DYNAMIC ANALYSIS OF A LIGHTWEIGHT CLUTCH DISC

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SUPERVISOR DECLARATION

'I admit that had read this thesis and in my opinion this thesis was satisfied from the aspect of scope and quality for the purpose to be awarded Bachelor of Mechanical Engineering (Automotive)'

Signature : .....

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Date : 30 MAY 2012

DECLARATION

"I verify that this report is my own work except for the citation and quotation that the source has been clarified for each one of them"

Signature : .....

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Date : 30 MAY 2012

To my father, Zainal Abiden bin Sayadi, my mother, Zauyah binti Abd Hamid, my siblings, my friends and my supervisor, Encik Fudhail bin Abdul Munir, for supporting me throughout this project and for their understanding in the way I am.

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ABSTRACT

The name of clutch has become established due to its meaning of grasp or grip tight. The clutch has the function to enable one rotary drive shaft to be coupled to another shaft, either when the both shaft are stationary or when there is relative motion between them.

In this project, we are focusing on the designing of dry clutch disc by using software of Computer Aided Drafting (CAD) that is CATIA V5. The method that arc we will go through of the designing in engineering which consist of research, observation, application of theory and justifying the result obtained and also analysis process. The designed parts are compatible and efficient with a companion parts.

In this study, both finite element analysis are conducted to explore the effects of design parameters on the slipping torque of lightweight clutch. Modeling by the Finite Element Model (FEM) which can result from the choice of numerical parameters such as: symmetry conditions, contact parameters, convergence parameters or mesh density. This dynamic analysis can be done using software of Finite Element Analysis (FEA) that is ANSYS.

It is found out in this study that the maximum shear stress value is $3.9109e^5\ Pa$ for spindle part, meanwhile the disc composition maximum shear stress is $1.0853e^5\ Pa$. The total deformation value for spindle part is $6.8442e^{-7}m$ and for disc composition is $6.0635e^{-7}m$.

TABLE OF CONTENT

CHAPTER TITLE **PAGE**

CHAPTER TITLE PAGE

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOL

T	=	torque transmitted, Nm
P_{max}	=	maximum pressure applied onto the clutch, Pa
F	=	force act
r_o	=	outer radius, m
r_i	=	inner radius, m
D_i	=	inner diameter of the clutch, m
D_o	=	outer diameter of the clutch, m
σ	=	stress (Yield Strength)
E	=	modulus of elasticity (Young's Modulus)
ε	=	strain
	=	change in length (deformation)
L	=	original length (thickness of clutch disc)
τ	=	shear stress
J	=	polar moment of inertia (hollow shaft)
A	=	area of part.

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Background

A clutch is a mechanical device, by convention understood to be rotating, which provides driving force to another mechanism when required, typically by connecting the driven mechanism to the driving mechanism. The name of clutch has become established due to its meaning of grasp or grip tight (Heinz Heisler, 1999).

Clutches are useful in devices that have two rotating shafts. In these devices, one shaft is typically attached to a motor or other power unit (the driving member), and the other shaft (the driven member) provides output power for work to be done. The clutch connects the two shafts so that they can either be locked together and spin at the same speed (engaged), or be decoupled and spin at different speeds (disengaged).

Dry clutch are widely used on large trucks and heavy industrial units. The main advantages of dry clutch are its large contact area and the main components of a dry disc clutch are pressure plate and the disc.

1.2 Objective

The objectives of this project are:

1. To design a lightweight dry clutch disc
2. To study dynamic analysis for lightweight dry clutch disc using CAE software.
3. To investigate the behavior of lightweight clutch disc under axial force.

1.3 Scopes

The scopes of study for this project are:

1. To generate 3-dimensional geometry model of a lightweight clutch disc by using CATIA V5R12.
2. To study the dynamic stress of a lightweight clutch for capacity under the torque of 150Nm.
3. Simulation analysis will be done by ANSYS 12.1 or ABAqus 6.9.

1.4 Problem Statement

This project will enable me to understand more about the clutch disc of a vehicle. As we know clutch system are crucial in the performance of a vehicle. Due to the project we will investigate the performance of vehicle by doing the dynamic analysis on the clutch disc.

