DESIGN AND FABRICATION OF A SEMI AUTOMATIC GEAR SHIFTING MECHANISM FOR UTeM FORMULA STYLE RACE CAR

AMMAR ALFAIZ BIN MUSTAFFA ALBAKRI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Laporan ini dikemukakan sebagai memenuhi sebahagiaan daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)

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DECLARATION

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

Signature :……

Author :……..

Date :…….

“To All Student, Learn By Heart”

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ABSTRACT

This project is about design and fabrication a semi – automatic gear shifting mechanism for a Formula Varsity race car based on the rules and specification. This gear shift mechanism system had been design to resolve shifting gear problem, eliminate fully mechanical gear shift and to have a better cockpit area. This design was referred to the many motorcycle shift mechanism patent as a benchmark and than had been modified to implement at the race car. All the concept design had been perform with computer aided drawing (CAD) software – CATIA to have a better physical view. After the drawing completed, material application was selected and perform some basic analysis. Then after performing the analysis, all the design will be transfer to the detail marking on the belong material to be fabricate. All the components must be fabricated according to detail design and after finished fabrication, all the component are installed and tested to evaluate system functionality. Test showed that the system can be operate normally (shift up or down) in a certain time. But for the maximum usage condition, an external power source must be attached to the system.

ABSTRAK

Projek ini adalah mengenai merekabentuk and memfabrikasi separuh automatic mekanisma penukar gear bagi jentera lumba Formula Varsity 2010 berdasarkan peraturan dan speksikasi. Mekanisma ini telah direka bagi bagi mengatasi penukaran gear, mengurangkan penggunaan penukar gear penuh mekanikal dan untuk mendapatkan ruang pemanduan yang lebih besar. Kebanyakkan rekabentuk ini bedasarkan rekabentuk mekanisma penukaran gear untuk motorsikal sebagai asas rekaan dan telah di modifikasi untuk penggunaan jentera lumba. Kesemua konsep rekabentuk menggunakan lukisan terbantu komputer – CATIA utuk memperolehi bentuk fizikal yang baik. Selepas rekabentuk selesai, pemilihan bahan dan analisis setiap komponen telah dilakukan. dan kesemua rekabentuk komponen telah diterjemahkan kepada pengukuran perincian pada bahan projek untuk difabrikasikan. Setiap komponen telah difabrikasi mengikut perincian rekabentuk. Selepas selesainya proses fabrikasi, semua komponen telah dipasang pada kenderaan dan telah diuji kefungsiannya. Ujian yang menunjukkan sistem berfungsi dengan sempurna tetapi untuk kegunaan yang extrim, sistem memerlukan janaan kusa daripada luar.

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LIST OF SYMBOLS

R = outer radius of the shaft.

τ = maximum shear stress at the outer surface.

φ = angle of twist in radians.

T = torque (N·m or ft·lbf).

ℓ = length of the object the torque is being applied to or over.

G = shear modulus or more commonly the modulus of rigidity and is usually given in giga pascals (GPa), lbf/in^2 (psi), or lbf/ft^2

J = torsion constant for the section

r = distance from the center of rotation

V = total shear force at the location in question

Q = statically moment of area

t = thickness in the material perpendicular to the shear

I = Moment of Inertia of the entire cross sectional area

τ = torque vector and τ is the magnitude of the torque,

F = force vector, and F is the magnitude of the force

θ = angle between the force vector and the lever arm vector.

CHAPTER 1

INTRODUCTION

1.0 Gear Shifter Background

A Shiftronic transmission can operate just as a conventional automatic transmission, but it also allows the driver to override the automatic mode by moving the shift lever into a second shift gate equipped with two spring-loaded positions: "up shift" and "downshift". Once in this gate, the driver takes over most of the shifting decisions ordinarily performed by the transmission's computer, permitting, for example, the delaying of an up shift for increased acceleration or to increase the braking effect of the engine (Crouse and Anglin 1993).

For a manual transmission, gear shift mechanism comprises a lever-receiving structure disposed on the engine/transmission structure. The lever-receiving structure includes a mechanical or with cable actuated. A manual transmission gear shift mechanism has a plurality of shift rods, each of which is provided with a shift fork and at least two of which are coaxially disposed, a control rod having at least two select arms which selectively engage with the shift rods, and a shift lever for sliding control rod so as to place the transmission into any one of a plurality of gears. The

select arms are disposed on the control rod either at specified axial separations along an axis of rotation of the control rod or at specified angular separations around an axis of rotation of the control rod. This is the same of the cable actuated gear shifter. Besides automatics, there are also other types of automated transmissions such as continuous variable transmissions (CVTs) and semi-automatic transmissions, that free up the driver from having to shift gears manually by using the transmission's computer to change gear, if for example the driver were redlining the engine. Despite superficial similarity to other automated transmissions, automatic transmissions differ significantly in internal operation and driver's "feel" from semi-automatics and CVTs. An automatic uses a torque converter instead of clutch to manage the link between the transmission and the engine, while a CVT uses a belt instead of a fixed number of gears, and a semi-automatic retains the clutch like a manual but activates the clutch through electrohydraulic means (http://en.wikipedia.org).

Formula One cars use semi-automatic sequential gearboxes, with regulations stating a maximum of seven forward gears and one reverse gear, using rear wheel drive. The gearbox is constructed of carbon fiber or titanium, and is bolted onto the back of the engine. Full automatic gearboxes, and systems such as launch control and traction control, are illegal, to keep driver skill important in controlling the car. The driver initiates gear changes using paddles mounted on the back of the steering wheel and electro-hydraulics perform the actual change as well as throttle control. Clutch control is also performed electro-hydraulically, except to and from a standstill, when the driver operates the clutch using a lever mounted on the back of the steering wheel. As of the race season, all teams are using seamless shift transmissions, which allow almost instantaneous changing of gears with minimum loss of drive. Shift times for Formula One cars are in the region of 0.05 seconds (Peter 2001).

