
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## Faculty of Engineering Technology

# INCORPORATING FLYWHEEL HYBRID MODULE IN MOTORCYCLE: PERFORMANCE OPTIMIZATION

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

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# INCORPORATING FLYWHEEL HYBRID MODULE IN MOTORCYCLE: PERFORMANCE OPTIMIZATION

**MUHAMMAD HATTA BIN ZAMBRI**

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

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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: INCORPORATING FLYWHEEL HYBRID MODULE IN MOTORCYCLE: PERFORMANCE OPTIMIZATION

SESI PENGAJIAN: 2016/17 Semester 1

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**DEDICATION**

To my beloved parents, Zambri Bin Mohamed Idris and Nawal Binti Abdul Aziz,

My brothers, Muhamad Syamim Bin Zambri, Muhammad Adib Bin Zambri and

Muhammad Zhafran Bin Zambri,

My sisters, Zawani Bt Zambri, Nurul Hannan Bt Zambri and Nurul Syairah Bt Zambri,

And my fellow friend those give me motivation and encourage me to finishing this task,

Thank you so much

## ABSTRACT

This study to optimize and analyze the structure and material of Flywheel Hybrid Module (FHM) in order to get the best performance. Optimization Performance Phase is the final stage before the prototype of this project were developed by P5: Prototype and Testing Team. The design of the Flywheel Hybrid Module (FHM) is divided into two main parts which are flywheel and rim. The design of the FHM is follow the correct parameters suggest by P2: Embodiment Design Team. The method that used to reduce the mass of the rim design is Topology. For flywheel design, Topograpghy method was used to increase the strength of the structure of flywheel. Before run the optimization, the loads and acceleration that applied on the design based on real life when the motorcycle moving. The acceleration that applied on the rim by P3: Simulation and Analysis Team is 9000 rpm, but during optimization the acceleration is 13500 rpm. This is because every component or parts have their own safety factor. Safety factor for the FHM designs is 1.5. so, the acceleration need to multiple with the safety of the rim. The optimization suggestion of the software being redraw in catia and the analysis of the comparison between before and after being discuss in this report. The final result rim and flywheel design being improve than the original drawing. Lastly, Ashby method is material selection in FHM components is being optimize. From here, the best material was chosen in order to develop FHM was aluminum 2024.

# ABSTRAK

Kajian ini untuk mengoptimumkan dan menganalisis struktur dan bahan Flywheel Hibrid Modul (FHM) untuk mendapatkan prestasi yang terbaik. Fasa Prestasi Optimization adalah peringkat terakhir sebelum prototaip projek ini telah dibangunkan oleh P5: Prototaip dan Ujian Team. Reka bentuk modul Flywheel Hibrid (FHM) dibahagikan kepada dua bahagian utama iaitu roda tenaga dan rim. Reka bentuk FHM adalah mengikut parameter yang betul disyorkan oleh P2: penjelmaan Design Team. Kaedah yang digunakan untuk mengurangkan jisim reka bentuk rim adalah Topologi. Untuk reka bentuk roda tenaga, kaedah Topograpghy telah digunakan untuk meningkatkan kekuatan struktur roda tenaga. Sebelum menjalankan pengoptimuman, beban dan accelearation yang digunakan pada reka bentuk berdasarkan kehidupan sebenar apabila motosikal yang bergerak. Pecutan yang digunakan pada rim oleh P3: Simulation dan Analisis Team ialah 9000 rpm, tetapi pada pengoptimuman accelarion 13500 rpm. Ini kerana setiap komponen atau bahagian mempunyai faktor keselamatan mereka sendiri. Faktor keselamatan untuk reka bentuk FHM 1.5. Jadi, accelarion yang perlu berganda dengan keselamatan rim. Cadangan pengoptimuman perisian makhluk melukis semula di Catia dan analisis perbandingan di antara sebelum dan selepas berbincang dalam laporan ini. Akhir hasil rim dan roda tenaga reka bentuk yang meningkatkan daripada lukisan asal. Akhir sekali, kaedah Ashby adalah pemilihan bahan dalam komponen FHM sedang mengoptimumkan. Dari sini, bahan yang terbaik telah dipilih untuk membangunkan FHM adalah aluminium 2024.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Motorcycle is the most famous transportation device cause of it size and low maintenance in Asian country. Until September 2012, the total numbers of vehicles on road reaches 22.3 million with 47.3% from it are motorcycles in Malaysia. Contribution of carbon based emission release by motorcycle alone in Malaysia reached around 900 tons per kilometre. The total amount of carbon that release by bikers in Malaysia is 22.500 tons daily by taking average daily travel distance of bikers is around 25km. Therefore, this research is to contributing on reduction of carbon release by reducing the usage of internal combustion engine without sacrificing the performance of the motorcycles. Hence, multiple methods have been developing to increase the internal combustion engine efficiency.

