UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYZE THE TRANSMISSION SYSTEM FOR FLYWHEEL HYBRID MODULE

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

by

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DECLARATION

I hereby, declared this report entitled "Design and Analyze the Transmission System for Flywheel Hybrid Module" is the results of my own research except as cited in references.

Signature	:	…………………………………………
Author's Name	:	…………………………………………
Date	:	…………………………………………

APPROVAL

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

………………………………

(Project Supervisor)

ABSTRAK

Projek ini bertajuk "Rekabentuk dan Analisis Sistem Penghantaran Mekanikal Roda Tenaga Modul Hibrid". Dalam kertas ini, pembangunan mekanisme asas dan reka bentuk konsep sistem penghantaran Modul Hibrid Mekanikal roda tenaga dipaparkan. Sistem gear planet atau sistem gear kisar digunakan dalam projek ini. Penggearan planet adalah sistem gear yang terdiri daripada satu atau lebih gear planet, berputar mengelilingi gear matahari yang terletak di tengah-tengah set gear. Biasanya, gear planet yang bercantum pada pembawa planet berputar berpaksikan gear matahari. Sistem penggearan kisar juga berfungsi dengan menggunakan gear cincin luar yang juga dikenali sebagai anulus. Gear planet bersentuhan dengan anulus. Keseluruhan kedudukan gear biasanya selari. Tambahan pula, pembawa gear planet, gear matahari dan kedudukan anulus umumnya sepaksi.

Kaedah yang digunakan untuk menyiapkan projek ini adalah dengan menggunakan Kaedah Pugh. Satu reka bentuk penyelidikan kajian kes telah dilakukan oleh bermula dengan pengumpulan data. Idea-idea untuk projek ini diletakkan dalam carta morfologi dan Spesifikasi Pembangunan Produk (PDS) telah dilakukan. Dalam langkah penjanaan konsep, beberapa idea telah dijana dan skor kemudiannya telah diberikan kepada setiap konsep. Tujuan langkah ini untuk mencari konsep yang terbaik di kalangan semua konsep-konsep yang dijana. Reka bentuk konsep bagi sistem penghantaran kemudiannya dihasilkan. Setelah melakukan reka bentuk detail, proses simulasi dijalankan dan analisa reka bentuk dilakukan. Kerja-kerja yang lebih lanjut perlu dilakukan untuk sistem penghantaran untuk diintegrasikan dengan komponen lain daripada modul hibrid roda tenaga.

ABSTRACT

This project is entitled "Design and Analyze of the Transmission System for Mechanical Flywheel Hybrid Module". In this paper, the development on basic mechanism and conceptual design of the transmission system of the Mechanical Flywheel Hybrid Module is shown. The planetary gear set or epicyclical gearing system is used. Planetary gearing is a gear system consisting of one or more planet gears, rotating about a sun gear which is located at the centre of the gearing set. Normally, the planet gears are attached on a planet carrier which itself revolve relative to the sun gear. Epicyclic gearing systems also function and use an outer ring gear acknowledged by the name of annulus. Planet gear meshes with the annulus. The axes of all of those gears are usually parallel. Furthermore, planet carrier, the sun and annulus axes are generally coaxial.

The method used in order to complete this project is by using the Pugh Method. A case study research design was done by starting with data collecting. The ideas for the project are the tabulated in the morphological chart and the Product Development Specification (PDS) then has been done. In the concept generation step, a few ideas were generated and score has then been given to each concept. The purpose of this step to find the best concept among all of the concepts generated. Conceptual design for the transmission system is then produced. When the detail design was conducted, the simulation process was done in order to analyze the design. Further works should be done in order for the transmission system to be integrated with other components of the flywheel hybrid module.

DEDICATION

To my beloved parents of my life, Abah and Emak;
Razali Bin Johari and Paridah Bt Saman,
for the great supports that both of you gave me.

ACKNOWLEDGEMENT

I would like to thank my supervisor, Mr Muhammad Zaidan Bin Abdul Manaf for his hard work in guiding me during this project was being held. Without his guides, this project will be unfinished. I would also like to express my gratitude to my supportive colleagues Muhammad Aiman Bin Abd Nasir, Muhamad Ashraf Bin Zulkifli and Muhammad Afiq Bin Jalaludin for their helps and companion during the hard times of this project. Lastly, I would like say thank you to my family, lectures and friends who assist me in completing this works directly or indirectly. Thank you.

