FAILURE OF DRIVE SHAFT USING FINITE ELEMENT ANALYSIS

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This project presented about a failure of drive shaft in conventional passenger vehicles. Perodua Kancil front wheel drive shaft was chosen as the specimen of this analysis. This project deals with analysis on stress using finite element method. The solid model of the drive shaft need to be constructs using SOLIDWORK software. The type of material used in the drive shaft need to be known first before stress analysis can be performed using Patran-Nastran software. The known material will provide the information such as density, modulus of elasticity and tensile strength required for the software to perform the stress and failure analysis. Spectroscopic analysis is carried out using FOUNDRY-MASTER UV instrument. The load applied at the ends of the shaft that are lateral bending load of 1/4 of weight of the full car. Boundary conditions are applied at the bearing and geared location. The highest stress at and displacement was predicted occurred at the fillet cross section location. Stresses will concentrate in the smaller diameter portion due to change in shaft diameter as they pass from large to the small diameter. In any case, one must determine the cause of failure and predict the fatigue life to prevent future occurrence and to improve the performance of the device, component or structure.

ABSTRAK

Projek ini mempersembahkan tentang kegagalan aci pemacu kenderaan penumpang konvensional. Aci pemacu roda depan Perodua Kancil dipilih sebagai spesimen dalam analisis ini. Projek ini berkaitan dengan analisis terhadap stres menggunakan kaedah unsur hingga. Model aci pemacu roda perlu pembina menggunakan perisian SOLIDWORK. Jenis bahan yang digunakan dalam aci pemacu perlu diketahui terlebih dahulu sebelum analisa tegangan boleh dilakukan dengan menggunakan perisian Patran-Nastran. Kandungan bahan yang dikenali akan memberikan maklumat seperti kerapatan, modulus elastisitas dan kekuatan tarik yang diperlukan untuk perisian bagi melakukan analisis stres dengan menggunakan perisian Patran-Nastran. Analisis spektroskopi dilakukan dengan menggunakan alat FOUNDRY-MASTER UV. Beban yang diterapkan pada hujung aci adalah 1 / 4 berat kereta penuh. Keadaan batasan diletakkan pada lokasi gear dan bebola. Tegangan dan pemindahan yang tertinggi diramalkan berlaku di kawasan keratan rentas filet.Tegangan akan menumpu pada kawasan diameter yang lebih kecil kerana perubahan diameter aci pemacu dari diameter besar ke diameter kecil. Dalam kes apapun, seseorang harus menentukan penyebab kegagalan dan meramal umur kelelahan untuk mengelakkan berlakunya kegagalan pada masa depan dan untuk meningkatkan prestasi komponen, peranti atau struktur.

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σ	Stress (MPa)
ε	Strain (MPa)

LIST OF ABBREVIATIONS

FWD	Front wheel drive
RWD	Rear wheel drive
4WD	Four wheel drive
CV	Constant velocity
OES	Optical Emission Spectroscopy

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The power produced from an engine of automobile can be transferred to the drive wheel by power transmission system. Each automobile has different power transmission system constructive features depend on the vehicle's driveline concept.(H.Bayrakceken et al., 2006) To transmit the driving torque from the engine or gear unit to the wheels, most of passenger car and light vehicle driven by combustion engine has at least two driveshaft as a basic requirement (Amborn, P. 1995).

During operation, torsional stress and bending stress was experienced by driveshaft due to the weight of the car or misalignment of journal bearing (Asi, 2006). In order to meet the requirements of one of the most highly stressed components in automotive assembly, a failure investigation must be conducted. Finite element method was used as stress analysis to determine the stress conditions at the failed section. Nearly all of driveshaft are metal shafts or metal tubes that has special joint at each end called universal joint (U-joint) or constant-velocity (CV) joint (Birch and Rockwood, 2005).

1.2 OBJECTIVE

The main objective of this project is:

i. To construct the geometry of the driveshaft using SOLIDWORK.
ii. To investigate the material composition of the drive shaft.
iii. To investigate the stress analysis and predict the failure of driveshaft using PATRAN-NASTRAN software.

