



**Faculty of Engineering Technology**

**INCORPORATING FLYWHEEL HYBRID MODULE IN  
AUTOMOBILE: A CONCEPTUAL DESIGN APPROACH**

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

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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.)**

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**2016**

## DECLARATION

I declare that this thesis entitled **“INCORPORATING FLYWHEEL HYBRID MODULE IN AUTOMOBILE: A CONCEPTUAL DESIGN 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 report is dedicated to my beloved family especially to my parents, Mr. Mustapha Bin Ishak and Mrs. Norsiah Binti Mohd Tajuddin for their endless support and opinion when completing this report. Next, I would like to thank to my supervisor, Mr. Muhammad Zaidan Bin Abdul Manaf for guidance and encouragement while doing this project. Lastly, special thanks to my friends that has help me in giving their ideas and opinion for completing this final year project.

## **ABSTRACT**

The Flywheel Hybrid Module of this project is essentially inspired by the Kinetic Energy Recovery System (KERS) of Formula One racing car and Flywheel Hybrid XF from Jaguar manufacturer. This KERS system is to produce and stored energy while braking. Besides that, the system also will released energy when the break is discharged. The project of Flywheel Hybrid Module is viably in the traffic light condition or while the car are not move (in static position) before the car move forward. In addition, the system is functionally to save fuel consumption. In this paper, it will focus on the initial concept which is Concept Generation in designing the Flywheel Hybrid Module. The first step is to determine the customer requirement about the hybrid technology. After that, is to produce the engineering specification based on the customer requirement. Then, all the data that have being obtained are used in constructing House of Quality thus producing Product Design Specification (PDS). Based on that, the best concept will be chose through several methods such as Morphological Chart, Concept Generation, Concept Screening, Concept Scoring and Concept Selection. Lastly, sketch of the bet concept will be draw.

## ABSTRAK

Projek *Flywheel Hybrid Module* ini pada dasarnya diinspirasi daripada sistem Kinetic Energy Recovery System (KERS) yang terdapat pada kereta lumba Formula One dan juga dari Flywheel Hybrid XF oleh pengeluar kereta Jaguar. Sistem KERS ini bertujuan untuk menghasilkan dan menyimpan tenaga ketika sedang membrek dan ia akan melepaskan tenaga tersebut apabila brek dilepaskan. *Flywheel Hybrid Module* ini berfungsi ketika kereta sedang berhenti di lampu isyarat atau di mana kereta berada pada keadaan statik sebelum kereta tersebut bergerak. Sebagai tambahan, sistem ini dapat mengurangkan penggunaan minyak pada kereta. Di dalam penulisan ini, ia akan fokus pada konsep awalan iaitu *Concept Generation* dalam mereka bentuk *Flywheel Hybrid Module*. Langkah pertama adalah dengan menentukan keperluan pelanggan mengenai teknologi hybrid ini. Selain itu, menghasilkan spesifikasi kejuruteraan berdasarkan daripada keperluan pelanggan tersebut. Kemudian, semua data yang telah diperolehi akan digunakan dalam merangka *House of Quality* seterusnya menghasilkan *Product Design Specification* (PDS). Berdasarkan daripada itu, konsep yang terbaik akan dipilih melalui beberapa kaedah seperti *Morphological Chart*, *Concept Generation*, *Concept Screening*, *Concept Scoring* dan *Concept Selection*. Akhir sekali, lakaran konsep yang terbaik akan dilukiskan.

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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.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

In modern times nowadays, car is one of the most important things in our daily lives as it is the main transportation for most of the people that want to get to their places. But, the increases of the cars on the road have makes the air more polluted. This is cause by imperfectly combustion of the air-fuel mixture of the internal combustion engine and causes the contaminated emissions out of the car. Furthermore, in the present of unstable economic situation right now, it will be hard for us to spend our money for refueling the car. Therefore, by choosing an efficiency car and environmentally friendly, it should help us to solve that problem.

There are many car manufacturers that have produced a car which does not only save fuel but also it help to reduced air pollution. Two of the biggest car manufacturer, Volvo and Jaguar have developed a Hybrid technology which equipped with a flywheel that can produce large amount of power for the car to speed quickly and also it enables for stored energy.

A flywheel is basically a wheel that need force to make it spin around. The flywheel works when it spinning at high speed, it tends to keep spinning which means it

can store large number of kinetic energy. This concept is likely from kid's toys car. It use small metal disk known as flywheel to store the kinetic energy transmitted from the wheel during the push action. When releases, the stored kinetic energy inside the flywheel are transferred back to the wheel and push the toy car forward. These simple innovations involve with two concepts which is the regenerative braking concept and power propulsion concept.