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Wheeled vehicle that transports passengers and carries its own engine is called an automobile. Nowadays automobiles comprise with modern technology such as sensors and actuator. Undoubtedly, it was not invented by a single inventor in a blink of time. In 1890s, with the horseless carriers were being invented, it was clearly indicated that the automotive industry has begun. Since then, the consumption of natural gas and fossil fuel had increased greatly and it is expected to be reduced as time goes by. Many alternatives and technologies had been invented and manufactured such as catalytic converters, electronic fuel injectors and aerodynamic body design in order to cut and reduce the engine fuel consumption. Besides, it is also to preserve the global towards a greener and cleaner world.

On the other hand, vehicle which uses two or more power sources to make the car propel is called as a hybrid car. The two power sources are an internal combustion engine (ICE) and an electric motor. This technology is slowly gaining popularity among the car buyers as they see the benefits that owning a hybrid will contribute to a greener world. With hybrid technology, the car's carbon footprint will be reduced as the energy usage is efficient. The mechanical hybrid system recycles kinetic energy which would be otherwise wasted when a vehicle brakes. The entirely mechanical arrangement provides a commercially possible and cost effective substitute to battery-based electric hybrid systems.

It is principally suited to vehicles such as subject, to extensive stop-start action and is incorporated with vehicle existing driveline. The flywheel hybrid system recovers kinetic energy, stores it in the revolving flywheel and subsequently returns the energy to the vehicle driveline. Flywheel hybrid module basic gears are; a flywheel plate, a clutch system, shaft and housing, and a transmission system. Focusing on transmission system, it is a gathering of parts including the speed-changing gears which the power is transmitted from regenerative braking to the flywheel and then to the drive train.

1.2 Project Title

Design and Analyze the Transmission System for Flywheel Hybrid Module.

1.3 Problem Statement

The biggest issue of indecision is the compact space of motorcycle. The issue arises when the flywheel hybrid module needs to be assembled on the motorcycle system. The flywheel hybrid module needs to be placed in the most suitable parts so that the module can perform at its best performance with low space needed. The motorcycle engine is already packed with the power and electrical system. Besides, the front side consists of the front brake and the front suspension system. Similarly, the rear side lays the rear brake and rear suspension system with the rear wheel attached to the engine system by chains.

The installation of the secondary power system will make a huge modification to the motorcycle itself. The most suitable place to apply the flywheel hybrid module is at the front wheel of the motorcycle. The rim section will be altered and the flywheel will be installed at the altered section. This rim's space will be used as optimum as it can. Furthermore, when the module is installed at the front wheel section, the module will not be interfering with the current engine system. The design will also be much simpler when it is placed at the front wheel compared to when it is installed at the rear wheel section.

1.4 Project Objective

1) To design the transmission system for Flywheel Hybrid Module.
2) To analyze the transmission system for Flywheel Hybrid Module.

1.5 Project Scope

The transmission system project scopes are restricted to some method and equipment that have been provided:

- Model the transmission system for flywheel hybrid module by using CATIA software.
- Simulate the model generated by using CATIA software.
- Analyze the transmission system developed by using CATIA software.

1.6 Project Significance

The project of designing and analyzing the transmission system of flywheel hybrid focuses on motorcycle with low engine capacity. The transmission system is needed in order for the flywheel hybrid to function smoothly from gear to gear. Good transmission system will extract the best output from the hybrid module. When the module is installed to the motorcycle, it will result in lower fuel consumption and promote a greener world. This project is significant for motorcyclists who demand this type of output for their motorcycle.

CHAPTER 2

LITERATURE REVIEW

2.1 Hybrid Vehicle

A hybrid vehicle is a vehicle that has more than one major source of propulsion power. When the expression hybrid vehicle is used, it frequently refers to a Hybrid Electric Vehicle (HEV). Most hybrid cars nowadays have two major power sources which are conventional internal combustion engine (ICE) and electric motors. These two power sources can operate the vehicle by either one alone or in parallel. The existence of the electric power train is proposed to attain enhanced fuel economy as compared to a conservative vehicle engine. As the engine of the hybrid vehicle is comparably smaller than usual internal conventional engine, it produces less emission.