1.3 SCOPE OF THE PROJECT

This project will focus on performing failure analysis to front wheel drive shaft of Perodua Kancil as in Figure 1.1 using PATRAN-NASTRAN software. The shaft has a total length of 677 mm with the outer diameter and the inner diameter of 117 mm and 100 mm respectively. The model must be constructed using SOLIDWORK software before it can be imported into PATRAN-NASTRAN to be analyzed. Spectroscopic analysis need to be done to the drive shaft using FOUNDRY-MASTER UV in order to know the type of material used. The physical and mechanical properties that will be used in stress analysis were taken from the material website database.

Figure 1.1: Perodua Kancil Front Drive Shaft

1.4 PROBLEM STATEMENT

Drive shafts are one of the most important components in vehicles. It generally subjected to torsional Stress and bending stress due to weights of components. Thus, these rotating components are susceptible to fatigue by the nature of their operation. Common sign of driveshaft failure is vibration or shudder during operation. Driveshaft mainly involves in steering operation of vehicle. Drivers will lose control of their vehicle if the drive shafts broke during high speed cornering. Because of this human life can be in great danger if we don’t know when, where and how the drive shaft will failed. It is very important to know the accurate prediction for the drive shaft to fail.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will explain more about the information collected related to this project such as automotive drive train concept, types of driveshaft, joint used in driveshaft, manufacturing process of driveshaft, the common type of failure to driveshaft, finite element method and fatigue.

2.2 DRIVETRAIN FUNDAMENTALS

An automotive drivetrain is an assembly of one or more driveshaft, universal joint, and slip joint that forms the connection between the transmission and the drive axle. The function of drivetrain is that it allows the driver to control the power flow, speed and multiple the engine's torque. Besides that, the drivetrain allow the driven wheels to make turns without causing excessive tire and gear wear. The design of the vehicle will determine how the configuration of the drivetrain is which can be front-wheel-drive (FWD), rear-wheel-drive (RWD), and four-wheel-drive (4WD) as shown in Figure 2.2 (Kershaw and Halderment, 2007).

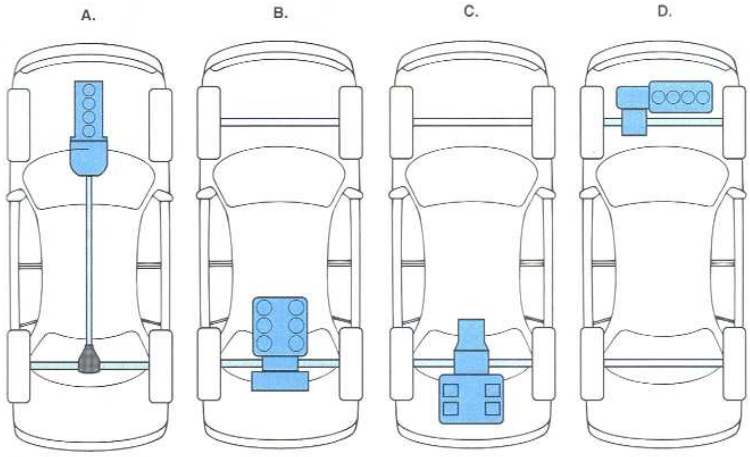

Figure 2.1: Four drivetrain configuration; (A) RWD with a front-mounted longitudinal engine. (B) RWD with a longitudinally mounted engine in front of the rear axle. (C) RWD with a horizontally-opposed engine mounted behind the rear axle. (D) FWD with a front-mounted transverse engine.

Source: Kershaw and Halderment (2007)

2.2.1 Rear-Wheel-Drive (RWD)

Nowadays, fewer vehicles were made as RWD except luxury car due to disadvantages compared to others drive train. This was the original layout for vehicle drive train concept before FWD was introduced. RWD is where the engine of the vehicle placed at the front while the drive line while the driven wheel located at the rear as shown in Figure 2.2. Moreover, moving the engine closer to the drive axle eliminates the need of a driveshaft. The drive train of a RWD consists of a clutch, transmission, driveshaft, and rear axle. The drive line connect the transmission output shaft to the rear axle (Crouse and Anglin, 1993).