Nowadays, lightweight disc clutch is an essential part for vehicle. The lighter the overall weight, the higher the fuel efficiency will be. Apart from that, the light clutch enables the manoeuvre without the feel of high contact pressure, it is driver friendly. There are not many references that can be obtained pertaining to methods need to be employed in order to design a proper clutch disc. The resources are very limited. Therefore, a reverse engineering for a design need to be done, this method are mostly base on a real model of clutch disc that available in market. Therefore, by embarking into this project, the methods to design a clutch disc can be acquired. Then, dynamic analysis will be conducted onto the designed disc to investigate the parameter that affected the performance of the clutch disc.

By reducing weight are able to reduce fuel consumption and enhance the performance that can be obtained and knowing how to design clutch disc, we are able to manipulate the parameters involves to improve the design feasibilities.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Clutches

A clutch is a mechanical device for quickly and easily connecting or disconnecting a pair of rotating coaxial shafts. It is usually placed between the driving motor and the input shaft to a machine, permitting the engine to be started in an unloaded state. Single plate, dry clutch is among the popular type of clutches in use (Lee and Cho 2006). Mechanical clutches fall into two main categories: positive engagement and progressive engagement. (Garret et al. 200 1).

2.1.1 History of Clutch Disc Development

In 1885, it was reported that when Karl Friedrich Benz has invented the first commercial gas powered automobile, the famous Tri-Cycle, he also was the first person to invent and use the clutch system to the car (Wikipedia website 2007). Exedy Corp., one of the major players for clutch technology, which manufactured clutches under the brand name of Exedy and Daikin, was reported to produce rigid type disc clutch since 1918, which was a clutch disc with the plate and spline hub

secured by rivets (Daikin Clutch website 2007). Until now, clutch manufactures has come out with new and efficient technologies for clutch system to compensate higher torque produced by bigger engine created especially for heavy vehicles.

2.1.2 Lightweight Clutch Disc

The heaviest components of the clutch system are the clutch cover, plates and flywheel. Full Carbon clutches utilize carbon clutch and intermediate achieving a reduction in total weight. Semi-Carbon clutches incorporate an improved cover configuration and lightened flywheel also enabling a reduction in vehicle weight. In 1995 Exedy supplied Carbon clutch products for use in the pinnacle series of motor sport, Formula One. This same technology is now applied to Carbon clutches developed by Exedy for use in various forms of motor-sport providing an explosive shift feeling and dramatic improvement in engine response. (www.exedy racing.com.). The carbon material exhibits a low density, excellent heat and wears resistance, high mechanical strength and excellent dimension stability. (www.sicom-brake.com).

The common materials for clutch disc are asbestos. Asbestos is nearly an ideal friction material for brake lining and clutch facing because it has a very good coefficient of friction, excellent heat characteristics, and low cost (Thomas Birch, 1999). However, it has the possibility to cause cancer from inhaling its fibers. Due to this, the use of asbestos has been decreased significantly. Asbestos has been replaced with fiberglass and aramid nonmetallic compounds and metallic friction facings using various mixtures of powdered iron, copper, graphite, and ceramics to obtain the desired friction and wear characteristics.

Some clutches use a ceramic material of clay and metal. Frequently a composite metallic friction material or a cellular paper material is used. These materials have good durability and friction capacity in oil. However, ceramics have several disadvantages. Firstly, it is difficult to be manufactured and secondly is ceramics can cause the mated pairs to wear excessively.

2.2 DISC CLUTCH

Disc clutch can be either dry or wet. Dry here means the clutch operates in dry condition. On the other hand, wet here means, the clutch operates in oil bath or spray. Dry clutch are widely used on large trucks and heavy industrial units. The main advantage is it large contact area. However, dry clutch are not recommended to be used in condition where frequent disengaging or slipping is required due to the heat build up (Donald etc al. 1974). Wet clutch are actuated either mechanically or hydraulically. Operation in oil reduces wear and provides cooler operation. The major difference between the dry and the wet clutch is that the disc facing material. In a wet clutch, this material must grip when soaked in oil.

