SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive)

Signature: …………………

supervisor: …………………

Date: ...……………….

DESIGN AND ANALYSIS OF A LIGHTWEIGHT CLUTCH DISC FOR A SINGLE SEATED RACE CAR

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quaotations which have been duly acknowledged"

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ABSTRAK

Sistem klac merupakan salah satu sistem yang utama di dalam kenderaan. Klac merupakan satu alat mekanikal yang terletak antara enjin kenderaan dan sistem penghantaran kenderaan dan ia juga menyediakan kopling mekanik antara enjin dan aci input sistem penghantaran. Klac akan bergerak bersama-sama dengan system penghantaran secara berperingkat dengan membiarkan sejumlah gelinciran berlaku antara roda tenaga dan aci input system penghantaran. Namun, gelinciran ini akan menghasilkan menghasilkan haba akibat daripada geseran antara cakera klac dan roda tenaga. Dalam projek ini, cakera klac yang ringan akan direka dengan menggunakan software CATIA V5. Diameter untuk cakera klac dan panjang hub akan dikira dengan menggunakan rumus. Untuk pemilihan bahan bagi permukaan geseran cakera klac, karbon-karbon komposit akan digunakan. Setelah rekaan cakera klac diselesaikan dalam perisian CATIA V5, ia akan dianalisa dengan menggunakan perisian ANSYS. Dalam perisian ini ciri-ciri terma dan statik daripada cakera klac akan dikaji. Keputusan analisis akan dibincang dalam factor keselamatan.

ABSTRACT

Clutch system is one of the main systems in a vehicle. Clutch is a mechanical device located between a vehicle engine and its transmission which provides mechanical coupling between the engine and transmission input shaft. The clutch engages the transmission gradually by allowing a certain amount of slippage between the flywheel and the transmission input shaft. However, the slipping mechanism of the clutch generates heat energy due to friction between the clutch disc and the flywheel. In this project, a lightweight clutch disc will be designed by using CATIA V5 software. The diameter of the clutch disc and the hub length of the clutch disc will be calculated by using formulas. For the friction facing material selection, materials will be differentiate in term of coefficient of friction, density, maximum pressure that can be applied, maximum temperature that the material can withstand and the coefficient of thermal of expansion of the material. The materials that are chosen are carbon-carbon composite. After completing the design in CATIA V5 software, the design will be analyze by using ANSYS finite element software. In this software both thermal and static characteristics of the clutch disc will be studied. The results obtained will be discussed in term of factor of safety.

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LIST OF SYMBOLS

T = torque transmitted, Nm

$P_{\max}$ = maximum pressure applied onto the clutch disc, Pascal

F = coefficient of friction (it depends on the material used)

r_o = outer radius diameter, mm

r_i = inner radius diameter, mm

N = number of friction surface

F_a = axial force

P = circumferential force

h' = height, mm

p = bearing pressure

i = number of splines

l = length of the hub, mm

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Nowadays, motorsport events have become a well known sport in the whole world. Ranging from the formula 1 racing events drag competition and also drift events. For all these events most cars are equipped with high performance parts which being produced with high technology equipments. One of these parts is the clutch system. The clutch system is one of the most important parts in a vehicle which consists of flywheel, clutch disc, clutch cover, pressure plate and throw-out bearing. The clutch system for a high performance car is usually lightweight in order to get more power. The term lightweight can be achieved by modifying the geometry of the system and also by using different material. Recently, a very high performance material has been discover which is the carbon-carbon composite. This material has very good properties for friction materials which are high coefficient of friction, low density, can withstand high pressure and temperature and also high thermal expansion.

1.1 PROJECT OBJECTIVE

This project objective is to design a lightweight clutch disc for a single seated race vehicle and to analyze the clutch disc design by using FEM software. The 1^{st} objective can be achieved by calculating the diameter of the clutch disc and the hub length by using formula. The 2^{nd} objective can be achieved by using ANSYS software. In this software, a simulation test will be done to the clutch disc

1.2 PROBLEM STATEMENT

The first problem that occurs when designing a clutch disc for a race car is its ability to transfer the engine torque to the transmission system and to the wheels. A race car engine produces high torque, so the clutch system for this type of car must be able to deliver the torque from the engine to the transmission system. So, an optimum clutch disc diameter for this engine must be calculated to make sure that it will not result in failure of clutch system.

