DESIGN AND DEVELOPMENT OF CARBON FIBER DOUBLE WISHBONE SUSPENSION ARM FOR UTeM FORMULA STYLE RACE CAR

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and from my opinion this thesis
is sufficient in aspect of scope and quality for awarding
Bachelor of Mechanical Engineering (Automotive)

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This report is presented as a requirement for a degree undergraduate in
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Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

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"I declare this report is on my own work except for summary and quotes that I have mentioned its sources"

Signature : …….

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Date : 24th MAY 2010

To my family
for their support and love.
Together with supports from friends,
honourable teachers and lecturer.

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Praise to Allah SWT to who seek help and guidance and under His benevolence we exist and without His help this project could not have been accomplished

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ABSTRACT

The one of most important factors in racing car is weight of car. This can reduce the performance of the car due to unnecessary weight. This study will reduce the weight by replacing their suspension system. By choosing current UTeM Formula Varsity racing car as a reference and FSAE rules as our guidance, a development of composite suspension has taken place. Most of racing car use double wishbone suspension link as their suspension system due to its advantages. The design of this suspension system involved the calculation of load transfer during cornering and braking condition. Then followed by the force acting on the link suspension is calculated by using matrix vector unit. After that, the strength of the composite is calculated by using stiffness matrix equation which it determines the strength of the composite layers according to its orientation. The value of composite must greater than value of force acting on the suspension system in order to prevent failure when it operating in certain condition. Then, the fabrication process of component will take place using carbon fiber polymer with polyester resin matrix using conventional hand lay-up technique. Final finished product will undergo compression testing using INSTRON Universal Testing Machine to determine the maximum compressive strength.

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ABSTRAK

Salah satu faktor penting dalam sesebuah kereta lumba adalah berat kereta tersebut. Keupayaan kereta tersebut akan berkurang disebabkan berat yang berlebihan. Kajian ini akan mengurangkan berat kereta tersebut dengan menggantikan sistem suspensinya. Dengan mengambil kereta lumba *UTeM Formula Varsity* sebagai contoh dan peraturan *FSAE* sebagai petunjuk, pembangunan sistem suspensi berasaskan komposit telah dibuat. Kebanyakkan kereta lumba menggunakan penyambung suspensi tulang selangka berdasarkan kelebihannya. Rekabentuk sistem suspensi ini melibatkan pengiraan pemindahan beban ketika dalam keadaan membelok dan membrek secara mengejut. Diikuti dengan daya yang bertindak terhadap penyambung suspensi tulang selangka dikira dengan menggunakan persamaan unit vektor matrik. Kemudian, kekuatan komposit dikira dengan menggunakan persamaan matrik simpulan yang akan menentukan kekuatan lapisan-lapisan komposit berdasarkan orientasinya. Nilai komposit mesti melebihi nilai daya yang bertindak terhadap sistem suspensi supaya dapat mencegah kegagalan semasa ia sedang beroperasi dalam keadaan tertentu. Kemudian, proses pembuatan komponen suspensi telah dilakuknn dengan menggunakan serat karbon bersama *resin polyester*. Proses ini menggunakan teknik *hand lay-up*. Hasil daripada proses tersebut akan digunakan untuk menentukan kekuatan tekanan kritikal dengan menggunakan mesin ujian universal INSTRON.

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CHAPTER 1

INTRODUCTION

1.1 Background Study

The objective of this study is to design and develop a racing car suspension system based on composite materials. The main goal is to decrease the weight of suspension but in the same time, it provides strength beyond metallic material.

In recent event, *Universiti Teknikal Malaysia Melaka* has participated in the Formula Varsity race event and secured second place during the competition. Improvements on the vehicle were later carried out in order to sustain the good performance and achieve better results for similar future races.

Suspension is one of important part in vehicle. The main purpose of suspension is to absorb vibration and impacts come from road profile due to load transfer and extreme manoeuvres. Sneaking into race car world, the suspension will hold the tyres to its maximum area contact with road profile in order to maximize its grip. The suspension design also affects the chamber gain in tyres and further information will explain in Chapter 2.

In over 40 years, carbon fiber polymer has been proven for its weight and stiffness in various fields. By expecting that our racing car weight will decrease by replacing their metal suspension with composite suspension, this study has taken their place.

1.2 Problem Statement

The current UTeM racing car used double wishbone suspension arm built from mild steel and it can affect the weight of vehicle. In addition, according to the racing team, they do not have conducted any strength analysis regarding the vehicle in extreme manoeuvre in racing circuit.

Therefore, in order to make new improvement and overcome this problem, a study about racing car suspension has been carry away and it involving composite material. Carbon fiber polymer has proven for it strength beyond the steel and provide less weight. By apply this fact; the study about racing car suspension in composite form has taken place.

1.3 Project Objective

The main purpose of this project is to design and develop the suspension arm for UTeM Formula Style Racing Car using carbon fiber polymer composite.

1.4 Project Scope

This study focuses on new composite racing car suspension. Before composite laminate analysis can be undergo, the analysis on load acting must done following the UTeM 2nd Formula Varsity Regulation and International FSAE Racing Event. Thus, the analysis has taken place.

In short the project scope is listed as follow:

i. To calculate the load acting on the component during operation.
ii. To perform composite laminate analysis.
iii. To produce detail design of the component using 3D CAD software.
iv. To fabricate the component using carbon fiber-polyester matrix.
v. To perform compression test and evaluate the component performance.

