UNIVERSITI TEKNIKAL MALAYSIA MELAKA

RECHARGING OF FLYWHEEL HYBRID MODULE THROUGH ACCELERATION PHASE

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

by

MUHAMMAD ARIF BIN RAMLI

B071210447

930603-04-5007

FACULTY OF ENGINEERING TECHNOLOGY

2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Recharging of flywheel module through acceleration phase**

SESI PENGAJIAN: **2015/16 Semester 2**

Saya **MUHAMMAD ARIF BIN RAMLI**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TERHAD	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TIDAK TERHAD	

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:

7104C,Jalan Hang Tuah

763000 Sungai Udang

Melaka

Cop Rasmi:

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled “PSM Title” is the results of my own research except as cited in references.

Signature **:……**

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)

ABSTRACT

Mechanical hybrid is a low cost hybrid. It using flywheel model and a push belt CVT. This research is make in order to get a new method to develop a method of flywheel charging behaviour during acceleration phase in order to reduce power loss Flywheel acts as energy storage that store kinetic energy. Flywheel can be stored using regenerative braking. Thus, the objective of this study is to develop a method of recharging flywheel hybrid module through acceleration phase. The study was conducted using actual test in order to get the speed of flywheel vs time graph where the motorcycle's wheel had been acted as flywheel and the speed of the wheel will be used as input. This method proves direct relationship between motorcycle speed and power flywheel. The result shows that power of flywheel can propel the car for a certain time as the flywheel speed rotates in order to give energy to push the motorcycle. This can be assimilate by looking at children car toy. A small disk that is attached inside it can store energy and push the toy during push action. When it released the energy from the disc is transfer back to the wheel in order to propel the toy forward. This thesis is about power propulsion concept. In addition the study is to run the experiment using different driving cycle data and analyse the power torque patern of the flywheel in order to identify which driving condition is better for the motorcycle driving. Based on the result it shows that highway driving cycle (HWFET) is the best condition for flywheel hybrid compare to other driving cycle and viscous model method is develop to charge flywheel during acceleration phase.

ABSTRAK

Hibrid mekanikal adalah hibrid kos yang rendah. Ia menggunakan model roda tenaga dan CVT belt push. Kajian ini membuat untuk mendapatkan satu kaedah baru untuk membangunkan satu kaedah roda tenaga mengecas tingkah laku semasa fasa pecutan untuk mengurangkan kehilangan kuasa roda tenaga bertindak sebagai penyimpanan tenaga yang menyimpan tenaga kinetik. Roda tenaga boleh disimpan menggunakan brek regeneratif. Oleh itu, objektif kajian ini adalah untuk membangunkan satu kaedah pengisian modul roda tenaga hibrid melalui fasa pecutan. Kajian ini dijalankan menggunakan ujian sebenar untuk mendapatkan kelajuan roda tenaga vs Graf masa di mana roda motosikal itu telah bertindak sebagai roda tenaga dan kelajuan roda akan digunakan sebagai input. Kaedah ini membuktikan hubungan langsung antara kelajuan motosikal dan kuasa roda tenaga. Hasil kajian menunjukkan bahawa kuasa roda tenaga boleh menggerakkan kereta untuk masa yang tertentu sebagai kelajuan roda tenaga berputar untuk memberi tenaga untuk menolak motosikal. Ini boleh mengasimilasikan dengan melihat mainan kanak-kanak kereta. Satu cakera kecil yang dipasang di dalamnya boleh menyimpan tenaga dan tolak mainan semasa tindakan push. Apabila ia mengeluarkan tenaga daripada cakera adalah pulang semula ke roda untuk menggerakkan mainan ke hadapan. Karya ini adalah mengenai konsep kuasa pendorongan. Di samping itu kajian ini adalah untuk menjalankan eksperimen menggunakan berbeza data kitaran memandu dan menganalisis patern kuasa tork roda tenaga untuk mengenal pasti yang memandu keadaan adalah lebih baik untuk memandu motosikal. Berdasarkan keputusan itu menunjukkan bahawa kitaran pemanduan di lebuh raya (HWFET) adalah keadaan yang terbaik untuk roda tenaga hibrid berbanding dengan kitaran memandu lain dan kaedah model likat membangunkan mengenakan roda tenaga semasa fasa pecutan..