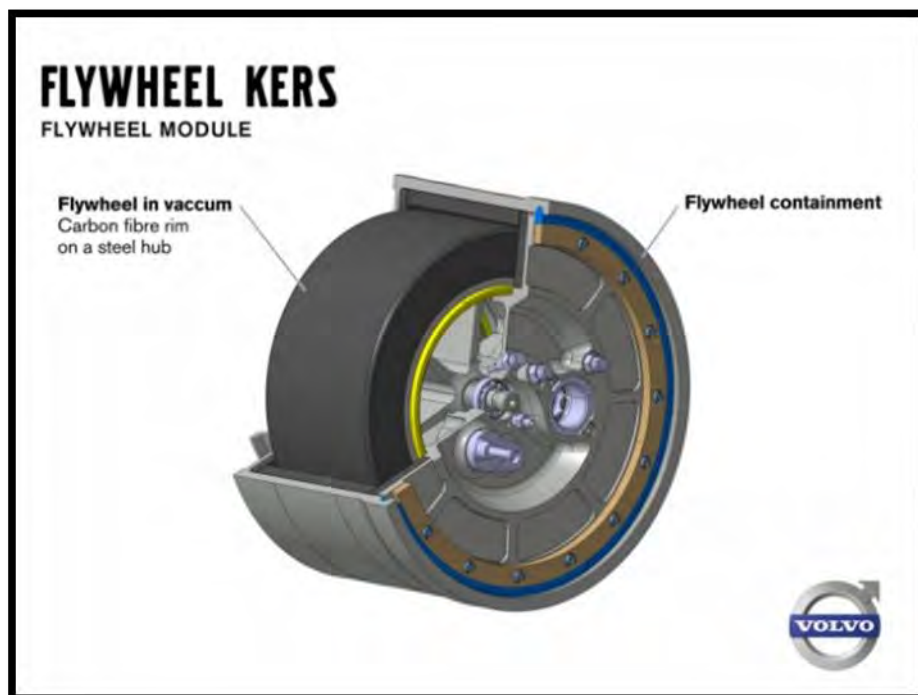


Figure 1.1: Volvo Hybrid Flywheel Diagram

Source by: (<http://www.extremetech.com/extreme/154405-volvo-hybrid-drive-60000-rpm-flywheel-25-boost-to-mpg>)

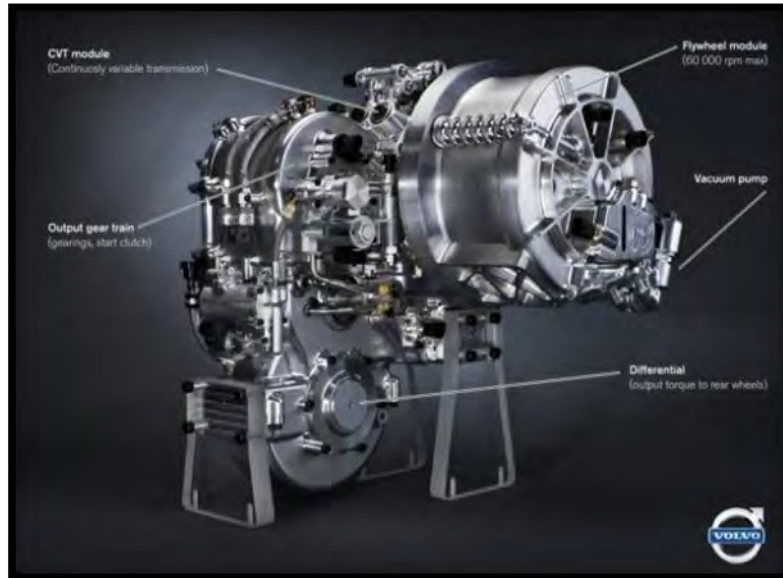


Figure 1.2: Volvo Hybrid Flywheel Engine

Source by : (<http://www.extremetech.com/extreme/154405-volvo-hybrid-drive-60000-rpm-flywheel-25-boost-to-mpg>)



Figure 1.3: Flybrid System Formula One Flywheel Engine

Source by : (<http://www.mdpi.com/1996-1073/8/10/10636/htm>)



