UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ASSEMBLY ANALYSIS OF DIFFERENTIAL GEAR BOX FOR UTeM FV CAR

This report submitted in accordance with requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology (Automotive) with Honours

by

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I hereby, declared this report entitled “Design and Analysis of Differential Gear Box for UTeM Fv Car” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the Bachelor Degree of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

…….

ABSTRACT

A differential is a device usually, but not necessarily employing gears capable of transmitting torque and rotation. It combines two inputs to create an output that is the sum, difference, or average, of the inputs. In automobiles and other wheeled vehicles, the differential allows each of the driving wheels to rotate at different speeds. A vehicle's wheels rotate at different speeds, mainly when turning corners. The differential is designed to drive a pair of wheels with equal torque while allowing them to rotate at different speeds. Up to now, UTeM FV car use differential to send the power from engine to tire. But almost all differential in the market really heavy and will impact on engine speed or engine torque. So that, this differential is not suitable for racing car especially for UTeM FV car. The main aim of this project is to focus on the mechanical design and analysis on assembly of gears in gear. Analysis is conducted using Solid Work Simulation by varying the materials for gears such as Cast Iron and Aluminum Alloy. In this analysis, the cast iron material was replace to Aluminum Alloy for reducing weight of the product.

ABSTRAK

Gear perbezaan ialah sejenis peranti yang biasanya digunakan dengan gear untuk menghantar daya kilas dan putaran. Ia menggabungkan dua daya yang masuk dan menggantikan daya yang keluar dalam keadaan berbeza dari segi jumlah, perbezaan dan purata daripada daya yang masuk. Dalam teknologi kereta atau pun kenderaan beroda lain, gear perbezaan ini digunakan untuk membenarkan setiap tayar yang dipacu berputar dalam kelajuan yang berbeza. Tayar kereta akan berputar dalam kelajuaan putaran yang berbeza terutamanya ketika membelok atau mengambil selekoh. Gear perbezaan ini direka untuk menggerakkan kedua roda dengan daya kilas yang sama tetapi dalam kelajuan yang berbeza. Sehingga hari ini, jentera FV utem menggunakan gear perbezaan untuk menghantar daya kilas dari enjin ke tayar. Akan tetapi, kebanyakan gear perbezaan yang ada masa kini terlalu berat dan akan memberi kesan terhadap prestasi enjin dan daya kilas enjin. Jadi gear perbezaan masa kini tidak sesuai untuk digunakan untuk kereta lumba terutamanya jentera FV Utem. Tujuan utama kajian ini dijalankan ialah untuk meghasilkan lukisan mekanikal dan untuk membuat analisis terhadap gear yang berada dalam gear perbezaan. Analisa juga dijalankan terhadap gear menggunakan bahan yang berbeza iaitu besi tuang dan aluminium aloi. Kebanyakan gear yang ada kini dibuat menggunakan besi tuang. Analisis ini akan menggantikan besi tuang kepada aluminium aloi untuk menghasilkan gear perbezaan yang lebih ringan. Analisis dijalankan menggunakan perisian "Solid Work".

DEDICATIONS

I dedicate this thesis to my family especially to my parent Mr. Md Salleh Bin Md Yusoff and my loving mother Mdm Saleha Binti Abd Rahim for nursing me with affections and love lecturer at UTeM especially for my supervisor Dr. Muhammad Zahir Bin Hassan, friends and those people who have guided and inspired me throughout my journey of education.

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LIST OF SYMBOLS AND ABBREVIATIONS

P = power

d_G = diameter of gear

α = helix angle

E = youngs modulus

T_p = no of teeth on pinion

Gear ratio = GR

No of teeth on gear = T_G

Diameter of gear = D_G

Diameter of pinion =D_P

Equivalent no of teeth on pinion = T_{EP}

Equivalent no of teeth on gear = T_{EG}

W_T = tangential tooth load

K =load stress factor

Ww=wear load

Torque =T

Equivalent twisting moment = T_e

Revolution per minute = RPM

Four wheel drive = 4WD

All-wheel drive = AWD

Computer aided engineering = CAE

Formula varsity = FV

Limited slip differential = LSD

Finite element analysis = FEA

Internal combustion engine = ICE

N = Rotation per minute (RPM)

Fc = Centrifugal force

M = mass

V = speed velocity

CHAPTER 1
INTRODUCTION

1.0 Introduction of Differential Gearbox

Differential is a device, usually but not necessarily employing gears, capable of transmitting torque and rotation through three shafts, almost always used in one of two ways in one way, it receives one input and provides two outputs this is found in most automobiles and in the other way, it combines two inputs to create an output that is the sum, difference, or average, of the inputs (Veeranjaneyulu and Babu, 2012).