DEDICATIONS

This project and research work is dedicated to my beloved parents for their enthusiastic caring throughout my life, my loving siblings and also my friends for their encouragement and love

ACKNOWLEDGMENTS

I would like to express my utmost appreciation to Mr. Muhammad Zaidan bin Abdul Manaf who is my final year project supervisor. The supervision and support that he gave truly help the progression and smoothness of completing this project. The co-operation is much indeed appreciated.

My grateful thanks also go to all lecturers who always give advices and motivate me to work harder and smarter. I believe that success is not a dime a dozen.

I am also heartily thankful my friend for their support and encouragement. Also, to who are directly or indirectly involved in completing this thesis.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF SYMBOLS AND ABBREVIATIONS

UDDS	=	Urban Driving Cycle
HWFET	=	Highway Fuel economy Driving schedule
FTP	=	Federal Test Procedure
CVT	=	Continuous Variable Transmission
ω_f	=	Flywheel speed
R_o	=	Flywheel radius outer
R_i	=	Flywheel radius inner
E	=	energy
I	=	Inertia
M	=	Mass
Þ	=	Density
V	=	Volume
ω	=	Angular velocity
ω_{max}	=	Maximum angular velocity
F_{rr}	=	Motorcycle's friction force
F_a	=	Aerodynamics force
F_r	=	Friction force
F_{ws}	=	Wheel speed force
Þ$_{wind}$	=	Density of wind
C_D	=	Drag coefficient

A_{front}	=	Frontal area
V_x	=	Velocity motorcycle
C_{rr}	=	Coefficient friction
M_i	=	Mass motorcycle and rider
g	=	Gravity (9.81 m/s^2)
Θ	=	Angle(°)
$P_{pulling}$	=	Motorcycle pulling power
$F_{pulling}$	=	Motorcycle pulling Force
ω_{wheel}	=	Wheel speed
η	=	Number of rotation
ω_{engine}	=	Engine speed
R	=	Wheel ratio

CHAPTER 1
INTRODUCTION

1.0 Introduction

Nowadays there are many cars produced at the road and cause increase of environment pollution. Therefore, in order to reduce the humongous amount of carbon flying on our atmosphere serious action should be make. An inefficient of internal combustion engine was the major contribution to number of carbon increase release to atmospheres. Therefore, hybridization process needs to establish in reducing the usage of combustion engine. The advantage is it can reduce carbon impact on environment and it also can give big saving to user.

There are many types of vehicles that have been produced by human. All of these car had been improved to get better in order to achieve optimum performance and convenient to the human and also to the nature. Hybrid vehicles is one of the successful things made. Hybrid vehicle is a vehicle that used two different type of power sources. A local company named Hybrid Scooter Sdn. Bhd had been launched two model of hybrid motorcycle which are "Gwheel Hybrid Scooter 80 cc (GW800HB)" and "Gwheel Hybrid Scooter 50 cc (GW500HB)". This motorcycle used 3 driving mode which are petrol, battery and both petrol and battery. (Syedz, 2011)

There are many researches about hybrid vehicle in order to improve it. The latest hybrid is by using flywheel as secondary power source. It had make the engine efficiency increase between 20% to 80% (Lagunoff 2008)

Automotive technology development has been improved a lot and Kinetic energy recovery system (KERS) has been introduced. This system works as a device to store kinetic energy and the energy will be used back in the future to increase the efficiency of the vehicles. For example, if it is installed at wheel the kinetic energy

will be stored when the vehicles are in deceleration or braking process. This mechanism called regenerative braking.(Cibulka 2009a)

This kinetic energy recovery system had been widely being used in F1 racing car which is Ferrari, Renault, BMW, and McLaren. Volvo are making research about this Kinetic energy recovery system to used it on the normal road. The effect of the first power source which is internal combustion engine with the secondary power source which is flywheel has reduced the usage of internal combustion engine about 20% (Wayne,2011)

This technology that had been widely used in four wheels car.it is not suitable for 2 wheel vehicles which is motorcycle. In 4 wheels cars, it used continuous variable transmission (CVT) which is so big and has many components. Therefore CVT is a complex transmission .In addition the motorcycle has limited space compare to cars. Thus this technology mechanical hybrid flywheel is suitable to be used for a motorcycle.