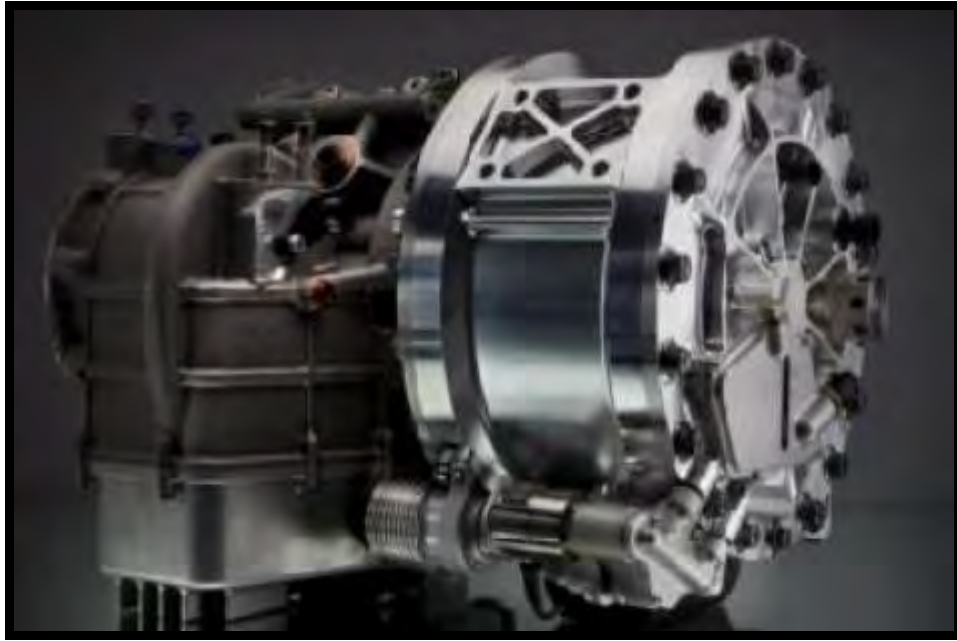


Figure 1.4: Jaguar Flywheel Hybrid Flywheel

Source by : (<http://www.mdpi.com/1996-1073/8/10/10636/htm>)

The advantages of this flywheel hybrid system are that it has a higher power capability compare to the usual hybrid car with the internal energy store in the flywheel so that it can supply the energy to the engine when needed. This is also making it safer rather than the hybrid system. Moreover, it has smaller size and compact weight compare to the battery hybrid system. Other than that, the flywheel is not harmfully influence by temperature changes so that it can operate at a much extensive temperature. Furthermore, because of it act to increase more power to the engine, thus it reducing the fuel consumption. This is a truly green solution for the environment. Besides that, flywheel has an easy measurement of the rotation speed so it is possible to know the precise amount of energy used. Lastly, this system is cheaper than the other hybrid system.

To achieve this flywheel hybrid concept, there are five phases that need to be completed. The first phase is the most important phase which is the Conceptual Design (P1). This is because this phase needs to generate the idea from the problem statement and need to produce Product Design Specification (PDS) from the House of Quality. Next phase is an Embodiment Design (P2). In this phase, the design concept is put with physical form such as the final dimension and tolerance part, the complete design and bill of material. Phase 3 is Simulation and Analysis (P3), which making an analysis for estimations of the parameters. This phase also showed a stress analysis to find out if the flywheel can handle stress force. After that, is a phase 4 which is Optimization and Detail of Configuration (P4). This phase use a topology, topography and ASHBY method and by using Hyperwork and Hypermesh programming to improve the design shape size and etc. Last phase is a phase 5 which is Prototyping and Testing (P5). Data from Phase 1 to Phase 4 is used to create a prototype and then several testing will be conducted on the prototype. If there is any problem occur, an improvement to be made.

In this project, I choose Phase 1 which is a Conceptual Design as my selected phase. This report will be focus on how to produce the Product Design Specification (PDS) based on customer requirement and House of Quality then using it to choose the suitable concept.

