Stress Analysis of Rear Axle Pick-up with Finite Element Method

F Mujahidin\textsuperscript{1} and Andoko\textsuperscript{2*}
\textsuperscript{1,2}Mechanical Engineering Department, Engineering Faculty, Universitas Negeri Malang, 65145 Semarang, Malang, Indonesia

\textsuperscript{*}Corresponding e-mail address: andoko.ft@um.ac.id

Abstract. The axle shaft wheel is the drive wheel shaft which functions to transmit power from the differential to the wheel. The rear wheels generally support heavier loads than the front wheels, consequently the wheel drive shaft construction is also relatively stronger. The method used was FEM with the help of ANSYS software. Based on the simulation results obtained the greatest stress value at Maximum principal stress is 365.02 Mpa. The results of crack analysis obtained J-Integral of 7,319 x 10^{-7} and based on the SIFS value (K1) showed the crack intensity every 1 mm\textsuperscript{2} was 0.34317 Mpa. material safety factor was 1.51 which indicates that the material is in good category. Means the fracture of the rear axle shaft occurs because of other factors between caused by a momentary shock load that is large enough or defective due to the fabrication process.

Keywords: atress analysis, rear axle, finite element, truck

1. Introduction

The axle shaft is the rotating shaft of the drive wheels which functions to transmit motion power from the differential to the wheels. The driving shaft in the vehicle is divided into two, namely the front axle shaft and rear axle shaft.

Failure or damage of a product still often occurs generally due to the load received over the capacity owned or other factors such as shock loads due to collisions, overloading [1]. Material damage usually starts from defects on the material surface due to the influence of environmental factors such as corrosion or wear due to interaction with other components [2]. The corrosion rate is dependent much on the solution concentration[3].

Failure can also be caused by the age usage of components that have exceeded the limit [4]. Failure on the rear axle shaft usually occurs due to excessive load. This makes the shaft work harder and when exposed to a slightly holey road will cause a shock load on the wheel that can break the drive shaft. Even though, safety aspects are most compulsory matter in the automotive world because they are closely related to the lives of the drivers and passangers [5].
Based on the explanation above, to reduce losses caused by a rear axle shaft fracture, a simulation of the rear axle shaft is needed to determine the stress distribution.

2. Method

Finite element method (FEM) was used to estimate the stress in the rear axle shaft [6]. Finite element analysis provides a way to carry out easy and efficient research on various parameters used with design conditions and manufacturing conditions that are easy to evaluate [6] [7] [8] [9].

2.1. Model Construction

The rear axle shaft in this article was designed using Autodesk Inventor Professional 2018 Software with the following dimensions as the rear axle shaft on the Mitsubishi L300 pick-up. This rear axle shaft uses JIS G4051 S43C material. Where the material properties consist of density = 7700 kg/m³, young's modulus = 200000 MPa, poisson's ratio = 0.3, yield strength = 550 MPa, and ultimate tensile strength = 880 MPa.

2.2 Simulation

Results of the rear axle shaft designs are simulated to the strength of the material used with ANSYS Workbench Software version 18.1. Simulation process of the rear axle shaft was by providing various loading conditions, including force giving of 23000 N, and a moment of 150 Nm, using a 3 mm meshing size.

The results of the simulation analysis performed, obtained stress and deformation on the rear axle shaft due to loading for maximum conditions. The results of the analysis are the basis for analyzing cracks on the rear axle shaft.

The crack dimensions include: 3 mm (major radius), 0.2 mm (minor radius), and 0.2 mm (large contour radius) with a meshing size of 3 mm. Then given a force of 23,000 N.
3. Result and discussion

Figure 3. Crack loading process

Figure 4. Equivalent stress (von-mises) of rear axle shaft

Figure 5. Maximum Principal Stress of rear axle shaft
3.1 Stress and Deformation

The maximum stress simulation results in Figure 4 showed the results of the equivalent stress simulation of the rear axle shaft with JIS G4051 - S43C material, the maximum equivalent stress value is located in red with the highest stress value of 238.61 Mpa. Figure 5 the maximum principal value of the highest stress is in red with the highest stress value of 365.02 Mpa. Figure 6 the highest maximum shear stress value of 125.51 Mpa. Failure in the form of a fracture rear axle shaft occurs on the outside of the bearing [4]. The bearing position is squeezed tightly on the shaft housing. This failure can occur because the load that is loaded is too heavy that causes the shaft to wear out quickly and because of the shock load from the holey road.