1.1 Problem Statement

The main problem is to create a method to recharge the flywheel by using acceleration process. There are 3 driving phase which is acceleration phase, steady velocity phase and deceleration phase. To recharge the flywheel, we need input torque from the wheel thru regenerative braking process. Acceleration phase and steady velocity phased can be classified as power mode, while deceleration phase classified as regenerative mode. It means that at power mode, internal engine and Kinetic energy recovery system will used their power to make the vehicles move.

Therefore this research is done in order to get a new method to develop a method of flywheel charging behaviour during acceleration phase in order to reduce power loss.

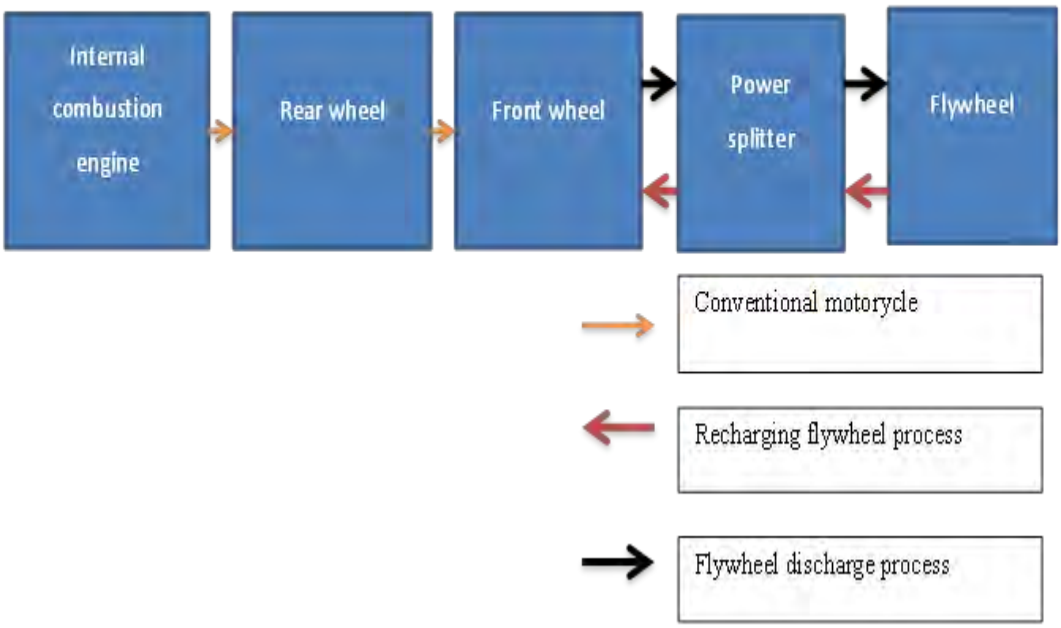

Figure 1.1: Flywheel Hybrid Module Integrated with Motorcycle Powertrain Module

Experiment and simulation are run based on this concept diagram. The concept of flywheel hybrid powertrain is being inspired from kid's toys car. A small metal disk known as flywheel is attached inside the toys is used to store kinetic energy and transmitted from wheel during push action. When released, the kinetic energy stored inside flywheel (small metal disk) is transfer back to the wheel and propelled the toys car forward. Two concepts gathered from these simple innovations which are the regenerative braking concept and the power propulsion concept.(Manaf et al. 2013)

Driving condition will affect the hybrid efficiency. Driving in highway, deceleration and braking process is less as in highway there are more acceleration or cruise compare to braking process and deceleration. Therefore recharging process of flywheel hybrid is minimum. It cause less energy provided by the flywheel. Therefore, the usage of flywheel hybrid in highway cycle is not efficient. At urban

cycle, driving condition need more acceleration and brake compare to highway (Reynolds and Kandlikar 2007).

1.2 Objectives

The objectives are firstly to implement heuristic energy management in hybrid concept. Heuristic is parameter-tuning techniques.it is simple, easy-to-use and robust so we can set or tune based on our setting made. The parameter used for heuristic energy management is by running the experiment using a set of driving cycle data. Secondly is to simulate the experiment using different highway driving data and to analyse power torque pattern of flywheel in different gear. Lastly is to develop a method of flywheel charging behaviour during acceleration phase.

