OPTIMIZATION OF MECHANICAL COUPLING IN ELECTRIC VEHICLE (ev)

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This report is submitted in accordance with requirement for the
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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive)"

Signature : ……..
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Date : …….

DECLARATION

"I hereby declare that the work in this report is my own except for citation and quotation that the sources has been clarified for each one of them"

Signature : ……..
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Date : …….

DEDICATION

I dedicated this report to my beloved mother,
Kemariah Binti Dagang,
Whose always highly support me, and understanding to make it possible
throughout my Bachelor In Mechanical (Automotive) program

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All praises and thanks be to Allah S.W.T. who has guided us to this, never could we have found guidance, were it not that Allah had guided us! (Quran 7:43)

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ABSTRACT

Evergreen is UTeM's latest Electric Vehicle (EV) being developed by lecturers and students from Faculty of Mechanical Engineering and Faculty of Electric Engineering in order to compete in PGMC (Proton Green Mobility Challenge) competition. Evergreen is a standard Proton Saga BLM with 5-speed manual transmission system. This car is transformed to electric vehicle by removing the ICE (Internal Combustion Engine) and replaced with DC electric motor. Mechanical Coupling is the parts of the engine system that integrate the DC electric motor with the 5-speed manual transmission. Literature review on the transmission analysis show most of the studies are done on the shaft or drive train. Thus, for this project, the study will focus on the performance of the Mechanical coupling. By using SolidWorks, two type of study is done on the Mechanical Coupling, which is static analysis and buckling analysis. Static analysis focus is to study the strength of the material used for the coupling while buckling analysis objective is to study the stability of the Mechanical Coupling's structure. The results obtain from static analysis shows that no material failure is occur on Mechanical Coupling. The material used, Alloy Steel, is strong enough to absorbs loads apply to Mechanical Coupling. However, the coupling experiencing structure instability based on the result obtains from buckling analysis. Data obtain from buckling analysis shows that buckling failure is occur on the structure of the Mechanical Coupling. As conclusions, no material failure is occur as the strength of the Alloy Steel able to overcome the loads apply to Mechanical Coupling. Unfortunately, due to the existing of buckling failure, the design of the Mechanical Coupling needs to change in order to minimize the buckling effect.

ABSTRAK

Evergreen adalah kereta elektrik terbaru yang dibangunkan oleh para pensyarah dan pelajar dari Fakulti Kejuruteraan Mekanikal dan Fakulti Kejuruteraan Elektrik untuk digunakan bagi memasuki pertandingan PGMC (Proton Green Mobility Challenge). Evergreen adalah sebuah kereta Proton Saga BLM yang mempunyai transmisi manual dengan 5-kelajuan. Kereta ini diubah menjadi kenderaan elektrik dengan menukarkan enjin ICE (enjin pembakaran dalaman) kepada motor elektrik berarus terus. Gandingan Mekanikal adalah sebahagian daripada sistem enjin yang telah menggabungkan motor elektrik berarus terus dengan transmisi manual 5-kelajuan. Kajian yang dijalankan mendapati kebanyakan analisis yang dilakukan terhadap system transmisi memfokuskan hanya kepada sistem pacuan kenderaan dan aci, . Bagaimanapun, analisis terhadap Gabungan Mekanikal jarang dilakukan. Oleh kerana itu, projek ini dilakukan untuk mengkaji prestasi gabungan mekanikal. Dengan menggunakan perisian SolidWorks, dua jenis analisis telah dilakukan ke atas Gandingan Mekanikal tersebut, iaitu analisis statik dan analisis lengkokan. Analisis statik akan menentukan kekuatan bahan digunakan untuk Gandingan Mekanikal tersebut, manakala analisis lengkokan akan menentukan ketidakstabilan struktur gandingan tersebut. Berdasarkan data yang diperoleh dari analisis statik, kekuatan bahan yang digunakan untuk Gandingan Mekanikal, iaitu *Alloy Steel*, mempunyai kemampuan yang cukup untuk menyerap semua jenis beban yang diberikan kepada Gandingan Mekanikal. Tetapi, keputusan analisis yang diperoleh dari analisis lengkokan menunjukkan Gandingan Mekanikal mengalami ketidakstabilan struktur. Kesimpulannya, kegagalan bahan tidak berlaku ke atas Gabungan Mekanikal oleh kerana bahan yang digunakan, iaitu Alloy Steel, mampu untuk menerima semua jenis beban yang diberikan kepada Gabungan Mekanikal. Bagaimanapun, struktur Gabungan Mekanikal mengalami kegagalan lengkokan. Oleh itu, reka bentuk yang baru perlu dilakukan bagi mengurangkan kesan kegagalan lengkokan tersebut.