3.2 Crack testing

Based on the results of the crack test presented the results of J-Integral crack analysis of $7.319 \times 10^{-7}$ mJ/mm², while the maximum value of SIFS (K1) was 0.34317 MPa.mm$^{0.5}$. Based on the J-Integral value, it shows that the strain energy release rate of every 1 mm² cracks is equal to $7.319 \times 10^{-7}$ mJ. Whereas based on the SIFS value (K1) shows the fracture intensity in terms of material tensile stress every 1 mm² is 0.34317 MPa.

Cracks on the rear axle shaft result from continuous stress concentration resulting in fatigue on the surface. The strength of the real fracture of the material is always lower than the theoretical value because most materials contain small cracks that focus stress. If the load is above a certain threshold, microscopic cracks will begin to form on the surface, eventually the crack will reach a critical size, and the structure will suddenly crack [10]. The orientation of the ferrite laths in matrix can influence the crack path [11]. Cracks always start from stress raisers, so to eliminate cracking defects can be done by increasing fatigue strength.

3.3 Safety factor

The safety factor is a factor used to carry out the evaluation process so that the planning of machine elements is guaranteed to be safe even though the minimum dimensions are used [12]. The safety factor in this article is based on the stress of the principal stress [13]. The safety factor value is 1.51. Based on the calculation results of the safety factor on the rear axle shaft above, according to Vidosic [14] therefore the rear axle shaft meets the safe criteria.

4. Conclusions

The results of the simulation of the rear axle shaft obtained the highest maximum principal stress of 362.02 Mpa. For crack test, the maximum J-Inter value is $7.319 \times 10^{-7}$ mJ/mm² and the maximum...
SIFS value is 0.34317 MPa.mm$^{0.5}$. In the calculation of material safety factors, the safety factor value is 1.51. The results of stress simulation analysis and deformation on the rear axle shaft found that the material safety factor meets the standards, this can be interpreted that failure is not due to material factors that are not good but failure occurs due to a large enough momentary shock load.

References
[1] Karmiadji D W 2018 Optimasi Disain : Material, Komponen, Konstruksi. Teori dan Aplikasi. Fakultas Teknik .Engineering clinic
[2] Puspitasari P, Andoko A, Suryanto H, Risdanareni P and Yudha S 2017 MATEC Web Conf. 101
[3] Gapsari F, Andoko and Wijaya H 2018 Metalurgija. 57
[4] Syahril M 2013 Majalah Metalurgi, 28
[5] Mardji, Andoko and D.Prasetyo 2018 Strenght analysis chassis of UM electric cars using finite element method MATEC Web of Conferences. 204
[6] Andoko and P.Puspitasari 2016 Finite element analysis of surface tension on piston due to pressure variation International Mechanical Engineering And Engineering Education Conferences IMEEEC
[7] Andoko and N.E.Saputro 2018 Strength analysis of connecting rods with pistons using finite element method MATEC Web of Conferences. 204
[8] Andoko and Poppy Puspitasari 2016 Effect Of Temperature And Time Of Two-Step Austempering Method On Mechanical Properties For Nodular Cast Iron ARPN Journal of Engineering and Applied Sciences .11
[9] Andoko, P.Puspitasari and F.Gapsari 2018 Fatigue Crack Growth Behavior Of Nodular Cast Iron Subjected To Two-Step Austempering METABK. 57
[10] Shamsuddin A K, Tajuddin M S, M M A M M. Aris, M M 2014 The International Journal Of Engineering And Science. 3
[11] Andoko and Puspitasari P 2017 MATEC Web Conf. 97
[12] L. A. L. A 2018,Simulasi Kekuatan Komponen Sarana Pengujian Roket Menggunakan Autodesk Inventor Professional 2017 (Solo: Bukukatta)
[13] Kurniawan A 2014 Analisa Kekuatan Struktur Crane Hook dengan Perangkat Lunak Elemen Hingga untuk Pembebanan 20 Ton (Bengkulu)
[14] Vidosic J P 1957 Machine Design Projects (New York: The Ronald Press Company)