UTeM Formula Varsity is a student racing competition that challenges students to design, manufacture and race their single seat open-wheel formula style racing car in real track condition. Therefore, there are a few systems to design for example engine and transmission. Each the design and fabrication must be following

by the rules specification to ensure each team racing has the almost same race car design and capability. One of the rules specifications is transmission and gearbox and the most popular gear shifter for the formula varsity race car are cable actuated and mechanical linkage. These two designs are the most common design and easily to fabricated to the formula varsity race car. Simply, a lever mounted in cockpit with attach to the cable or link arm it will actuated transmission shaft. A motorcycle engine with capacity up to 135 cc will be use as the power generate to the race car. This moped bike engine come completed with variable gear ratio or gear box and need a gear shifter to engage and disengage the gear to transmit the torque to the tire (http://www.f1technical.net).

For the further design, a new system call FVTRONIC is design to eliminate fully mechanical gear shift and shifting the gear simply by pressing a shift button on the steering wheel. This is because of the, the older design had a weakness such as shifting delay and easily deformed after a few usage. This new system needed a forces and motion to operate the transmission shaft that can be supplied by electromagnet mechanism. This electromagnet mechanism has helped the size and light weight. Much than that, this system will be offer a quick gear shift response and maximize the cockpit size – eliminate gear lever.

Table 1.1: Part of the technical specification – transmission/gearbox (http://formulavarsity.utem.edu.my)

Transmission/Gearbox
• The engine must drive the rear wheel axle. Four wheel drive transmission is forbidden. • Method of final drive must remain as the homologated engine. • All transmission/gearbox ratio, shafts, drums, and selector forks are free. • Primary gear ratios are free. • The number of gears must remain as homologated. • Additions to gearbox or selector mechanism, such as quick shift system, are not allowed. • Countershaft sprocket, rear sprocket, chain pitch, and size can be changed. • Any form of traction control system is forbidden.

1.1 Scope

- To produce detail and 3D design of the semi – auto gear shifting mechanism using CAD software based on FV UTeM 2010
- To perform material selection and load analysis
- To fabricate the system

1.3 Problem Investigation

This new invention started when a few problems comes out from the current design. The most obvious problem is fully mechanical either cable actuated or linkage gear shift can be deformed at the certain part and after that difficult to change the gear after a few training session or race event. This is notice on the current race car FV2010 model. The most critical part is the hinge and gear selector on the transmission shaft. These two parts will be start deform and break at the welding point because of the force acting on them especially variable driver' hand force while move the gear lever. Race car driver also notice that the current design are very delay while engage or disengage and not quickly response. During the race, driver needs a very quick response due to the gear shift because to maintain the engine torque and speed during cornering or accelerating. This is the one important factor to ensure driver win the race. Moreover, driver complains that ability to maneuver while changing gear is very poor. During taking the 'hair pin' cornering, driver must be concern on steering input and also have to maintain the speed. It is very difficult to change gear while maneuver in a tiny cockpit. As mention on above, a formula varsity race car must be single seated that mean very tiny cockpit. If a gear lever mount in the cockpit, driver layout position become space less and not ergonomic. It will disturb driver comfortable and focus when racing. For that, a new shift system will encounter all the problems (http://american muscle cars: power to the people).

Figure 1.1 Formula Varsity race cars

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

A literature review is a body of text that aims to review the critical points of current knowledge including substantive findings as well as theoretical and methodological contributions to a particular topic. Literature reviews are secondary sources, and as such, do not report any new or original experimental work.

Most often associated with academic-oriented literature, such as theses, a literature review usually precedes a research proposal and results section. Its ultimate goal is to bring the reader up to date with current literature on a topic and forms the basis for another goal, such as future research that may be needed in the area. A well-structured literature review is characterized by a logical flow of ideas; current and relevant references with consistent, appropriate referencing style; proper use of terminology; and an unbiased and comprehensive view of the previous research on the topic.

In this case, most of the literature review will covers all the fact, design and technical discussion and invention to be evaluated and idea generate for the concept design. The main literature review will cover formula one transmission technology, new invention on motorcycle invention and material selection method. Most of the research done by reviews the journals, technical paper, books, patent and internet source.

2.1 Current Design

The gear shift is the part of the gearbox which has the shift forks and allows the contact from the driver to the synchronization. Most of the time they are so much like the gear counter plus the reverse gear. And they make it possible to choose the gear (gear ratio) and to switch this in or out. The invention of the gear shift is attributed to Karl Benz. These are the parts for which it is possible to make automation. Further these parts can be designed so compact so that it is also possible to build a very modular transmission with less weight.

The benefit of the compact build of the shifting is not only the gain of modulation and less weight but also the time during the production and space in the whole drive train. Depending on the space around the whole drive train and type of car, for automatisation a hydraulic, pneumatic or electric actuator can be used. For personal cars, a hydraulic or electric actuator is most often used. Further, such a system also needs an electronic application. (Harbans, 2005)

Based on the current Formula Varsity car gear shifter mechanism, most of the design was cable actuated or fully mechanical linkage mechanism. Normally the gear shifter will be located in the cockpit as the easy to driver to reach and to engage gear ration. Therefore, this will cause a limited space in the cockpit. Much than that, this cable actuated and mechanical linkage gear shifter easily has a failure at the certain time for the racing use. A test had been done to both mechanism and shows the result