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LIST OF SYMBOLS

σ'	=	Maximum von Mises Stress
S_y	=	Yield Strength
σ	=	Stress
$\in$	=	Strain
δ	=	Magnitude of Deformation (or Displacement)
L	=	Length of the part
K_F	=	The additional "geometric stiffness" due to the stresses caused by the loading
δ_m	=	The associated buckling displacement shape for the *m- th* mode
$\prec_m$	=	The buckling load factor (BLF) the *m – th* mode

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CHAPTER 1

INTRODUCTION

1.1 Project Background

In year 2012, PROTON Holdings Berhad (PROTON), a Malaysian automotive company, and Agensi Inovasi Malaysia (AIM) have organized Proton Green Mobility Challenge (PGMC). This competition is held as path of collaboration between universities and industry in order to develop an electric vehicle based on the conventional Proton Saga specification and features. Ten universities is chosen to enter the competition and UTeM is one of it. Every team is given about 10 months to complete their electric vehicle from January 2012 until the day of competition that is 5-7th October 2012. In 10 months, every team need to transform a conventional Proton Saga BLM into an Electric Vehicle. This transformation including the removing of ICE engine, the installation of electric motor, implementing new mechanical coupling system, the changes to the cooling system, the installation of battery and many more.

1.2 Problem Statement

Mechanical coupling system is one of the changes that have been made to the Proton Saga BLM by UTeM PGMC's team. The changes that have been made is by combining the electric motor used with the Proton Saga's 5 speed-transmission system. Due to the lack of time, this change is made without doing proper analysis to the coupling system. Thus, the optimum capability of the mechanical coupling

system is unknown. Study on the mechanical coupling system is required to analyze problems that may occur to the mechanical coupling system and data obtain from the analysis can be used to optimize the performance of the system.

1.3 Objectives

The main purpose of this study is to study the mechanical coupling that have been implemented in UTeM's electric vehicle, Evergreen. Analysis is done to identify any weakness and failure that may occur in the mechanical coupling system since the system does not going through any proper analysis before the system is set up in Evergreen.

1.4 Scopes

The scope of this project is to analyze the performance of the existing mechanical coupling system in Evergreen. The scopes will include the failure analysis of the mechanical coupling by using SolidWorks and the optimization of the product by using DFM methods.

CHAPTER 2

LITERATURE REVIEW

2.1 Evergreen's Mechanical Coupling System

Mechanical coupling in Evergreen is a set of components that combined power source (in this case DC Motor) and transmission (5-speed transmission system). Mechanical coupling system is placed between DC Motor and transmission. The components are Adapter Plate, Friction Disc, Pressure Plate, Flywheel and Shaft Coupler. The arrangement of the Mechanical coupling component is as shown in Figure 2.1.1 below.