Today's passenger cars and light trucks are now almost exclusively equipped with conventional friction clutches (i.e. diaphragm spring clutches). In this work,
We only consider dry friction clutches. It is composed of the clutch disc, the flywheel, and the mechanism, which is itself composed of a cover, a diaphragm spring, and a pressure plate (Fig. 2.1). When the engine rotates freely (no gear engaged) no torque is transmitted because the clutch disc is not in contact with the mechanism and rotates freely (Fig. 2.1). When a gear is engaged, the clutch disc is compressed by the diaphragm spring between the pressure plate of the mechanism and the flywheel transmitting the rotary motion and the torque to the mechanism and thus to the wheels.

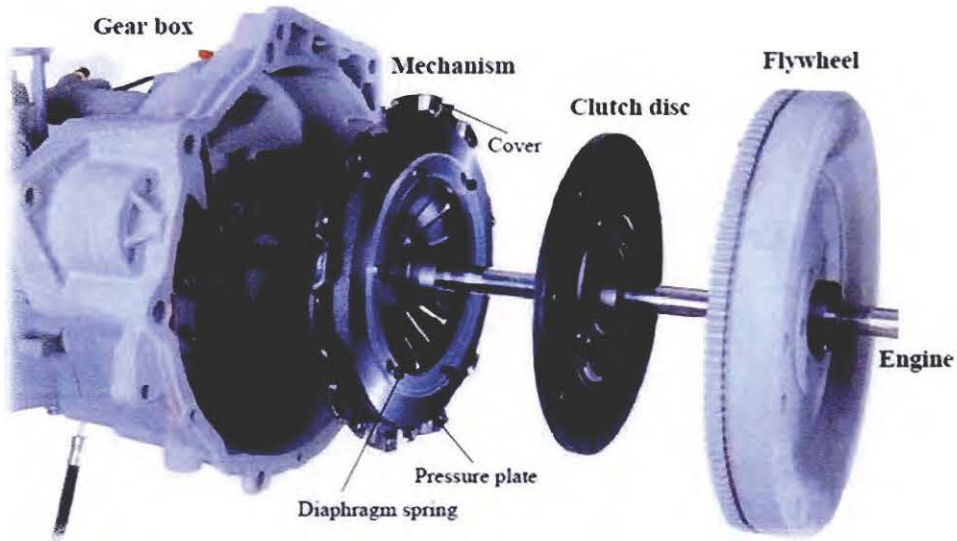

Fig. 2.1: View of the clutch.

The clutch disc is crushed between the mechanism pressure plate and the flywheel to transmit the torque from the combustion engine to the transmission. The necessity of coupling or decoupling the engine and transmission during gearshift induced the development of optimized clutch components that aim to transmit the torque between the pressure plate and the flywheel. In this work, we investigate the behavior of the clutch disc (Fig. 2.2). It allows a soft gradual re-engagement of torque transmission. This progressive re-engagement obtained by the clutch disc characteristics in the axial direction preserves the driver's comfort and avoids mechanical shocks. It also plays the role of a damper through the springs disposed around the hub. They enable the clutch disc to filter the torque variations of the combustion engine (Fig. 2.2).

