UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## Faculty of Engineering Technology

# INCORPORATING FLYWHEEL HYBRID MODULE IN MOTORCYCLE : AN EMBODIMENT APPROACH

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**Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours**

**2016**

# INCORPORATING FLYWHEEL HYBRID MODULE IN MOTORCYCLE : AN EMBODIMENT APPROACH

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

**Faculty of Engineering Technology**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2015**

## DECLARATION

I declare that this thesis entitled “Incorporating Flywheel Hybrid Module In Motorcycle : An Embodiment Approach” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

**APPROVAL**

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfillment of Bachelor of Mechanical Engineering Technology (Automotive Technology) (Hons.).

Signature :…….....……

SupervisorName :…….....…

Date :…….....

## DEDICATION

This Thesis i dedicated to my beloved parents Nor Nasarudin B. Lebai Isa and Aine Hayati Bt. Md. Zain. It is woth immense gratitude that i acknowledge the support to my supervisor, Mr Muhammad Zaidan B Abdul Manaf and my friend that helped me during the time to finish my thesis.

## ABSTRACT

This study investigates about incorporating Flywheel Hybrid Module in motorcycles : an embodiment approach. The Fywheel Hybrid Module(FHM) is a system that is installed inside the rims of the motorcycle. The system will become the medium to store and re use the energy. At the same time, the system will promote a better performance with a less use of fuel/gasoline compared to the actual motorcycle. The flywheel hybrid module system adapt a few concept of the latest technology which is the Kinetic Energy Recovery System (KERS). There are several stages that need to be done before obtaining the Flywheel Hybrid Module. There five stages which are generating concept, embodiment, simulation, optimisation and prototype and testing. Next, in this paper, it explained further about the embodiment pheses. For the embodiment phases, there is one thing that is very important which are the dimensions with the acceptable tolerances. There would be four method use in this paper to complete the phases of embodiment which are Product Architecture, Parametric models, Preliminary selection of material and Design for reliability. Each of the phase will be explained in details in this paper of Flywheel Hybrid Module. In this Paper of Flywheel Hybrid Module, most of the result are about the dimension with the acceptable tolerances which are shown in the table at the selected chapter. Besides, there are also result about the preliminary selection material and the design for reliabilty which used the Failure Mode Effect Analysis. The conclusion that can be made from this paper are the design of the Flywheel Hybrid Module can be configured using the product architecture. Next, the design of parametric components are determined. Then , the preliminary materials for the components are chosen. Lastly, The Risk priority number are obained by using the Failure Mode Effect Analysis method ,which shows the design for reliability level of this product.

## *ABSTRAK*

*Kajian ini menyiasat bagaimana menggabungkan Modul Hibrid Flywheel di motosikal: pendekatan penjelmaan. Modul Fywheel Hibrid (FHM) adalah satu sistem yang dipasang di dalam rim motosikal. Sistem ini akan menjadi medium untuk menyimpan dan menggunakan semula tenaga. Pada masa yang sama, sistem akan menggalakkan prestasi yang lebih baik dengan penggunaan yang kurang bahan api / petrol berbanding motosikal yang sebenar. Sistem modul roda tenaga hibrid menyesuaikan diri satu konsep beberapa teknologi terkini yang merupakan Sistem Pemulihan Tenaga Kinetik (KERS). Terdapat beberapa peringkat yang perlu dilakukan sebelum mendapatkan Modul Hibrid roda tenaga. Terdapat lima peringkat yang menjana konsep, penjelmaan, simulasi, pengoptimuman dan prototaip dan ujian. Seterusnya, dalam kertas ini, ia menjelaskan tentang pheses penjelmaan. Bagi fasa penjelmaan, ada satu perkara yang sangat penting iaitu dimensi dengan had terima yang diterima. Terdapat empat kaedah yang digunakan dalam kertas kerja ini untuk melengkapkan fasa penjelmaan yang Architecture Produk, model berparameter, pemilihan awal bahan dan reka bentuk untuk kebolehpercayaan. Setiap fasa akan dijelaskan secara terperinci dalam kertas ini Flywheel Modul Hibrid. Dalam projek ini Modul Flywheel Hybrid, kebanyakan hasil kira-kira dimensi dengan had terima yang boleh diterima yang ditunjukkan dalam jadual di bab yang dipilih. Selain itu, terdapat juga menyebabkan mengenai bahan pemilihan awal dan reka bentuk untuk reliabilty yang digunakan Kegagalan Mod Kesan Analisis. Kesimpulan yang boleh dibuat daripada projek ini adalah reka bentuk Modul Hibrid Flywheel boleh dikonfigurasikan menggunakan seni bina produk. Seterusnya, reka bentuk komponen parametrik ditentukan. Kemudian, bahan-bahan awal bagi komponen yang dipilih. Akhir sekali, Bilangan keutamaan Risiko adalah obained dengan menggunakan Kegagalan Mod Analisis Kesan kaedah, yang menunjukkan reka bentuk untuk tahap kebolehpercayaan produk ini.*