There are two types of hybrid system which are Electrical system and Mechanical system. Hybrid system is power systems that use two of different system that are internal combustion system and electrical system. Flywheel is one of the methods to increase the efficiency of combustion engine. Flywheel is a rotating mechanical device that is used to

store rotational energy. Flywheels have an inertia called the moment of inertia and thus resist changes in rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to a flywheel by the application of a torque to it, thereby increasing its rotational speed, and hence its stored energy. Conversely, a flywheel releases stored energy by applying torque to a mechanical load, thereby decreasing the flywheel's rotational speed.

In the Automotive industries, there a number of UK Government funded projects applying flywheel based mechanical hybrid systems are ongoing, developing the technology and building mechanical hybrid equipped demonstrator vehicles. Participants include OEM's Jaguar Land Rover, Ford, JCB and Optare using advanced technology from Allison Transmission Inc, Flybrid Systems, Ricardo, SKF and Torotrak.

Figure1.1 : Jaguar Land Rover
(Source:http://www.electric-vehiclenews.com/2010/09/jaguar-reveal-flywheel-hybrid-system.html)

Furthermore, the first motorcycle hybrid is The ET-120. It will be heading to Indian shores and boasts a mpg rating of about 280 mpg and top speed of 40mph. Developed in collaboration with US based Emerging Technologies Inc the ET-120 could set the stage to grow a grass-roots hybrid motor following rather than the trickle-down to the masses approach you'll see with the Mission One and Mavizen. With a tandem 70cc gasoline engine and battery system, you can expect the power and torque of a 120cc gas-powered engine. Those specs may be laughable to you against our super-powered motorcycles, but small displacement motorcycles are a major mode of transportation throughout much of India. Having a 100-percent increase of hill climbing capability from almost four-degrees to eight, along with a tripling of fuel economy is life changing. And with roughly three-fold decrease in emissions, everyone can start breathing a little easier.


Figure1.2 : Eko Vehicles
(Source: http://www.wired.com/2009/12/worlds-first-hybrid-motorcycle-heads-to-india/)

The advantages for this system are flywheel is one of the most suitable solutions for power-intensive applications due to its high reliability, relative immunity to environment aspects and long lifespan. Furthermore, the concept of using flywheel as alternative power source in vehicle is parallel with global initiative to reduce harmful carbon release to atmosphere.

In order to develop this Flywheel Hybrid Module (FHM), there are five stages incorporate to finish the fundamental target. The main stage for this project known as a Conceptual Configuration or P1. In this stage, issue definition and idea for this participate will be pick utilizing a PDS idea. The concept also will be evaluate and finalize on this stage. Next, the second stage or P2 known as an Embodiment Design. In this stage is more to scanning for physical standards and advances that can give required capacities. While it is convincible to scan for such standards and advances, it is far speedier to definitely think about standards and innovation. ASHBEY strategy will be used in this stage. The third stage or P3 is a Simulation and Analysis. In this stage, it is to demonstrate the undertaking and indicate the estimation of the parameters. Optimization and Detail the configuration is the stage four or P4. Stage 4 is final process after embodiment design. The design is ready to manufacture. The methods that used in this stage are topology, topography and ASHBY. The venture will be enhance from it shape, material and size. The software that used in this stage is Hyperworks and Hypermesh. Last stage or P5 is Prototyping and Testing. In this stage, the prototype is a rudimentary working model of a product or information system, usually built for demonstration purposes or as part of the development process. In the systems development life cycle (SDLC) Prototyping Model, a basic version of the system

is built, tested, and then reworked as necessary until an acceptable prototype is finally achieved from which the complete system or product can now be developed.

In this paper, the Optimization and Detail Design or P4 was selected. This report will focus based on three methods. The methods that used for this phase are Topology, Topography and Ashby method.

## 1.2 Problem Statement

In current product, rim is design by using conventional method or try and error method. For example, to design the rim, they do not have support design and they design the product by using their creativity or experience of the persons. To solve that problem, the topology method was used. When using topology method, the mass of flywheel can reduce without changing their dimension. The time that takes to design the rim of Flywheel Hybrid Module (FHM) decreases. Next, the problem that happened in this project was the strength of flywheel. Before that, to increase the flywheel strength, they just increase the thickness of the flywheel. That will be the mass of the rim also increase. By using topography method, it will reduce the mass and increase the strength.