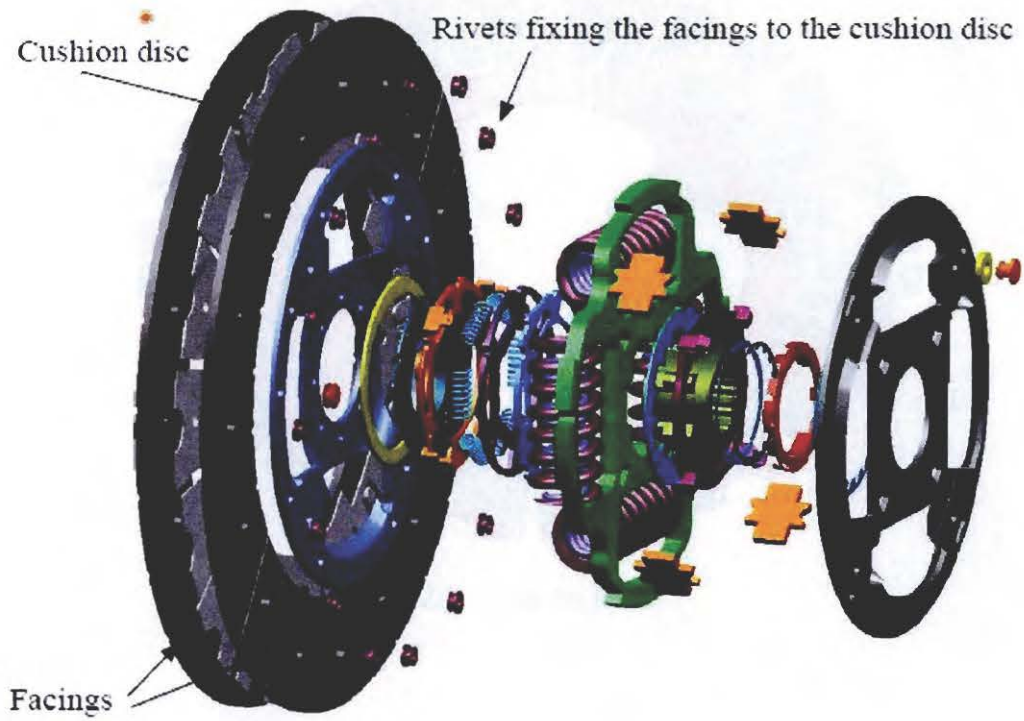

Fig. 2.2: Detailed design of the clutch disc

The axial elastic stiffness of the clutch disc is obtained by a cushion disc (Fig. 2.3) which is a thin waved sheet, located between the two facings and fixed by rivets. It acts like a spring allowing a soft gradual reengagement. This nonlinear axial stiffness is obtained by cutting the cushion disc into paddles and forming them to get the wavy shape.

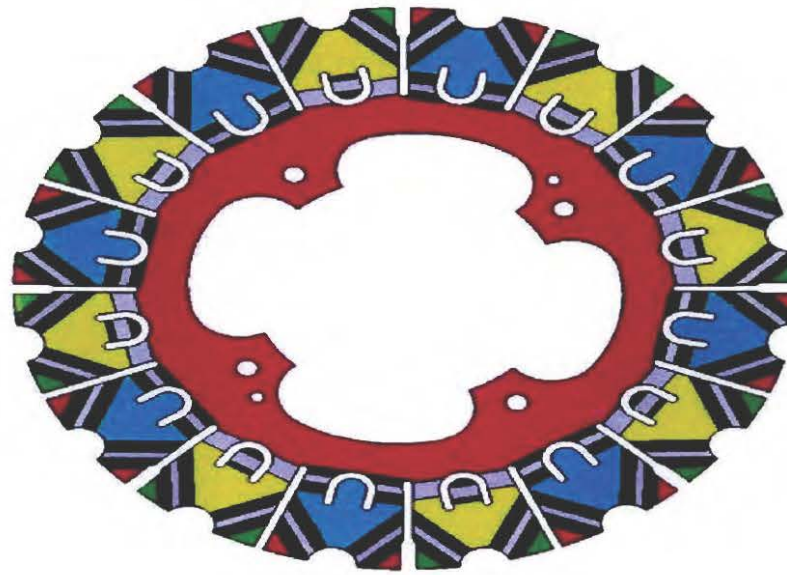

Fig. 2.3: Cushion Disc.

2.2.1 Type of clutch disc

The name of clutch has become established due to its meaning of grasp or grip tight. The clutch has the function to enable one rotary drive shaft to be coupled to another shaft, either when the both shaft are stationary or when there is relative motion between them (Heinz Heisler, 1999). The need for the clutch stems is mainly from the characteristics of the turning effort developed by the engine over its lower speed range. When idling, the engine develops insufficient torque for the transmission to be positively engaged. The engine speed has to be increased before complete coupling without slip may be made. Basically, in agricultural machinery, there are three main clutches that normally used. These clutches are disc clutch, cone clutch, and overrunning clutch (Donald etc. al. 1974). All these types of clutches come under axial friction clutches (Sandhu, 2001).