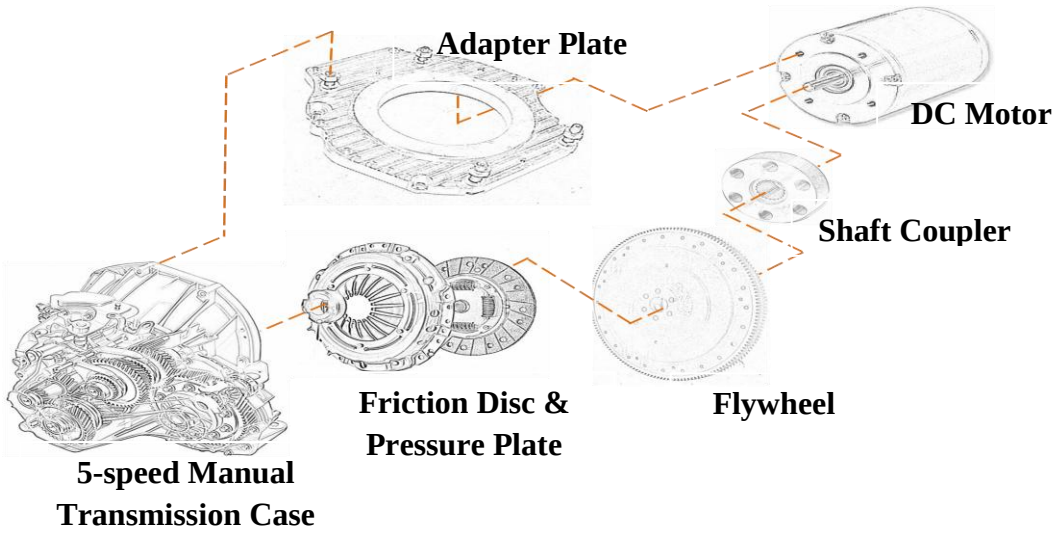

Figure 2.1.1: The arrangement of Evergreen's Mechanical Coupling System (Source: UTeM's PGMS Presentation, 2012)

2.2 DC Electric Motor

There are many types of electric motor. It comes in various shape, weight and size depend on its functions. Electric motor is used in almost everything like toys, robot, CD players, watches, subway trains and many more. The main function of electric motor is similar for every type, which is to convert electrical energy into mechanical energy. Basically, there are two types of electrical motor that is Direct Current (DC) electric motor and Alternating Current (AC) electric motor. DC electric motor is motor that runs on direct current, which the current flow in the circuit is in one direction only. AC electric motor is a motor that runs on alternating current, which the direction of current flowing in a circuit is constantly being reversed back and forth.

The specification of DC motor used in Evergreen is a DC motor with power of 25kW and powered with up to 144V battery. The power of the DC motor can achieved 60kW at peak power supply. The DC motor can achieved speed up to 4000rpm. The average torque produce is 60Nm and can achieved up to 130Nm. Average current flow in the motor is 191.4A and can achieved until 380A. The weight of the DC motor is 58kg and has efficiency of 94.8%. (Source: UTeM's PGMC Presentation, 2012)

2.3 5-Speeds Manual Transmission

Transmission is a set of gears that function to transmitted energy from power source to a drive mechanism. The transmission will change the speed energy that gain from the power source (in this case, the electric motor) and transfer it to torque energy through the drive mechanism. A transmission system is also called gearbox as it is basically a box that containing a configuration of gears. Another main function of transmission system in automobile is to allow the drive mechanism to shift from forward into reverse without needed to shut off the engine and to provide neutral position when engine is running and vehicle is in stationary state. The transmission system containing a range of gears, from low to high gear, to make the used of the engine's torque more effective as driving conditions change. The larger gear (low gear) convert higher engine rpm (revolution per minutes) into higher torque or

energy at lower at lower drive wheel speed by spinning more slowly than crankshaft while the smaller gear (high gear) convert lower engine rpm into higher speed and efficiently by spinning faster than crankcase

Basically, there are two types of automobile transmission system, which is manual and automatic. A manual transmission system is an assembly of shafts, gears, and related parts contained in a metal case or gearbox partially filled with lubricant. In manual transmission system, gears are selected manually by the driver. The driver will decide whether he want to set low gear or high gear, to reverse or to move forward. An automatic transmission system is a transmission that can change gear ratios automatically as the vehicle moves. In automatic transmission, the driver only needs to operate a gear-shift once (forward or reverse) and do not need to control a clutch. The transmission system will decide when to change the gear ratios by referring to the rpm of the engine.

The transmission system that used in Evergreen is a manual 5-speed transmission system. This transmission is the actual transmission been used in Proton Saga BLM. The condition of PGMC (Proton Green Mobility Challenge) competition stated that every participants need to change the ICE engine of the Proton Saga BLM with a DC electric motor, but they need to used the 5-speed manual transmission that already in the vehicle. The 5-speed transmission system in Evergreen is a transmission that contains 5 choices of gears (gear 1 until gear 5) with additional reverse gear. The gear ratio for every gear in this transmission system is as stated in Table 2.3.1 below:

Gear	1	2	3	4	5
Ratio	3.333	1.954	1.285	0.926	0.755

Table 2.3.1: The gear ratios of the 5-speed manual transmission

(Source: UTeM's PGMC Presentation, 2012)

2.4 Adapter plate

Adapter plate is used to cover the mechanical coupling that connects the DC electric motor with 5-speed manual transmission. The cover plate is specially design

with the profile of the plate follow the profile of the transmission bell housing. This plate is made from aluminium with thickness 5mm. The adapter plate is bolted to DC motor register at one side and transmission bell housing at another side. Another function of this plate is to ensure the clutch fluid that will be inserted in the mechanical coupling does not flow out from the mechanical coupling system. Figure 2.4.1 below shows the design of the adapter plate by using Catia. The dimensions of adapter plate can refer to Appendix C