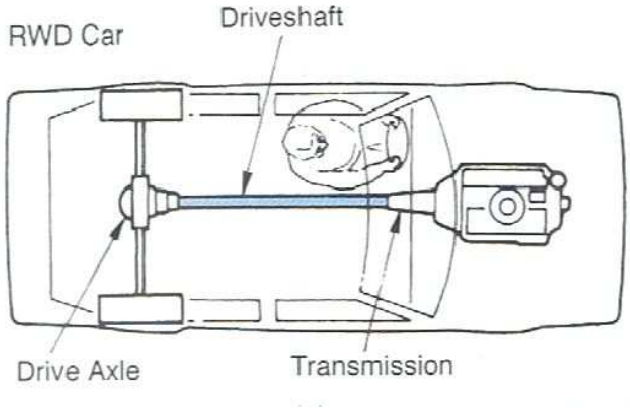

Figure 2.2: The drivetrain of RWD.

Source: Crouse and Anglin (1993)

The advantages of RWD is that there is no body vibration because the engine and gearbox are attach to the car frame through mount so that their vibration does not pass to the body.This will creates better confort to the user. By focusing the front wheels to do the steering, and the rear wheels driving the car will result in a better-balanced vehicle on dry pavement.This eliminates torque steer and improves acceleration. However there is disadvantages in RVD that make car manufacturer shift from RVD to FWD. It is more expensive to produce RVD vehicle because long rear driveshaft and rear drive axle is needed.Besides that, RVD cars are heavier and they have a tunnel in the middle of the body, which reduce the saloon space. More importantly, RVD tend to slip more in sharp snow or rain.

2.2.2 Front-Wheel-Drive (FWD)

The driveline concept that is more commonly used nowadays is the front-wheel drive (FWD) as shown in Figure 2.3. It consists of a clutch, transaxle, and a pair of drive shaft.(Birch and Rockwood, 2005).The major difference of FWD compared to RWD is that there is no propeller shaft used in FWD. The movement of the vehicle is generated by flowing the power from the differential section of the transaxle through halfshafts to the wheels.

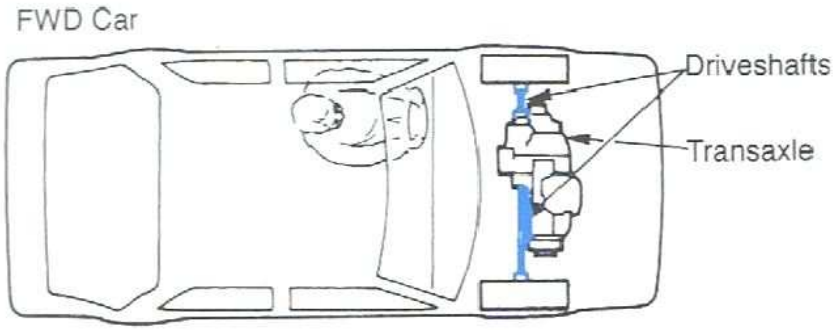

Figure 2.3: The drivetrain on FWD.

Source: Birch and Rockwood (2005)

The production cost far FWD vehicle is more economical due to the removal of propeller shaft and rear drive axle installation. Moreover manufacturer can lowered and flattened the floor in order to increase the amount of passanger compartment and trunk space due to the absence of propeller shaft. With most of its weight at the front, FWD holds an advantage in slippery conditions such as ice or snow as more weight is over the drive wheels reducing slip during acceleration. Weight reduction due to less component used will improve the fuel eficiency.However, the disadvantages of FWD are mainly the decrease in vehicle handling ability. With more weight over the front of the automobile, the back end tends to become very light. Rear tire traction is decreased and the car may swap ends on icy roads easier.

2.2.3 Four-Wheel-Drive (4WD)

A four-wheel-drive (4WD) vehicle is where the vehicle can drive two wheel all of the time all four wheel part of the time depending on the road condition as shown in Figure 2.4. Different 4WD vehicle has different four-wheel configuration. The basic types of configuration commonly use in industry is part-time 4WD, full-time 4WD, all-wheel-drive (AWD) and automatic 4WD. The 4WD vehicle drivetrain consist of a clutch, transmission, driveshaft, rear axle, transfer case, front driveshaft and front drive axle. Some of the component is similar to RWD drivetrain.