**ACKNOWLEDGEMENTS**

First and foremost, I would like to take this opportunity to express my sincere acknowledgement to my supervisor Mr Muhammad Zaidan Bin Abdul Manaf from the Faculty of Engineering Technology Universiti Teknikal Malaysia Melaka (UTeM) for his essential supervision, support and encouragement towards the completion of this thesis.

Special thanks to my beloved family for their moral support in completing this degree. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Engines are most effective while they're producing power at a same state, relatively high speed. But, there would be problem in this engine situation when it need to drive all kind of components and parts at different speed and sometimes they need to stop all of them at the same time. Thus, the solution of the problem are the clutches and the gears. Mechanical "switch" that function to disengage an engine from the machine it's driving is technically called a clutch. Next, a pair of interlocked wheels with teeth that changes the speed and torque or turning force of a machine so that it can go faster or slower even when the engine operating at the constant speed is known as the gears. There is a things that both clutches and gear unable to do which are save the energy you waste when you brake and get the energy back again later. Therefore, the flywheel plays the role in thus situations.

A flywheel is a zinc, aluminium or a cast iron that is assemble at one end of crankshaft that use to give amount of inertia for the internal combustion engine. The property of matter by which any physical body persists in its state of rest or uniform motion until acted upon by an external force is known as inertia. While the process of reciprocating engine, combustion occurs at distinct period. The flywheel provide the inertia that is needed to avoid loss of engine speed and possible stoppage of crankshaft rotation between combustions period.

A flywheel as a energy storage is also known a Flywheel energy storage systems (FESS). Flywheel energy storage systems gain the electric energy input which is stored in the form of kinetic energy. Kinetic energy can also be label as the "energy of motion",

in this situation of a rotating mass, known as a rotor. The rotor rotates in a slightly no frictions enclosure. When short-term alternative power is needed due to utility power lost or fluctuates, the inertia will permits the rotor to keep on rotating and the result of kinetic energy is changed or transform to the electricity states. Nowadays, there are a lots of relating aspects of flywheels technology and hybrid technology. In the transportation industry, both of the technology are very important and intercepting each other.

Hybrid system nowadays are very popular technology that are study and discover. The technology are also been very valuable as it is relate to the environment factors. As most citizens know, it is environment friendly or in other terms green concept technology. In terms of vehicle hybrid, a vehicle hybrid is a vehicle that use more than one kind of energy to get propulsion. A hybrid will have a current internal-combustion engine and a fuel tank, as well as one or more electric motors and a battery-pack. A hybrid cars sometimes wrongly differentiate with the electric vehicles. Hybrids are most frequently gasoline-burning machine that use their electric bits to gather and use back energy that usually waste in non-hybrid cars (standard cars).

There are two types of hybrid configurations which are the series hybrid systems and the parallel hybrid systems. The parallel hybrid combustion engine and electric motor work together to give propulsion to the vehicle. The electric motor and engine are both linked to the transmissions. When fuels flow to the engine or when the electric is switched on, the power that is produce propels the cars to move. When to operates the electric motor and when to switch to the gasoline are decided by the controller in the transmissions.