1.3 Scope

The scope is to run a heuristic simulation model of flywheel hybrid motorcycle. The simulation being tune using 3 driving cycle condition. In the simulation process, we assume energy loss is zero. In simulation method, we used the Microsoft excel to analyse the pattern of 3 driving cycle which are Federal Test Procedure (FTP), Highway Fuel economy Driving schedule (HWFET), and Urban dynamometer driving schedule (UDDS) . The pattern of 3 different types will be analysed in order to get expected result. The material used for making the flywheel. The material influenced the energy stored. If the material is heavy it can't store more energy but difficult to start store energy in order to move the flywheel. The material use is mild steel.

1.4 Report arrangement

Chapter 1 explained about researches that had been make about hybrid system and sub system of hybrid clearly. In this chapter had been clearly stated the problem that are been faced in nowadays cars. Objective statement had been clearly stated about the develop a method to of flywheel charging behaviour and analyse the method in 3 different dring cycle which are Federal Test Procedure (FTP), Highway Fuel economy Driving schedule (HWFET), and Urban dynamometer driving schedule (UDDS).

Chapter 2 is about literature review about past years research and thesis. All of the research and thesis are used to get the idea of mechanical hybrid. It also help to get the better vision to do the thesis in the future.

Chapter 3 is about analysing the data from the driving cycle. All the driving cycle choosed are different. There is at highway condition, urban condition and urban-highway condition. This analyse is important in order to know which driving condition are good for the method. It also briefly explain about the methodology that will be used in this thesis.

Chapter 4 is about analyse the graph from actual test. Actual test had been conduct using Ex5 motorcycle model. The graph will be analyse and the power of engine used can be determined. It also produced an expression to use for these model The expression is important in order to make a Power flywheel vs speed of flywheel. From this graph we can know how long does the energy can last in certain time.

Chapter 5 is about conclusion for this thesis. At this chapter it will conclude the thesis and will suggest the future work for this hybrid motorcycle.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter will discuss mainly on the last research about these topic which is flywheel hybrid motorcycle. It is important in order to get the idea about the flywheel hybrid motorcycle. It also help a lot in advancing these type of technology. It also will give the benefits about these technology in todays life.

2.1 Increase Internal Engine Efficiency and Performance

Human used vehicle in order to move quickly to other place. The vehicle involves are vehicles on land, water and even on air. This research is about a two wheel vehicle which is motorcycle. For an internal engine, the usage of fuel is only 25%-30% from thermal energy exchange to mechanical energy the rest will be released to the surrounding. In addition, vehicle powertrain consist of two parts which are the engine and the driveline. There are several energy losses during driving the vehicles in urban or highway (Lagunoff 2008)

In the area of the engines, efforts are underway to develop direct injection gasoline and diesel engine technologies to improve fuel efficiency (Taymaz and Benli 2014). Direct injection gasoline is also known as GDI is fuel injection that is installed in modern two-stroke and four-stroke gasoline engines. GDI engines are more efficient compare to conventional fuel injected or caburated engine because the piston 'pumping losses' has been reduced due to no air throttle that no air throttle plate eliminating air throttling losses in GDI. (US DOE, 2005)

In addition, the engine development had been made in order to increase the engine efficiency. For example is variable valve timing actuation (VVT). These systems will alter timing and lifting of the valve in order to get an optimum setting

for the engine speed. These methods had been improving the fuel efficiency by 5%. Other example is turbocharging and supercharging. Both used fans that are used to force compressed air into engine cylinder. A turbocharger is powered by exhaust gas from engine through exhaust manifold while supercharger powered by its own fan. Both allow more air compressed and fuel inject to the engine in order to increase the engine performance. This method increases the engine efficiency by 7.5% (US DOE, 2005).

