DEVELOPMENT OF DOUBLE WISHBONE SUSPENSION USING GLASS FIBER REINFORCED POLYMER (GFRP) FOR FORMULA STUDENT RACE CAR

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‘Saya/Kami* akui bahawa telah membaca
karya ini dan pada pandangan saya/kami* karya ini
adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan
Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)’

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Tarikh :…… ……

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Laporan ini dikemukakan sebagai
memenuhi sebahagian daripada syarat penganugerahan
Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)

Fakulti Kejuruteraan Mekanikal
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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya telah jelaskan sumbernya"

Tandatangan : ……..

Nama penulis: Muhsin bin Abdul Razak

Tarikh : ...……

For my lovely mother and greatest father, for my beloved sisters,
for my beautiful friends and for my honorable teachers and lecturers

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Thank you.

ABSTRACT

In development of the double wishbone suspension link, there are 3 stages involved which are design, analysis and fabrication. The design of the suspension involved the calculation of load transfer during cornering and braking condition. Then the force acting on the link suspension is calculated by using quasi-static equation. 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. Analysis is done by using Patran Nastran software which it determines the maximum stress for the double wishbone suspension link and the critical area which needs to be concerned. Then it contains the method of the fabrication by using hand lay up technique.

ABSTRAK

Dalam perkembangan untuk penyambung suspensi tulang selangka, terdapat 3 peringkat yang terlibat iaitu rekabentuk, analisis dan pembuatan. Rekabentuk suspensi melibatkan pengiraan pemindahan beban ketika keadaan berhenti dan belokan. Kemudian daya yang bertindak ke atas penyambung suspensi tulang selangka dikira dengan menggunakan persamaan quasi-statik. Kekuatan komposit dikira dengan menggunakan persamaan matriks kekerasan di mana ia menentukan kekuatan lapisan-lapisan komposit mengikut orientasinya. Analisis dilakukan dengan menggunakan perisian Patran Nastran di mana ia menentukan tegasan maksimum untuk penyambung suspensi tulang selangka dan kawasan kritikal yang perlu diberi perhatian. Kemudian ia mengandungi cara-cara pembuatan dengan menggunakan *hand lay up technique*.

TABLE OF CONTENT

LIST OF TABLE

LIST OF DIAGRAM

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Background

Suspension systems have been widely applied to vehicle from the simple bicycle to the modern automobile with complex control algorithms. The suspension of a road vehicle is usually designed with 2 objectives which are to isolate the vehicle body from road irregularities and to maintain contact of the wheels with the road. The suspension of modern vehicles need to satisfy a number of requirements whose aims partly conflict because of different operating conditions which are loaded and unloaded weight, acceleration and braking force, level or uneven road and straight running or cornering.

From a system design point of view, 2 main categories of disturbances on a vehicle can be constructed which are road and load disturbances. Road disturbances have the characteristics of large magnitude in low frequency (such as hills) and small magnitude in high frequency (such as road roughness). Load disturbances include the variations of loads induced by accelerating, braking and cornering. Therefore, a good

suspension design is concerned with eliminating disturbances at the outputs. In other words of car driver, a conventional suspension needs to be “soft” to insulate against road disturbances and “hard” to insulate against load disturbances. Hence, the design needs compromise between these 2 goals.

Formula student race car is a racing car developed by the students (particularly from university) by following the standard rules set by Society of Automotive Engineering (SAE). It is called Formula SAE which gives opportunities to the students to create a Formula-style race car by some restrictions so that the students will have opportunity to apply the theories from textbook to real work place and also come with clever problem solving of racing car.

Currently, Universiti Teknikal Malaysia Melaka (UTeM) has a racing car which developed from the mild steel and do not apply to the SAE standard. The suspension system used now is double wishbone suspension type. Thus, in order to increase it performances and abide to the SAE standard, the new development of suspension is needed. The idea is to optimize the characteristics of suspension and hence, the performance of the racing car by changing its material from mild steel to Glass Fiber Reinforced Polymer. Also, the design needs to reconsider again to optimize the strength of double wishbone by reducing the stress concentration at critical point.

1.2 Objective of study

The aim of the study is to develop a composite suspension wishbone using Glass Fiber Reinforced Polymer (GFRP) composite for formula student racing car.