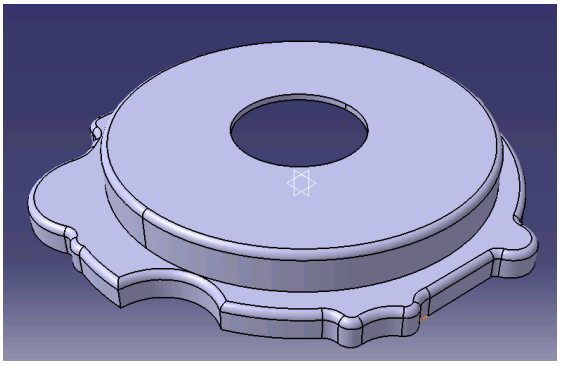

Figure 2.4.1: The design of the adapter plate by using Catia.

2.5 Shaft Coupler

Shaft coupler function is to ensure the power transmitted from the electric motor to the transmission is delivered to the wheel smoothly without any unwanted vibration or jerking. Figure 2.5.1 and Figure 2.5.2 shows the geometry of the shaft coupler. The lower side of the shaft coupler is combining with the propeller shaft of the electric motor. The lower side is designed to have locked mechanism so that it can attach to the DC motor propeller. It also have two hole on the side of the lower side that used to give extra locked of the shaft coupler to the DC motor propeller. The upper side of the shaft coupler have five bolts on its. The upper side will be bolts to the 5-speed manual transmission.

Figure 2.5.1: The side view of Shaft Coupler

Figure 2.5.2: The lower side of the Shaft Coupler

2.6 Designs for Manufacturing (DFM)

DFM is the method used when designs a product with aiming for manufacturing of the products. DFM is the first step for anyone that want to develop the product so that it capable to be done in massive manufacturing and sell to public. DFM is like an umbrella that covers variety of tools and techniques to accomplish a manufacturable product. The application of DFM can help the industry in lowering their development cost, shorting their development time; enhance faster manufacturing start of build, lowering assembly and test costs without effect the quality of the product developed.

The objectives of DFM method is to identify product concepts that are easy to manufacture and can sell to public with low cost. DFM is focus on component design for the ease of manufacturing and assembly. It's focused to design a product that easy to manufacture and assembly. There are several factors been considered in DFM that is environmental, customer, supplier, and process and tooling. Table 2.6.1 below shows the consideration of DFM by respect to its factors:

Table 2.6.1: The consideration taken in DFM

FACTORS	EXAMPLES
Environmental	Ergonomics Safety Pollution Recycling Shock/vibration Temperature

Customer	Depth of product line Customization Test requirements
Suppliers	Cycle time Quality Ease of Assembly Ease of Testing Rework Shipping and Handling Tooling Costs
Process and Tooling	Partnerships Supplier tolerance capability Merging mechanical sub-assemblies Costs

2.7 SolidWorks Software

SolidWorks is a 3D mechanical CAD (Computer Aided Drawing) software that developed by Dassault Systemes SolidWorks Corporation. SolidWorks is software that can help its users to enhance their imagination into reality. SolidWorks can help in drawing and developed 3D designs in easy ways, without needed to use traditional method (by using hand and Engineering drawing tools). This easy-to-learn software help mechanical designer to quickly sketch ideas, experiment with features and dimensions, and produce models and detailed drawings.

This software also comes with the features to do analysis to the product design in its. By using the principle of Finite Element Analysis (FEA), this program capable of doing static analysis, dynamic analysis thermal analysis, drop test analysis, fatigue analysis and many more. These features can be used to help in doing analysis of the Evergreen's mechanical coupling system. The analysis of the mechanical coupling can only be done virtually since the coupling system that already implement in Evergreen cannot disassembled anymore.

New SolidWorks program, that is SolidWorks 2012 also come with new features, Design for Sustainability. This feature helps the users to determine best material that can be used to produce their product. With the help of this feature, users can design a product that has minimum negative effects to the environment. The function of Design for Sustainability is like the function of DFMEA (Design for Failure Mode and Effect Analysis) and DFM (Design For Manufacturing).