Hydrogen and carbon are two main elements that are exist in the fuel. It will mix with the air to burn and will produce heat energy. The heat energy is converted to mechanical energy. The development of fuel had been made in order to increase the engine efficiency to burn the fuel. The fuel had been added by additives in order to increase its efficiency. It will make the fuel easy to vaporize, quick to start at cold wheater, smooth acceleration and give maximum power. High quality of fuel will increase the engine efficiency (Li 2007)

2.2 Basic hybrid concept

System hybrid used 2 different power sources to move a vehicle. For example, an electric hybrid vehicle such as Toyota hybrid Prius. It can move using an internal combustion engine and using the electric that had been stored in battery. Internal combustion engine is a normal system for normal car that used fuel. Electric that had been stored in battery can be used as secondary power source. This system has increase the fuel efficiency by 80%.

Internal combustion engine has 2 types which are petrol engine and diesel engine. There are 4 types of hybrid that used electric energy stored in battery which is hybrid electric vehicle, plug in hybrid vehicle, electric extended range vehicle and electric battery vehicle. Mild hybrid, medium hybrid and fully hybrid car are the types of hybrid car exist nowadays. There are 3 component exist in hybrid technology which are motor, generator and energy storage. There are 3 hybrid class which are series hybrid, parallel hybrid and series-parallel hybrid (Lagunoff 2008).

2.2.1 Parallel hybrid drivetrain

Parallel hybrid drive train consists of battery, converter, electric motor, and internal combustion engine. Variety of power source can be combined or used one power source in order to move the vehicle. Battery and engine are connected with the energy transfer system. Basically, motor electric is used to help the internal combustion engine.

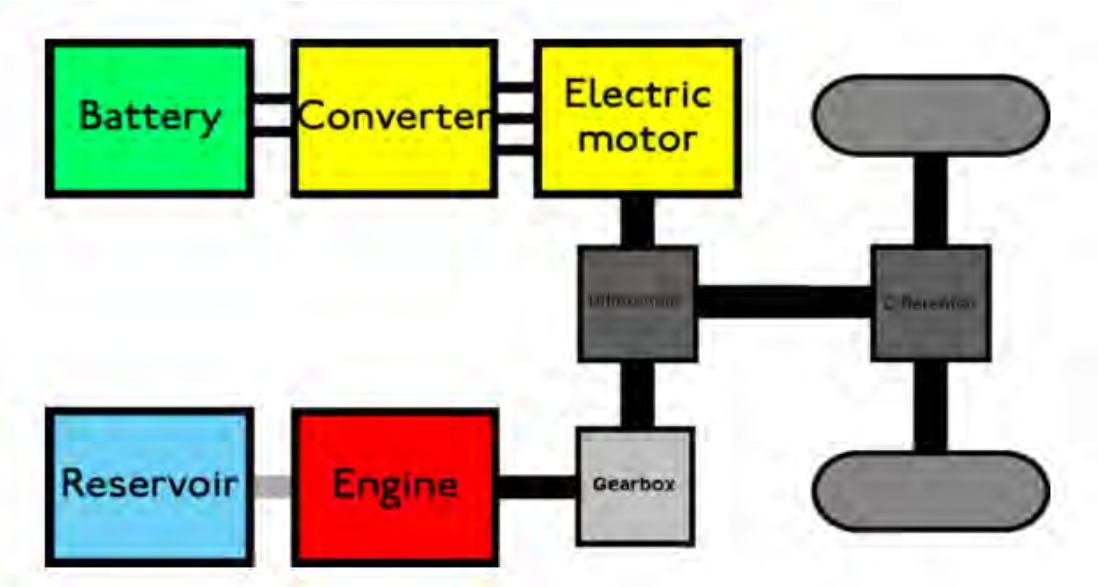

Figure 2.1: Parallel Hybrid Powertrain(Lagunoff 2008)

2.2.2 Series hybrid powertrain

There are 3 major components for hybrid technology which are motor, generator, and energy storage. For series hybrid vehicles, engine is used to run the generator. Generator is used to charge the battery or to help motor electric to move the vehicles. The figure below show the series hybrid powertrain. The main advantage of series hybrid powertrain is it is fully independent operation for the internal combustion engine. (Lagunoff 2008)