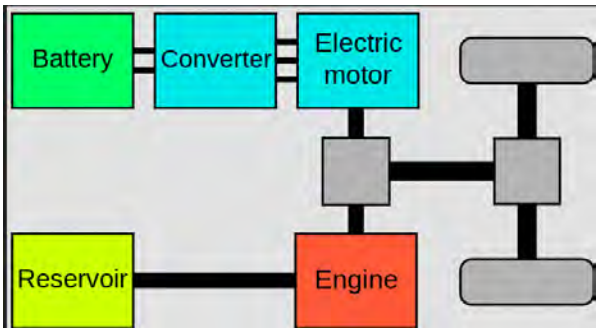


Figure 1 : Parallel hybrid Configuration

On the other side, series hybrid electric motor is solely responsible for for spinning the vehicle wheels. The electric motor is charged by the battery or charge by the generator, that is powered by the gasoline engine. The series hybrid gasoline engine is not coupled to the wheels and does not directly power the car. How much power is required to propel the vehicle and either to pull it from the generator or the battery are determines by the controller in the transmissions.

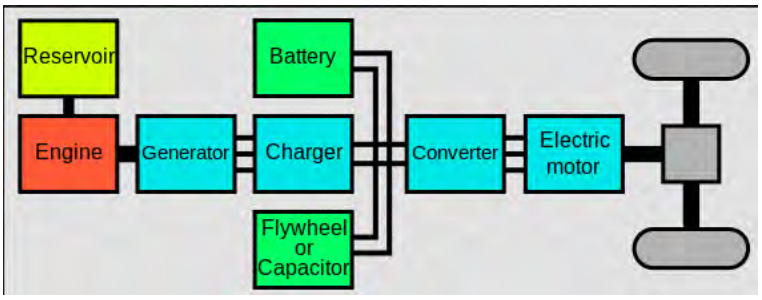


Figure 2 : Series Hybrid Configuration

From the above expalanations, hybrid technology and flywheel hybrid technology plays a big role in the industrial transportation recently due to the efficiency and other factors. There are many types of transport that familiarly known which are the transport on air, transport on water and mostly transport on land.

There are also many types of transport on land which are cars(automobile), trucks and motorcycle as examples. In motorcycle, it uses the internal combustion engines. Same as the cars, they both have the internal combustion engine and both have the problems of power efficiency and wasted energy. Thus, motorcycle can also use the concept of flywheel in order to avoid the wastage of energy. Motorcycles can also use the concept of hybridisation in the systems to improve the whole systems efficiency. Therefore, The systems that combines the two of the systems in the motorcycle which are the flywheel and hybrid is known as the flywheel hybrid module(FHM) in motorcycle.

The flywheel Hybrid module concept is similarly to the concept of kinetic energy recovery systems(KERS). Even though the concept is in the automobile, it is stil can be applied to the motorcycle. KERS is a latest automotive development that can make a temporary storage of braking energy by means of a supercapacitors, flywheel and batteries. The energy that is stored is utilise for extra acceleration when required. This

systems are being used in the Formula One vehicles. The flywheel hybrid systems recovers kinetic energy, stores it in the rotating flywheel and then return the energy to the vehicle driveline. Flywheel hybrid module basic gears are flywheel plate , a clutch system, transmissions sysytems and a shaft and housing.

There are also some advantges of the flywheel hybrid module in motorcyle. One of the advantages of the flywheel hybrid module in motorcycle is it can increase the pwer efficiency of the motorcycle sysytems. This is because there are two power sources on the systems which are the internal combustion engines and the flywheel as th seconday power source that can supprort the internal combustions engine.

Besides that, the flywheel hybrid module can also results in the reduce in fuel consumption of a motorcycle.There are three phases in driving which are the accelerations, constant speed and decelerations. The motorcycle has two power sources which are the internal combustion engine and the flywheel. During the first two phase, the flywheel will produce more energy, therefore ICE can reduce the operations and at the same time reducing the fuel consume.

The third advantages of the flywheel hybrid module is the emission reductions. The emissions are the polluted product of gaseous that are obtained at the exhaust which can affect the environment. The emsisson can be reduce when use the flywheel hybrid system because engine emissions reduced by engine decoupling, reducing amount engine revolutions and total time of operating engine(engine on-off strategy).