The second problem is to make this clutch system lightweight. This is because one of the factors that can increase the performance of a race car is its power to weight ratio. This can be achieved by using a lightweight clutch system that consists of lightweight flywheel, lightweight clutch disc and lightweight clutch cover. Lightweight material can be used to overcome this problem. Reducing the weight of the clutch disc can reduce the moment of inertia of the clutch disc, thus resulting in quick shift response.

1.3 PROJECT SCOPE

The first project scope is to design a lightweight clutch disc based on SAE formula engine specification which the Mc Master SAE team is chosen. The Mc Master SAE team use Honda CBR 600 Fi engine. This engine produces maximum torque of 65 Nm.

The second project scope is to complete the technical drawing of the clutch disc by using CATIA software.

The last project scope is to perform a simulation test on thermal and static analysis by using ANSYS.

CHAPTER 2

LITERATURE REVIEW

2.1 CLUTCH

The manual transmission clutch is a device used to connect and disconnect engine power flow to the transmission at the will of the driver (Jack. E. 2005). A driver operates the clutch with a clutch pedal inside the vehicle. This pedal allows engine power flow to be gradually applied when the vehicle is starting out from a stop and interrupts power flow to avoid gear clashing when shifting gear. Engagement of the clutch allows for power transfer from the engine to the transmission and eventually to the drive wheels. Disengagement of the clutch provides necessary halt of power transfer that allows the engine to continue running while no power is supplied to drive wheels. Engagement and disengagement of the clutch is controlled by a pedal and clutch linkage. Most clutches used in the modern vehicles are called friction clutches. This mean that they rely on the friction created between two surfaces to transmit the power from the engine to the transmission system. Clutch slippage, vibration and noise can be minimized by the proper alignment of engine and transmission/transaxle and of the clutch components. The clutch system is located between the engine and the transmission. Clutch system basically consists of six major parts which are flywheel, diaphragm spring, clutch disc, pressure plate, clutch cover and linkage that is necessary to operate the clutch (Derek. N & Allan. B. 2000)

Figure 1: clutch system assembly (Jack, E. 2005)

2.1.1 Flywheel

A flywheel is usually made of nodular cast iron with high graphite content to lubricate the engagement of the clutch. It acts as a balancer for the engine and it smoothens out or dampens engine vibrations caused by firing pulses. The flywheel adds inertia to the rotating crankshaft and also acts as a friction surface and heat sink for one side of the clutch disc.

Figure 2: flywheel (Jack, E. 2005)

2.1.2 Clutch Disc

The clutch disc receives the rotating motion from the flywheel and transfer the motion to the transmission input shaft (Derek. N & Allan. B. 2000). A clutch disc comprise of grey cast iron counter mate disc, friction facing, and cushioning springs. The friction facing is the main component in contact with the flywheel, and provides the required friction force to maintain that contact. It is either riveted or bonded to the disc. The cushioning spring, or torsion springs, cause the contact pressure of the facings to rise gradually as the springs flatten out when the clutch is engage. It also eliminates chatter during engagement and avoiding the flywheel and pressure plate sticking to the clutch disc when disengaging the clutch.

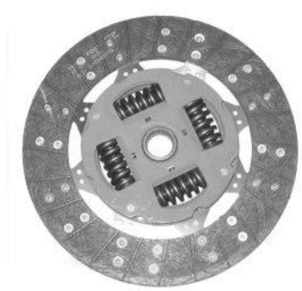

Figure 3: clutch disc (Derek, N & Allan, B. 2000)

2.1.3 Pressure Plate

The pressure plate squeezes the clutch disc onto the flywheel when the clutch disc is engaged and moves away from the disc when the clutch pedal is depressed. These actions allow the clutch disc to transmit or not transmit the engine's torque to the transmission system. A pressure plate is basically a large spring loaded clamp that is bolted to and rotates with the flywheel. A pressure plate assembly includes a sheet metal cover, heavy release spring, a metal pressure ring that provides a friction surface for the clutch disc, a thrust ring or fingers for the release bearing and a release levers. The release leavers release the holding force of the springs when the clutch is disengaged. The spring used in most pressure plate is Belleville spring or diaphragm spring.