The hybrid-electric vehicle did not become widely available until the release of the Toyota Prius in Japan in 1997. The hybrid vehicle model is followed by the Honda Insight in 1999. Both of these models were the first mass production of the HEV. Back in 1901 Ferdinand Porsche developed the Lohner-Porsche Mixte Hybrid, the earliest gasoline-electric hybrid automobile in the world but it is not commonly accessible. Figure 2.1 shows two modern HEV in the automotive market. The general concept of a HEV is to combine the right proportion of an electric drive with an internal combustion engine, depending on cruising situation, so mutually can work in their most favourable working range as greatly as possible.

(a)

(b)

Figure 2.1: (a) Toyota Prius (b) Honda Insight

(Sources: (a) Toyota, 2013 (b) Honda Malaysia, 2013)

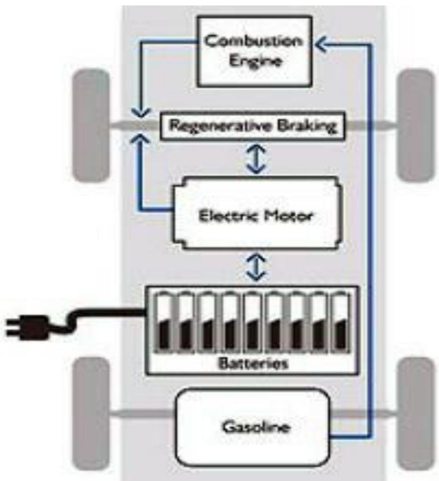

Figure 2.2: Diagram of a Plug-in Hybrid Electric Vehicle [1].

The hybrids maintain the batteries charged by generating electric power via the regenerative braking system. The electric motor turns into a generator and the magnetic drag retard the vehicle down when the driver applies the brakes. In addition, when the regenerative braking is not adequate, the typical hydraulic braking system will assist the braking mechanism in order to stop the vehicle. In general, regenerative brakes capture energy and turn it into electricity to charge the battery that provides power to an electric motor [2]. The power sources found in a HEV can be combined in numerous ways. However, the most common drive train configurations are the series and parallel HEV.

2.1.1 Series Hybrid

A series hybrid is an arrangement in which merely one energy converter can supply propulsion power. The combustion engine, which is operating in its mainly finest system, drives an electric generator and therefore mechanical power is transformed into electrical power which is stored in the battery. The propulsion power is provided exclusively by the electric motor as shown on Figure 2.1.1. Remarkably towering power-to-weight ratios which offer a sufficient torque when operating over a large speed range make electric motors very much efficient. Series hybrids have also acknowledged as extended-range electric vehicles (EREV) or range-extended electric vehicle (REEV).

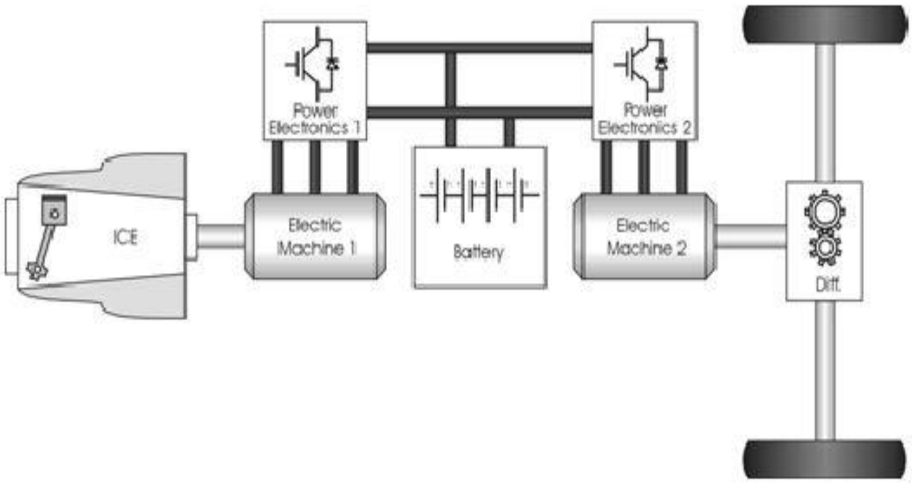

Figure 2.3: Illustration of a series hybrid drive train.