In addition, the operating range of the flywheel hybrid system is comparable with the non conventional vehicle where as this is the big issue and problem that is face by the electric vehicles and not yet overcome.

Next, the advantages of the flywheel hybrid module is the energy that is produce by the motorcyles is not easily wasted. The energy that is produce from braking action will be used back later.

There are many phase that need to be done in order to design flywheel hybrid module in motorcycle. Each of this phase must be finished completely to get an expected result. There are fives phase that involve in this projects which are the conceptual design phase, embodiment phase, simulating phase, optimisation phase and the last phase is the prototype and testing phase.

The first phase which are the conceptual design phase is the phase to develop the optimum concept in how the flywheels hybrid module can be incorporating inside wheel of motorcycle. Intensive benchmarks and review need to be done. This steps will be use embodiment design stage. There are also various of methods in this phase that is provide to get a good and better quality concept. This step is important because it is the main phase in a projects. It would be the phase that guide all of the upcoming phase.

The next phase is the embodiment design phase, the embodiment design phase is a phase that deal with the design concept physical form. There are three main things in embodiment phase which are the product architecture, configuration design and parametric design. This phase will also focused on the necessary issues like setting the dimensions of the parts, designing to enhance the aesthetic values of the design, and achieving a design that is both user friendly and environmentally safe.
The Simulating phase is a phase about translating concept and embodiment design of flywheel hybrid module for motorcycle into a CAD model. The computer simulated model will be used to stimulate the structural performance and kinematic analysis of the products.

The optimisation phase is the process of perform structural and energy optimizations to the flywheel hybrid module for motorcycles. In structural optimizations, topology and shape method will be use while in energy optimization, the focus is on to reduce the weight and frictions. Once the design is agree, the manufacturing drawing will then be produce.

The last phase is the phase of prototype and testing. This phase will develop the prototype of the product which is the flywheel hybrid module for motorcycle. The fabrication process will be done in house using equipment available in the campus or faculty labs. Then, the product will be test. The testing include structural integrity testing

and hybrid performance testing. There are several character of the prototype and testing which are to evaluate new designs prior to the actual go live to ensure that the designs are clear, easy to use and meet users requirements. Next, Is best when iterative testing is built into the development process, so that changes can be easily made often to ensure that major issues do not arise well before going live. Lastly, Provides confirmation about the new design direction, branding and messaging are going in the right direction.

Based on this paper, the title is incorporating flywheel hybrid module in motorcycle by the approach of embodiment design. As being mentioned like above paragraph, the embodiment design phase will consider about the physical form of the conceptual design. This research is about to determine the physical configuration of the components of the flywheel hybrid module for motorcycle. After that, parametric is given to the component actual sizing. Both steps above are known as embodiment design approach. The concept of this product is taken from "conceptual design team" which run parallel with this project.

## 1.2 Problem Statement

There are several things need to be considered before designing the flywheel hybrid module (FHM) and problems is one of them. There are a few problems during the embodiment phase. As we know, the motorcycle parts at the tyre are very compact due to the rear suspensions and the brake components.

One of the problems is to set the general shape and dimensions of the parts. Besides, the configuration of the system are also need to be establish at this part. Next, selecting the suitable materials is one of the problems that occurring during this phase. The materials must be fit in all conditions. In addition, the parametric design of the components must be consider. The components should be acceptable and suitable based on the real size of the product. Finally, the component must meet the design for reliability by based on the risk priority number (RPN) .

## 1.3 Aim and Objectives

The aim of this report is to determine the physical configuration of the components of the flywheel hybrid module for motorcycle. After that, parametric is given to the component, actual sizing. Both steps above are known as embodiment design approach. The Objectives of this papers are :

1. To configure the design of Flywheel Hybrid Module in Motorcycle using the product Architecture.
2. To determine the design of parametric of the components.
3. To choose the preliminary materials for the components by using the Ashby methods.
4. To find the optimum Risk Priority Number (RPN) in design for reliability (DFR) by using Failure Mode Effect Analysis (FMEA).

