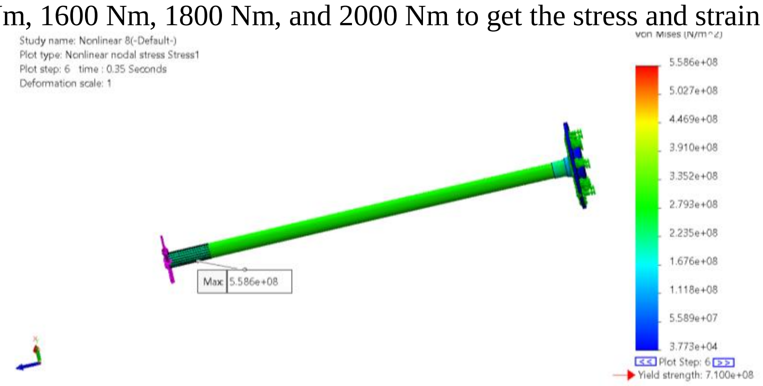

Figure 2 Maximum Stress at Torque Load 2000 Nm

Figure 3 Maximum Strain at Torque Load 2000 Nm

3.1 Stress

The stress value is obtained when the value of the force acting on the test object is divided by the surface area of the test object [7]. The value of the stress distribution is obtained in table 2.

Tabel 2 Nilai Simulasi Tegangan Maksimum

	Stress (Nm^2)				
Variation	1200 Nm	1400 Nm	1600 Nm	1800 Nm	2000 Nm
Maximum Stress	$3,366 \times 10^8$	$3,924 \times 10^8$	$4,480 \times 10^8$	$5,034 \times 10^8$	$5,586 \times 10^8$

3.2 Strain

The value of strain is obtained when the value of the initial length increase is multiplied by the value of the initial length of the test object [7]. The simulation results of the rear axle shaft strain distribution using AISI 4340 Normalized material are shown in table 3.

Table 3 Maximum Strain Simulation Value

Strain					
Variation	1200 Nm	1400 Nm	1600 Nm	1800 Nm	2000 Nm
Maximum Strain	3,565 x 10^{-3}	4,132 x 10^{-3}	4,687 x 10^{-3}	5,230 x 10^{-3}	5,034 x 10^{-3}

3.3 Safety Factor

The safety factor value obtained from the AISI 4340 Normalized axle shaft by dividing the yield strength value by the maximum stress value is shown in table 4.

Tabel 4 Safety Factor Simulation Value

Safety Factors					
Variation	1200 Nm	1400 Nm	1600 Nm	1800 Nm	2000 Nm
Yield Strength			7,1 x 10^8		
Safety Factor	2,1	1,8	1,58	1,41	1,27

The effect of torque variations on the stress and strain values on the rear axle shaft with AISI 4340 Normalized material shows that the data results are directly proportional. The higher the torque value given, the higher the stress and strain values obtained [5]. Based on table 2 the highest maximum stress value is obtained at 2000 Nm of torque with a value of 5.586 x 10^8 Nm. Meanwhile, the highest maximum strain value occurs at 2000 Nm of torque with a value of 5.034 x 10^3.

The yield strength value of the AISI 4340 Steel Normalized material is 7.1 x 10^8, where the safety factor value is obtained by dividing the yield strength by the maximum stress [8], the results of the safety factor values at 1200 Nm, 1400 Nm, 1600 Nm, 1800 Nm, and 2000 Nm torques are 2.1; 1.8; 1.58; 1.41; and 1.27. The maximum stress value obtained is equal to the yield strength value of AISI 4340 Steel Normalized. If the maximum stress value obtained is greater than the yield strength value, the safety factor value obtained will fracture [9] [10].

4. Conclusion

1. The simulation results obtained that the highest maximum stress value occurs at a torque of 2000 Nm of 5.586 x 108 Nm^2 and the lowest maximum stress value occurs at a torque of 1200 Nm of 3.366 x 108 Nm^2.
2. The highest maximum strain value obtained in the simulation results occurs at a torque of 2000 of 5.034 x 10^3 and the lowest maximum strain value occurs at a torque of 1200 Nm of 3.565 x 10^3.
3. The safest safety factor value occurs at 1200 Nm torque of 2.1 and the unsafe value occurs at 2000 Nm torque of 1.27.

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