The advantage of series hybrid is that the internal combustion engine can be turned off when the vehicle is cruising in a zero-emission mode. Furthermore, another merit of the series hybrid is that the internal combustion engine and the electric machine can be mounted separately. This involves a possibility to distribute the weight of the vehicle drive system and in buses an opportunity to use low floor (Hemmingsson, 1999, Van Mierla et al, 1998).

2.1.2 Parallel Hybrid

A typical parallel hybrid uses its internal combustion engine to control the drive wheels straight as well as using the surplus ICE power to store energy through an electric generator and a battery pack to be used afterward by the electric drive motor. In cooperation, the engine and the battery pack via the electric motor are in parallel linked to the transmission. When maximum power is needed, a parallel hybrid uses the electric motors to enhance the power of the ICE. The cooperation between the ICE and the electric machine can be selected in such a way that the current insist for power can be met. Nevertheless, as the engine is linked straight to the transmission, it cannot always be operated in its most efficient region.

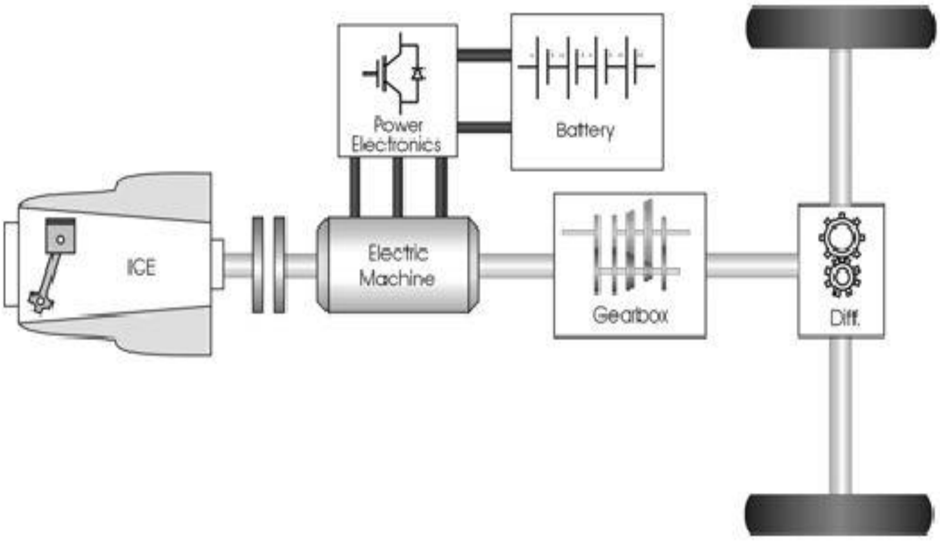

Figure 2.4: Illustration of a parallel hybrid drive train.

[3] The major advantage of the parallel hybrid compared to the series hybrid is that the ICE is directly coupled to the wheels. This eliminates the inefficiency of converting mechanical power to electricity and back. Unlike the series hybrids, this makes the parallel hybrid drive trains suitable for highway traffic. However, the mechanical coupling is also a drawback of the parallel configuration, since the ICE is to some extent forced to follow the power request. This is, however, not a major problem, since a gearbox is normally used and the operating point of the ICE can thereby be varied. The compactness of the parallel hybrid drive train and the fact that it can be used both for city- and highway traffic makes it suitable for both small and heavy vehicles.

2.2 Regenerative Braking

Regenerative braking relates to a method in which a part of the kinetic force of the vehicle is stored by a small period storage space system. Energy generally scattered in the brakes is commanded by a power transmission system to the energy storage space during deceleration. That energy is detained until called for once again by the vehicle, whereby it is changed back into kinetic force and used to step up the vehicle. The amount of the part accessible for energy storage alters according to the storage type, drive train effectiveness, and drive cycle and inertia weight (Clegg, 1996).