1.5 Project Outline

This report on "Design and Development Carbon Fiber Double Wishbone Suspension Arm for UTeM Formula Style Race Car" is divided into several chapters. Chapter 1 introduces the audience to the general background of this research, the problem statement, project objectives, as well as the project scope. Also, it offers an overall view of the project outline.

Chapter 2 is a literature reviews and background study gathered from electronic media, published journals, and books. This chapter will elaborate about this project briefly.

Chapter 3 explains about the methodology used in this project pictured as flow chart along with explanation of every stage process. This chapter also explains the theoretical calculation of load acting on component followed by composite laminate analysis calculation along with the new double wishbone suspension design. The fabrication process along with components fabrication using carbon fiber and polyester matrix as resin including the design of testing jig and its fabrication process will be included in this chapter In addition; the testing procedure also will be explained in this chapter.

Chapter 4 indicates the results of the calculation and compared with actual value (experimental data). This chapter also will discuss on the difference of the value obtained in this project with previous researcher.

Finally, Chapter 5 will present the conclusion and suggestion in upgrading the project for a better performance in future.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview Suspension System

The main functions of a vehicle's suspension systems are to isolate the structure and the occupants from shocks and vibrations generated by the road surface. The suspension systems basically consist of all the elements that provide the connection between the tires and the vehicle body. According to Gillepsie (1992), the primary functions for suspension systems are;

- Provide vertical compliance so the wheels can follow the uneven road, isolating the chassis from roughness in the road.
- Maintain the wheels in the proper steer and camber attitudes to the road surface.
- React to the control forces produced by the tires-longitudinal (acceleration and braking) forces, lateral (cornering) forces, and braking and driving torques.
- Resist roll of the chassis.
- Keep the tires in contact with the road with minimal load variations

To accomplish all functions, the suspension system requires an elastic resistance to absorb the road shocks and this job is fulfilled by the suspension springs. Various different types of springs have been used in vehicle suspensions such as leaf springs, helical coil springs, torsion bar springs, air springs, rubber springs. It is obvious that a suspension system must be able to withstand the loads acting on it.

These forces may be in the longitudinal direction such as acceleration and braking forces, in the lateral direction such as cornering forces, and in the vertical direction.

This chapter consists of three main sections. In the first section, the types of suspension systems are introduced and the advantages of double wishbone suspension system are presented. In the second section, vehicle dynamics and suspension kinematics are presented under different cases in order to obtain axial loads on the double wishbone suspension links.

2.2 Types of Suspension System

Suspensions basically can be identify into two main groups-non-independent and independent suspensions. Each group carried different functions and therefore, this differentiation will be discussed generally in this chapter.

2.2.1 Non-Independent Suspension System

In non-independent suspension systems (known as solid axle suspension system), wheels are mounted at the ends of a rigid beam so that any movement of one wheel is transmitted to the opposite wheel causing them to steer and camber together.

Solid drive axles are used on the rear of many cars and most trucks and on the front of many four-wheel-drive trucks. Solid beam (non-driven) axles are commonly used on the front of heavy trucks where high load-carrying capacity is required.

These types of suspension have the advantage that wheel camber is not affected by body roll. Thus there is little wheel camber in cornering, except for that which arises from slightly greater compression of the tires on the outside of the turn. In addition, wheel alignment is readily maintained, minimizing tire wear. It also claimed to be cheaper than independent suspension. The major disadvantage of non-independent suspension system is their bad ride quality, and both wheel chambered on bump which we want to reduce in Formula Varsity Race. The most common solid axles are Hotchkiss, Four link and De Dion (Figure 2.1).

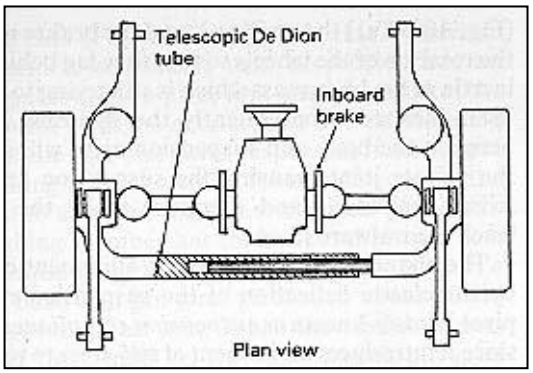

Figure 2.1: De Dion Axle Suspension System (Mark Wan, 1998-2000)

2.2.2 Independent Suspension System

In contrast to non-independent suspension system, independent suspensions allow each wheel to move vertically without affecting the opposite wheel. Nearly all passenger cars and light trucks use independent front suspensions, because of the advantages in providing room for the engine and the better resistance to steering vibrations. The independent suspension also has the advantage that it provides inherently higher roll stiffness relative to the vertical spring rate. Further advantages include easy control of the roll centre by choice of the geometry of the control arms, larger suspension deflections, ideal chamber control and greater roll stiffness for a given suspension vertical rate.

Over the years, many types of independent front suspension have been tried such as Mac Pherson, Trailing arm, Swing axle, Torsion Beam, Multi link and Double Wishbone suspension (Figure 2.2). Many of them have been discarded for a variety of reasons, with only two basic concepts, the double wishbone and the Macpherson strut, finding widespread success in many varied forms.