Heng Sun had a detailed study to the differential gear trains about its force and efficiency (Heng, 1990). Shaolie and Cao had a research about the movement of the differential gear trains under the inotropic effect (Cao and Shaolie, 1997). A vehicle's wheels rotate at different speeds, mainly when turning corners. The differential is designed to drive a pair of wheels with equal torque while allowing them to rotate at different speeds. A conventional "open" (non-locked or otherwise traction-aided) differential always supplies close to equal (because of limited internal friction) torque to each side (Chocholek, 1988).

Today's, manufacturing industries are very much interested about the quality of their products. They are focused on producing at higher productivity and quality in time and at minimum cost (Domnita F. F., 2013). Gear manufacturing process has been one of the most complicated of the metal cutting processes. Spur Gears are very useful in numerous applications. They can transfer power from one shaft to another (V. Siva Prasad et al, 2012).

1.1 History of Differential

It is not known who developed differential gear system. It seems obvious that the idea is older than many of Leonardo da Vinci's (1452-1519) innovations. English innovator James Starley (1830-1881), known as " Father of the Bicycle Industry', utilized a differential apparatus system as a part of an exceptional sewing machine in around 1850. In 1877 he utilized the differential gear as a part of a street vehicle. As far as anyone knows, differential gear was utilized as a part of a street vehicle surprisingly by German Rudolph Ackerman in 1810. Discoveries in China demonstrate the presence of this component going back to around 300. In the year 1900 a greatly complex Antikythera system (named after nearby antikythera island of Greece, where the ship was found) was found in a boat wreck. The component was a precisely composed and created in bronze and wood. It was a kind of computer to compute the position of planets and stars (Kobal, 2006). Others analyse the force stream and cross section productivity of the differential gear trains demonstrates that while cornering, the inward wheel needs to travel a shorter separation than the external wheel, so with no differential, the outcome is the internal wheel turning and the external wheel dragging. This outcomes in troublesome and eccentric taking care of, harm to tires and streets, and strain on (or conceivable disappointment of) the whole drive train (Baoxian and Wenfeng, 1999). It takes almost no torque to turn the side on elusive ice, and on the grounds that a differential parts torque similarly to every side, the torque that is connected to the side that is on black-top is restricted to this sum (Bonnick and Allan, 2001).

1.2 Problem statement

At first, this research made a detailed description on analysis to the UTeM FV car differential gear train, and the obtained the relationship between speed and torque of the input/output side of type differential. Up to now, almost differential in the market really heavy and will impact on engine speed or engine torque. Existing differential has low tensile strength, elastic modulus. This is not suitable to use for racing car

especially for UTeM FV car. However, differential must build using harden and withstand high torque material. Thus Differential gear box needs to be redesigned providing energy saving by weight reduction, providing internal damping, reducing lubrication requirements and have high tensile strength, elastic modulus, poison‟s ratio, mass density and shear modulus without increasing cost. A proposed way to distribute the power to the wheel is to use the concept of gearless differential of which a review has been reported by Provatidis (Provatidis, 2003). To create some lightweight and compact differential, the detail analysis is conducted using Solid Work simulation to verify the best material for the gears in the gear box at higher speeds by analysing stress, displacement and also by considering weight reduction. This study was carry out to reduce the weight of UTeM FV car and improve the car to take a cornering at high speed without over steer or understeer issue.

1.3 Aim and Objective of Research

1.3.1 Aim

The overall aim of this research is focus to develop the mechanical design and static analysis on the assembly of gear in gear box when the UTeM FV car differential transmit power at 1000 rpm and 5000 rpm. Besides that, this analysis research also conducted by varying the material for gear. The selected material is Grey Cast Iron and Aluminium Alloy. The analysis is conducted to verify the best material for the gears in the gear box at higher speeds by analysing stress, displacement and also by considering strain.

Design calculations are done on the differential of Daihatsu Mira L2 by varying materials and speeds. Differential gear is modelled in Solid Work. Analysis is done on the differential by applying force at static. Analysis is carried out using Solid Work simulation.

1.3.2 Objective

Based on the problem statement the objective have been drawn:

I. To design and analyse differential for UTeM FV car

II. To determine the best material for UTeM FV car differential

1.4 Organization Thesis

Chapter 2: Review for any available journal or thesis that had been made preciously for any connections with the purpose of this analysis. Any journal that can be found to have any information regarding some of the analysis.

Chapter 3: Making a mere draft on how the analysis project can be done to verify each and every single step. Making sure the analysis is done according and save time while doing the analysis. Appointing the material that are usually easy to be fine in the market by doing a survey for types of differential and select the best material for analysis. Showing the list of material and brand available. Sketch all of component that be related to differential and all of the component design need to assemble using assemble design at Solid Work 2015. List of all material chosen and its behaviour using Solid Work Simulation. Knowing the percentage and it effect on other material.

Chapter 4: Showing the analysis result and its properties. Discussion on what size and type of differential system. Shows the step of making a dimension for drawing use in analysis. Showing how the software been use to make an exact drawing with the type of differential material chosen.