Regenerative braking is an effective approach to extend the driving range of EV and can save from 8% to as much as 25% of the total energy used by the vehicle, depending on the driving cycle and how it was driven [4]. Generally, the regenerative braking torque cannot be made large enough to provide all the required braking torque of the vehicle. In addition, the regenerative braking system may not be used under many conditions, such as with a high state of charge State of Charge (SOC) or a high temperature of the battery. In these cases, the conventional hydraulic braking system works to cover the required total braking torque. Thus, cooperation between the hydraulic braking system and the regenerative braking system is a main part of the design of the EV braking control strategy and is known as torque blending. This torque blending strategy helps to avoid the driveline disturbances [5].

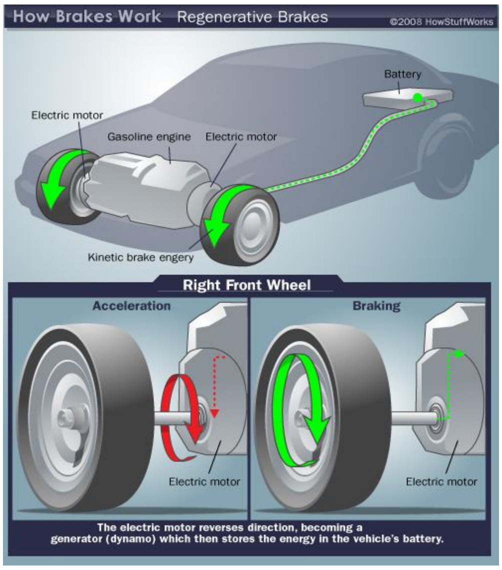

Figure 2.5: How regenerative brake system works. [6].

To be successful, a regenerative braking system should ideally have the following properties [7]:

1) Efficient energy conversion
2) An energy store with a high capacity per unit weight and volume
3) A high power rating so large amounts of energy can flow in a short space of time
4) Not require over complicated control system to link it with the vehicle transmission
5) Smooth delivery of power from the regenerative system
6) Absorb and store braking energy in direct proportion to braking, with the least delay and loss over a wide range of road speeds and wheel torques.

Regenerative braking only promises significant gains in town driving since 62.5% of energy is dissipated in the Metropolitan cycle due to frequent braking. If all brake energy could be regenerated with no loss in the regenerative system, fuel consumption would be improved by 33% [8]. Alternative sources state that the addition of regenerative energy storage systems to motor vehicle can achieve theoretical fuel savings up to 23% in a 1600 kg vehicle on a level road urban driving schedule. This relative saving is reduced as the weight of the vehicle reduces. A 1000 kg vehicle can achieve theoretical savings of 15% [9, 10].

The main advantages of regenerative braking systems can be summarized [11] as:

1) Improved fuel economy – dependant on duty cycle, power train design, control strategy and the efficiency of the individual components.
2) Emissions reduction – engine emissions reduced by engine decoupling, reducing total engine revolutions and total time of engine operation (engine on – off strategy).
3) Improved performance.
4) Reduction in engine wear – engine on/off strategy.
5) Reduced in brake wear reducing cost of replacement brake linings cost of labour to install them and vehicle downtime.
6) Smaller accessories – hybrid power train offers potential for eliminating (electric starter) or cost due to the hybrid hardware additions.
7) The operating range is comparable with non conventional vehicles – a problem not yet overcome by electric vehicles.

The possible disadvantages of regenerative braking system can be summarized [11] as:

1) Added weight/bulk – extra components can increase weight, increasing fuel consumption, offset by smaller engine operating at its best efficiency.
2) Complexity – depends on control necessary for operation of regenerative braking system.
3) Cost – of components, engineering, manufacturing and installation. Mass production would bring costs down to a more reasonable level.
4) Noise – depends on the system.
5) Safety – Primary concern with any energy storage unit of high energy density. There must be very little chance of dangerous failure during normal vehicle operation. Passengers must be protected from risks that may be caused by the failure of the hybrid system.
6) Size and packaging constrains – most important for cars.
7) Added maintenance required – depending on complexity of design.