## 1.3 Aim and Objectives

The aim of this study is to prevent the effect Incorporating Flywheel Hybrid Module in Motorcycle: Performance Optimization. In order to achieve the aim, following are thethree objectives that need to be accomplished:

1. To reduce rim mass using topology optimization method.
2. To increase flywheel strength using topography optimization method.
3. To optimize material in FHM components using Ashby method.

## 1.4 Scope

This study conducted in Flywheel Hybrid Module which is among the tier The work scope of this study is divided into three phases as discuss below.

Scopes of phase #1: **TOPOLOGY OPTIMIZATION METHOD**

1. Identify the factors how to reduce rim mass using topology optimization method. To optimize rim mass, size and shape for suitable requirement.
2. Define the maximum stress on rim. Apply load for maximum stress that riml can handle.
3. Identify the factor how to finalize the optimization for rim. To visualize displacement, factor of safety, percent of yield, tension and compression, maximum shear stress, von Mises stress, and major principal stress.

Scopes of phase #2: **TOPOGRAPHY OPTIMIZATION METHOD**

1. To increase flywheel strength using topography optimization method. To increase the maximum strength for flywheel.
2. To optimize design variable for rim using topography method. To solves topography optimization problems using shape optimization with shape variables for flywheel.
3. To optimize the material for flywheel. To choose a suitable and strong material that meet the requirement for rim being apply to flywheel.

Scopes for phase #3: **ASHBY METHOD**

1. Suggest list of preventive to choose the material. Material will be choosing for suitable for the components in FHM.
2. Define stress analysis. The material that was being choose will be analyze to get the maximum force that can be apply for the material of the components in FHM.
3. Selection of Composite Materials. Composite flywheel is needed because the decision must be made to make sure the composite are tough, solid and long lasting with light material.

## 1.5 Significance of Study

While a variety of definitions of the term flywheel have been suggested, this paper will use the definition first suggested by T. Nadu (2015) who saw it as smart design of flywheel geometry has significant effect on its specific energy performance. Amount of kinetic energy stored by wheel–shaped structure flywheel is greater than any other flywheel. Other than that, there is a large volume of published studies describing the role of by changing the materials with Polymer Matrix Composite and taking the stress and weight into account PEEK with 30% carbon reinforced is suggested as best material to replace the aluminium alloy. Adding more, Historically, research investigating the factors associated with flywheel has focused on possible improvements of the KERS are either reducing its cost by bigger production amounts or by achievement of better accelerations. This can be done by further optimization of the electromotor.

In recent years, there has been an increasing amount of literature on when considering other criteria, such as control complexity, clutch wear, and driving comfort, the mecHybrid topology, as described in is expected to be the most competitive. Traditionally, it has been argued that steel alloy not to recommend for any type of rims manufacturing and the Mg alloy is good for all types of rims manufacturing in the second place Al alloy may be used. In the consideration of models the new optimized 4 spokes can be used by changing the ribs thickness form this rims weight also reduces. (T. Rao, K. Deepthi, and K. N. D. M. Rao, 2014). Other than that, previous several investigation also have indentify that the non design space is the standard design and cannot be modified. The design space is the region for optimizing the weight and shape of the arms. The wheel

design space is optimized in order to withstand the existing load of the vehicle with the factor of safety with a least quantity of material and manufacturing cost and losses.

## 1.6 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. It explains about the Flywheel Hybrid Module. The method of diagnosis and preventive are also discussed here.

Chapter 3 explains the methodology of this study. There are three phases in this study. Phase 1 is the investigation how to reduce flywheel mass using topology optimization method. Phase 2 focuses on how to increase rim strength using topography method. Final phase suggests the preventive Ashby method to optimize material in Flywheel Hybrid Module (FHM).

Chapter 4 is analysis and discussion chapter. The results from the survey in phase 1 and experiments in phase 2 are analyzed here. In experiment result, the final result will be analyzed until it satisfies the objective of the project.

Chapter 5 is conclusion chapter. It concludes the findings from this study. Generally, there are energy store in hybrid flywheel. This is proven through the past review on research and past paper. The experiment result also shown to get a better result other the past experiment. Finally future preventive method is suggested to make some improvement for the hybrid flywheel focus on optimization in the future.