## 1.2 Problem Statement

1. At the present time, the design of a new product, every customer has their own requirements such as product quality, the size of a product, and also a speed that can be generated. But, for design team engineer, they have a limitation of engineering characteristic for design this same product. For an example of engineering characteristic is the weight of the product, dimension and durability. Because of that, the problems that occur are to relate the customer requirement with the engineering characteristic in a systematic method. For that reason, Quality Function Deployment (QFD) method is used to solve this problem. Voice of the customer in the QFD is correlated with the engineering characteristic through the House of Quality method.
2. Once the correlation of customer requirement and engineering characteristic has been determined which is the important criteria, the Function Analysis Model need to be done. In this step, it has a physical decomposition and function decomposition in which when an issues emerge, the improvement need to be done to the product. Therefore, Concept Generation needs to be done to solve this problem. The methods that contain in this concept generation are Function Analysis Model and Morphological Chart where couple of new idea can be produced methodically.
3. When choosing the most appropriate concept toward the end of the concept generation, there is a argument for the same importance percentage rank amongst the concept and choosing the process should be done without knowing the definite

possibilities. Accordingly, the Pugh Chart is chosen to solve this problem. This method looks at every concept that related with the reference or datum concept and for each criterion is determines whether the concept is the best, poor or the same than the datum.

### **1.3 Aim and Objectives**

The aim of this study is to incorporating flywheel hybrid module in automobile by using an Conceptual Design approach . In order to achieve the aim, following are the three objectives that need to be accomplished:

1. To develop the Product Design Specification (PDS) for Flywheel Hybrid Module using House of Quality method.
2. To generate the concepts of Flywheel Hybrid Module using Functional Model Analysis and Morphological Chart methods.
3. To evaluate and select the best concept of Flywheel Hybrid Module using Pugh Chart method.

## **1.4 Scope**

This study is conducted in conceptual design for automobile which is among the tier. The work scope of this study is divided into three phases as discussed below.

Scopes of phase #1:

1. Identify the customer requirements and making an engineering specification. Both data then combine together to produce House of Quality.
2. Interpreting the result from House of Quality and produce Product Design Specification (PDS).

Scopes of phase #2:

1. Produce concept generation by generate it from Morphological Chart.

Scopes for phase #3:

3. Making decision based on the decision tree.
4. Selection method by using the Pugh method.

## **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. It explains about the past review from other journal that explain about the method in Conceptual Design. 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 to producing a Product Design Specification (PDS) by interpreting the result from House of Quality. Phase 2 focus on produce concept generation based on Morphological Chart. Final is selection method which based on the Pugh Chart.

Chapter 4 is about analysis and discussion chapter. In this chapter, the result from the investigation and experiment from Phase 1 until Phase 3 are analyzed here. The final result from the experiment will be analyze until it fulfill the project objective.

Chapter 5 is the conclusion chapter. It conclude the all the findings from this study. Generally, flywheel hybrid can store energy and it is proven with past research and review. The result from testing of the prototype flywheel hybrid are shown to improve the result from past testing. Lastly, future preventive method is proposed to make some change for the flywheel hybrid which focus on Conceptual Design in future.

## **CHAPTER 2**

### **LITERATURE STUDY**

#### **2.1 Introduction**

Literature review is one of the methods which are a theoretical and methodological contribution for a certain issue that being done for finding more information about the project. Besides that, literature review also acts as a solid background or as a supporting proved of method that being done in designing this flywheel hybrid module. The sources for this literature review was been used from previous project done or current knowledge findings by several researcher and other such as journal, thesis, article, books and etc. Moreover, literature review can help to overview deeply about the project that being carried out.

### **2.1.1 FLYWHEEL HYBRID CONCEPT AND ADVANTAGES**

It is now accepted that the present production and use of energy pose a serious threat to the global environment and consequent climate change. One significant manner using energy storage unit is very attractive and expected to show up (Liu & Jiang, 2007). Based from this journal, it was right about too many of vehicle which in turn causes more pollutant to occur and it will affect the climate changes. The design of flywheel in which can store energy will help to solve the pollutant problem. This is because the flywheel energy storage has a high efficiency which helps the engine emission, and can produce high power energy.

From the past research, it had been inferred that the flywheel function is to store the energy and reuse it again when it is required. For example, when the car is stopped and want to move again, the flywheel will supply it energy to the wheel of the car so that the car will move based only from the energy. Therefore, it helps the engine to increase the fuel consumption and less pollutant. But when the car is accelerating again, the flywheel will back to store the energy. This concept is proven by research of “Modeling of Flywheel Hybrid Powertrain to Optimize Energy Consumption in Mechanical Hybrid Motorcycle”.

The concept of flywheel hybrid powertrain is originated from kid’s toys car. It is used small metal disk known as flywheel to store the kinetic energy transmitted from the wheel during the push action. When releases, the store kinetic energy inside the flywheel is transfer back to the wheel and propel the toys car forward (Manaf, Mohamed, Zakaria, Saadun, & Mohd Hanafi, 2013).