Chapter 5: Conclusion been made based on the result and the recommendations made from this analysis.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The subject of differential has produced a significant volume of writing which incorporates various speculations that have been planned to clarify the systems of differential. This chapter begins with an introduction to the automotive powertrain system, to give an overview of differential components and their function. The scientific findings are categorised into theoretical, Solid Work Simulation is used to tackle and analyse the best material for differential. A review of differential analysis is also described. The consequent segment talks about exploratory examinations that have been utilized to ensure this studies achievement. The structure of the chapter is shown in **Figure 2-1**.

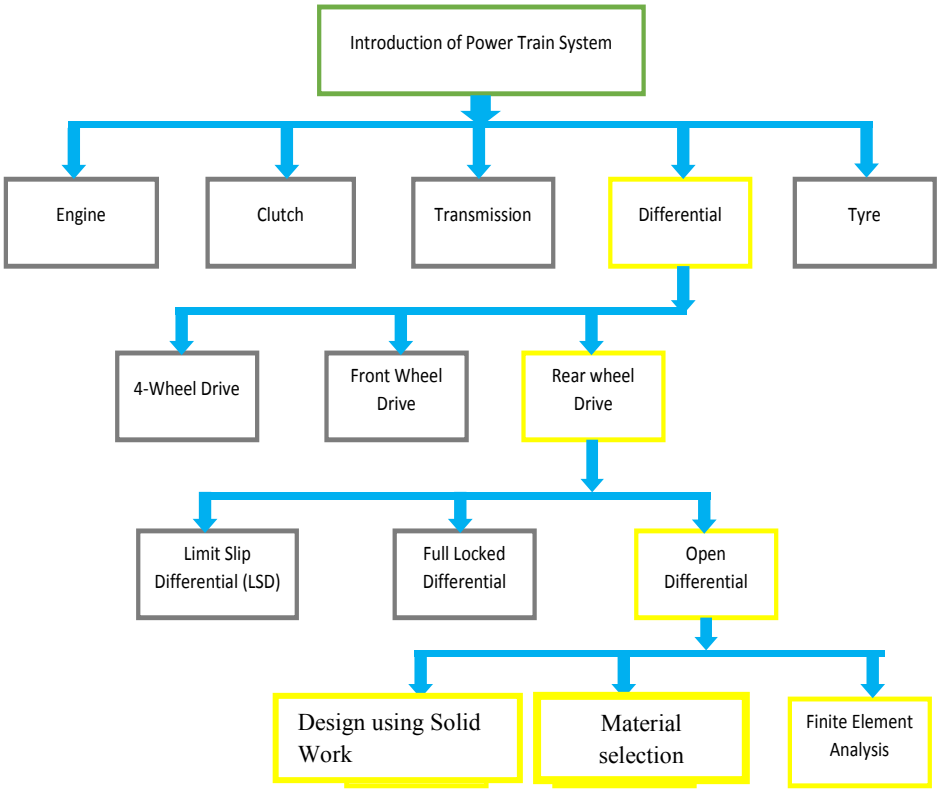

Figure 2.1: Overview of Literature Review

2.1 Power Drive train

The drive train serves two capacities. It transmits power from the motor to the drive wheels, and it changes the measure of torque. Force is the rate or speed at which work is performed. Torque is turning or bending power. Various proportion gearboxes are important on the grounds that the motor conveys its greatest force at specific velocities, or RPM (Rotations every Minute). With a specific end goal to utilize the same motor RPM's at distinctive street speeds, it is important to change the apparatus proportion between the motor and the drive wheels. The main component of power train is shown in **Figure 2-2**.

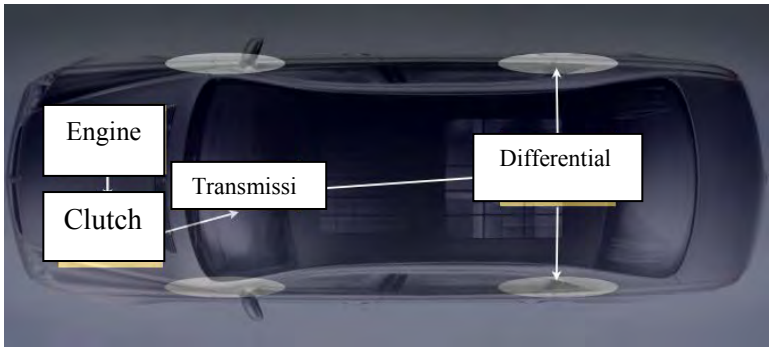

Figure 2.2: Topology of the powertrain System (Makaran, 2007)

There are really two arrangements of gear in the drive train, the transmission and the differential. The transmission allows the gear ratio to be balanced, and the differential lets the drive wheels turn at difference speed. Manual transmissions ordinarily have four or five speed. A transmission is a speed and power changing device installed at some point between the engine and driving wheels of a vehicle. It provides a means for changing the ratio between engine RPM and driving wheel RPM to best meet each particular driving situation. Torque is derived from power. The amount of torque obtainable from a source of power is proportional to the distance from the center of rotation at which it is applied.