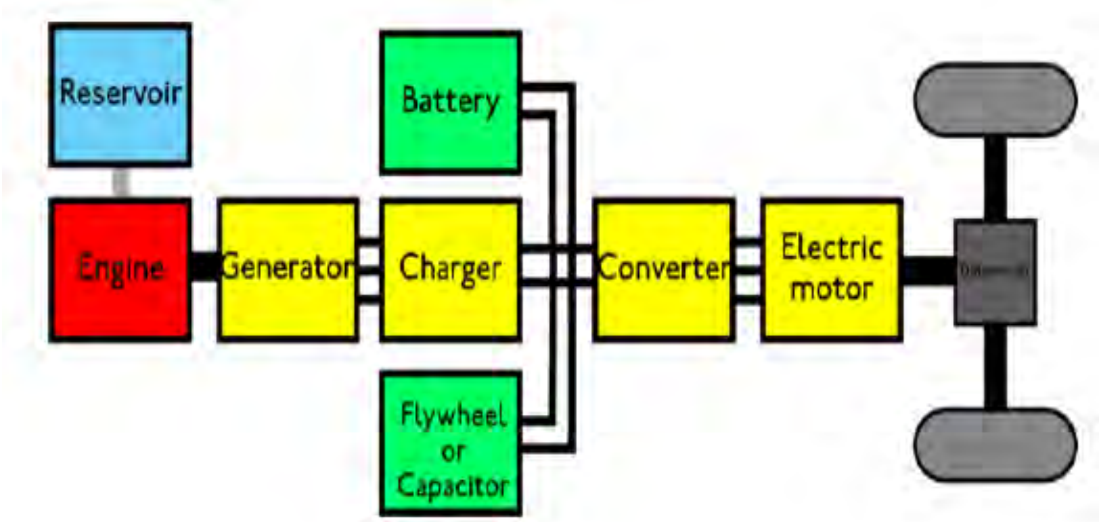

Figure 2.2 : Series Hybrid Powertrain(Lagunoff 2008

2.3 Low Cost System Hybrid Powertrain

System hybrid consists of 2 types which is electrical hybrid and mechanical hybrid. Electrical hybrid works using more than 2 power supplies which is internal combustion engine and a motor that used electrical energy (Kamper 2008) .

In electrical hybrid vehicles, the process of recharging its own battery is by electricity provided by its own electrical recharge system and cause the cruising mileages increase. Electric motor operates as the primary power source when the vehicle is in low operation cycle. When it at medium and high operation cycle, it will used gasoline engine to operate. At the same time the battery system is recharged (Hsu and Lu 2010).

Degree of hybridization, the reference vehicle, driving cycle are the example that effect the hybrid electric vehicles from 5% to 30%. Electric component of electric vehicle are at higher cost compare to conventional vehicles. Electric component such as battery pack, high- power electronic converters and additional motor and/or generator are costly but it offer large fuel savings(Berkel et al. 2010)

A low cost hybrid had been introduced. It was mechanical hybrid. These mechanical hybrid using a flywheel model and a push belt CVT. Flywheel will act as

an energy storage that store kinetic energy. CVT act as power transmission. This assemble allow hybrid functionality to be make. Regenerative braking, driving on the flywheel and engine shut-off during standstill are the example of hybrid functionality.(Berkel et al. 2010)

2.4 Advantages using flywheel

Mechanical hybrid used kinetic energy to store energy. Thus, it needs some mechanism to help it store the energy. One of the mechanical hybrids is flywheel mechanical hybrid. Since the Kinetic Energy Recovery System (KERS) had been widely used in racing car especially in formula one. Jaguar and Volvo are the company that had make a step to use it to a normal car at normal road.

Table 2.1: Comparison between Flywheel hybrid and Hybrid Motor Electric

Criteria	Flywheel Hybrid	Hybrid Motor Electric
Component	Flywheel only	Motor/generator & energy storage (battery)
Energy storage	Flywheel	Battery
Electronic	Logic gate flywheel	Logic gate motor and battery
Weight	Light	Heavy
Installation Space	Small	Big

Flywheel is a wheel that looks like a disc. It rotates to store energy in kinetic energy form. When the flywheel speed is increase, there will be more energy can be stored. The flywheel rotates with a connecting rod that is called shaft. The shaft will transfer the energy to the flywheel or release the energy from the flywheel. Flywheel