Figure 4: pressure plate (Derek, N & Allan, B. 2000)

2.1.4 Release Bearing

The release bearing is a ball type bearing located in the bell housing and operated by the clutch linkage. Release bearing are usually sealed and pre lubricated to provide smooth and quiet operation as they move against the pressure plate to disengage the clutch (Derek. N & Allan. B. 2000). When the clutch pedal is depressed to disengage the clutch, the release bearing moves toward the flywheel, depressing the pressure plate's release fingers or thrust pad and moving the pressure plate fingers or lever against pressure plate spring force. This action moves the pressure plate away from the clutch disc. A clutch release bearing is often referred as throw-out bearing.

Figure 5: throw-out bearing (Derek, N & Allan, B. 2000)

2.1.5 Linkage

Clutches are normally operated by either mechanical or hydraulic linkages. There are two types of mechanical linkage that's been used which are the cable type and the shaft and lever type (Jack. E. 2005). The shaft and lever clutch linkage have many parts and pivot joints and transfers the movement of the clutch pedal to the release bearing via shafts, levers, and bell cranks. A typical shaft and lever clutch control assembly includes a release lever and rod, an equalizer or cross shaft, a pedal to equalizer rod, an assist or over center spring and the pedal assembly. Depressing the pedal moves the equalizer that in turn, moves the release rod. When the pedal is released, the assist spring returns the linkage to its normal position and removes the pressure on the release rod. This action causes the release bearing to move away from the pressure plate.

A cable-type clutch linkage is simple and, lightweight. Normally the cable connects the pivot of the clutch pedal directly to the release fork. This simple set-up is compact, flexible and eliminates the wearing pivot points of a shaft and lever linkage. However, cables will gradually stretch and can break due to electrolysis. Typically, one end of the cable is connected to the pedal assembly. At the assembly is located a spring that keeps the pedal in the up position. The cable is held under tension by the spring and a cable stop located on the fire wall. The other end of the cable is connected to the outer end of the clutch release fork. This end is threaded and fitted with an adjusting nut and locknut that allows for pedal free play adjustments. When the clutch pedal is depressed, the cable pulls on the clutch fork, which causes the release bearing to move against the pressure plate (Jack. E. 2005).

A hydraulic linkage consists of a master cylinder, hydraulic tubing and slave cylinder. The master cylinder is attached to and activated by the clutch pedal through the use of an actuator rod. The slave cylinder is connected to the master cylinder by flexible pressure hose or metal tubing. The slave cylinder is positioned so that it can work directly on the clutch release yoke lever. Depressing the clutch pedal pushes the actuator rod into the bore of the master cylinder. This faction forces a plunger or piston up the bore of the master cylinder. During the initial 1/32 inch of pedal travel, the valve seal at the end of the master cylinder bore closes to the port to the fluid reservoir. As the pedal is further depressed, the movement of the plunger forces fluid from the master cylinder through a line to the slave cylinder. This fluid is under pressure and causes the piston of the slave cylinder to move. Movement of the slave cylinder’s piston causes its push rod to move against the release fork and bearing, thus engaging the clutch. When the clutch pedal is released, the springs of the pressure plate push the slave cylinder’s push rod back, forcing the hydraulic fluid back into the master cylinder (Jack. E. 2005).

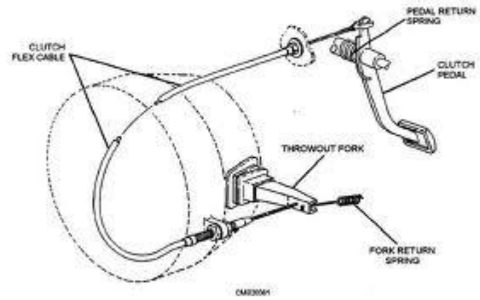

Figure 6: clutch linkage (Jack, E. 2005)

2.2 THEORY OF HEAT TRANSFER

Heat transfer is the study of thermal energy transfer rate between material bodies as a result of temperature difference. There are three types of heat transfer method, which are through conduction, convection and radiation. A rough explanation of each heat transfer mode is stated below.