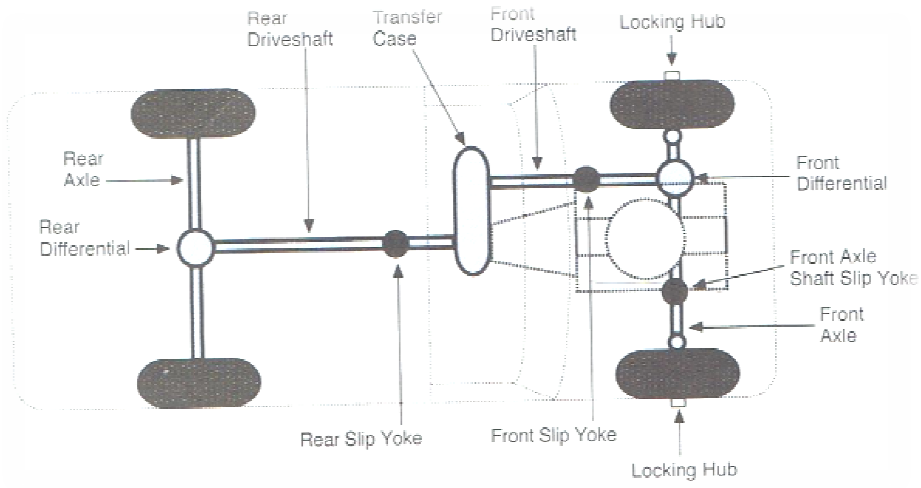

Figure 2.4: The drivetrain of 4WD.

Source: F.Kershaw and D.Halderman (2007)

During off-road driving and driving on wet or icy road, the 4WD drive train can increase traction to ensure safer driving experience (F.Kershaw and D.Halderman, 2007). Moreover, the vehicle will have more pulling power when it drives its entire wheel. The main disadvantage of 4WD is that higher manufacturing costs required due to complex transmission component and require more machinery. Moreover 4WD need more complex procedure of maintenance and repair compared to two-wheel-drive design.

2.3 DRIVE SHAFTS

Power produced by the engine will be transferred to the wheel though driveshaft. The usage of driveshaft as a power transmitter in automobile is more convenience because it is less likely to become jammed or broken compared to chain-drive. The construction features of driveshaft used is different depending on the drivetrain of the vehicle. RWD vehicle usually use drive shaft called propeller shafts that has universal joint (U-joint) and slip joint at each end. As for FWD vehicle use driveshaft called half shafts that has constant-velocity joint at each end (Crouse and Anglin, 1993). The function of the joint is to allow changes in suspension angle.

2.4 UNIVERSAL JOINT (U-JOINT)

A universal joint (U-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 driveshaft as shown in Figure 2.5. The most common types of U-joint used in automotive industry is Hooke or Cardan joint (Birch and Rockwood, 2005). A basic U-joint consists of driving yoke, driven yoke, spider and trunnions. Each connection part of the spider and trunnion are assembled in needle bearing together with the two yokes. The driving yoke force the spider to rotate the other two trunnions. The previous action causes the driven yoke to rotate.

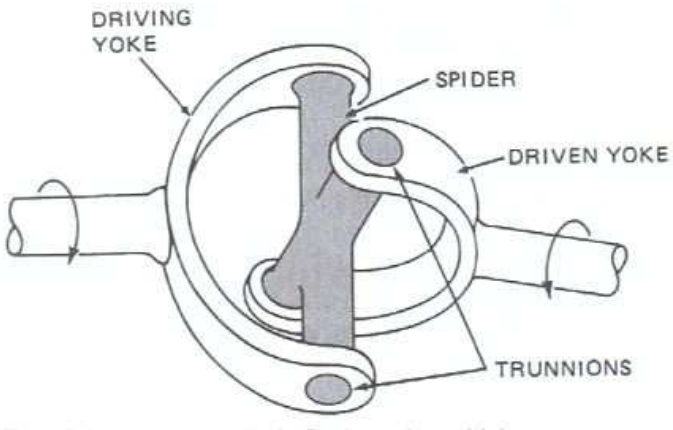

Figure 2.5: Universal joint

Source: Birch and Rockwood (2005)