## 1.4 Scope

The working scope of this paper is incorporating flywheel hybrid module in motorcycle by using the embodiment design approach. There are four scope that were listed in order to make sure the project is conducted and operated within the acceptable time interval. This will also ensure the right ways to the aims that were set. There are four workspace which are :

Phase scope #1:

1. Identify the preliminary design and Flywheel Hybrid module in Motorcycle using the Product Architecture.
2. Identify the configuration of the component and where should it be located.

Phase Scope #2:

1. Identify the parametric design of the components.
2. Identify the exact dimensions and tolerances of the components.

Phase Scope #3:

1. Identify the preliminary materials for the components by using the Ashby methods.
2. Identify the exact material to use by consider the properties of yield strength versus density to all the chosen material.

Phase Scope #4:

1. Identify the optimum risk priority number (RPN) in design for reliability by using Failure Mode Effect Analysis(FMEA).
2. Risk priority number in FMEA will represent the risk index when the failure occur. By doing corrective action, this RPN can be reduced.

## 1.5 Structure of the Project

Chapter 1 states the problem and background of the study. This chapter also discussed the objective, hypothesis and scope of the project. So that the reader can get an initial idea about what the project is all about.

Chapter 2 explains in detail about literature review of the study. It consists of the general problem that this study tries to overcome. This chapter also include the basic principles of the flywheel hybrid module and the components. There is also include the embodiment design approach in this chapter with its method together.

Chapter 3 explains about the methodology of this study. There are 4 phases involves in this study. Phase 1 is the configuration of preliminary design and flywheel Hybrid Module in Motorcycle using product architecture. Phase 2 explains the design of parametric of the components. Phase 3 explains about the preliminary materials for the component by using the Ashby method. Phase 4 explains about the optimum risk priority number (RPN) in design for reliability by using Failure Mode Effect Analysis (FMEA).

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introductions

This study will provide review from previous research in order to make a large scope of Flywheel hybrid module, obtain the problems, generates new ideas and concepts. This previous study will also be the references in doing the project. This section will also included the previous study related to the selected phase which is the embodiment design that deals with the physical configuration form of the conceptual design.

## 2.2 General Concepts

### 2.2.1 FLYWHEEL HYBRID MODULE (FHM)

According to (Manaf, Mohamed, Zakaria, Saadun, & Mohd Hanafi, 2013), The production of internal combustion engine is a important steps in empower engineering world which the high mechanical energy demands job can be simplified like make a vehicle move and machinery. The internal combustion engine gives many good benefits, but this kind of engine is incapable to change the heat energy from fuel combustion to the mechanical energy with efficient. There are motorcycles with small capacity engine which have power conversion at range of 25-30%. Thus, in order to improve the overall system efficiency, secondary power source is needed to support the internal combustion engine. These situations leads to the implement of the hybridization process which at the

same time can improve the system efficiency in delivering the power to the wheel.

The application of hybridization can improve the power efficiency to the level 30-80%. By applying the hybridization to the motorcycle, it can increase the power efficiency to 36% compared to the conventional motorcycle which have wasted energy at the amount of 200%. To moves the motorcycle forward, flywheel is capable to do such thing in order to supply enough energy (Manaf et al., 2013).

As stated by (Manaf et al., 2013), Kid's toys car has initiate the idea in order to generate the concept of flywheel hybrid module. The kid's toy car used a mini metal disk or flywheel to keep the kinetic energy delivered from the wheel during the action of push. While release, the kinetic energy which is keep inside the small metal disk is delivered back to the wheel and make the cars to move forward. By combining these two concepts, which are the power propulsion and regenerative brakes, an simple innovation is created. There are no chemical and electrical concepts and it is totally using the power of mechanical energy. Thus, the concepts is apply to the full scale motorcycle to reduce the operation time by internal combustion engine in moving the motorcycle forward.

In addition, to reduce the carbon emission release to the atmosphere, the concept of applying flywheel hybrid as the secondary power source is related to it. Due to the size and maintenance factors, the motorcycles are very popular transportation used among the Malaysians. By looking at the statistics, 47.3% of vehicles on the road are motorcycles and the emissions produce by all of them are about 900tons per kilometers. (Manaf et al., 2013).