1.3 Problem statement

The current racing car uses double wishbone suspension built from mild steel and it contributes a lot of weight to the car. Also, it does not have proper analysis of strength which is essential for standardization and does not have standard method and calculation. In addition, the calculation of load distribution does not exist during the worst situations. The needed data for further study (CAD data) is not available which it is essential for troubleshooting and optimization or improvements.

Therefore, to reduce these problems, the GFRP will be studied to determine whether it is suitable material for suspension system because it is known that composite has a light weight compared to mild steel and it can resist high force in organized direction. The analysis of structural strength will be done also which it will determine the stress area and the prevention of high distribution will be done if possible. Also, the dynamic forces will be calculated and the manual calculation will be prepared. The data will be kept as a CAD format which this data will be available for the next review in future.

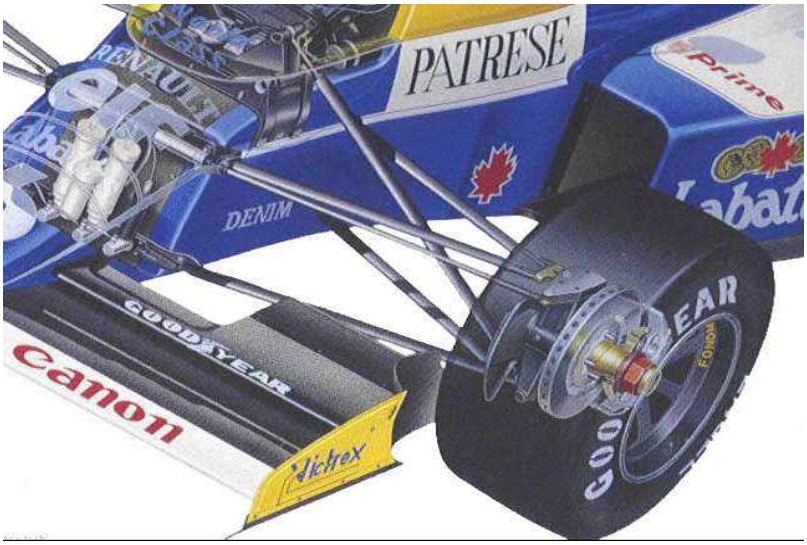

Figure 1.1: Racing car using composite material at suspension
(Source: http://www.f1-country.com/f1-engineer/suspension.html)

1.4 Scopes

The scopes of the project are as following points.

1) To design a suspension wishbone using computer aided design software
2) To analyze the structural strength of the design using finite element analysis software in static condition
3) To fabricate the suspension wishbone design using GFRP composite material

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to suspension systems

The function of a vehicle's suspension systems is primarily to isolate the structure and the occupants from shocks and vibrations generated by the road surface. The suspension systems consists the element which it provides the connection between the tires and the body and considerations taken into design are

i) ride comfort
ii) road-holding
iii) handling

The idea to isolate the structure and the occupants from shocks and vibrations is to install an elastic element to absorb the road shocks. Thus, the most practical solution would be the spring of the suspension. There are various types of springs that used in vehicle suspensions such as torsion bar springs, rubber springs, helical coil springs, air springs and leaf springs.

The most crucial part would be how to design the suspension to sustain with the acting loads. These forces may come in the longitudinal direction such as braking and acceleration forces, in the lateral direction such as cornering forces and in the vertical direction.

In this study, the only considered forces would be during braking and cornering due to the weight transfer during these dynamic behaviors. The static force would only be considered as the summation of forces during the design of double wishbone as it needs the optimum force value that acted on it. All of these can be seen in the next chapter.

In this chapter, explanations about the types of suspension systems are given, the advantages of double wishbone suspension system and the case of vehicle dynamics during braking and cornering in order to obtain loads on the double wishbone suspension links.

2.2 Types of suspension systems

There are generally 2 types of suspension systems. First is a solid axle which has a rigid connection of the wheels to an axle and second is independent suspensions which wheels are suspended independently of each other. There is also a form of axle which combines the characteristic of rigid axles and independent wheel suspensions. This suspension is called semi-rigid axles.

2.2.1 Solid axle suspension system

A solid axle has a rigid beam which the wheels are mounted at both end of it. Thus, this connection will cause the steer of camber for both of the wheels because any movements of one wheel will be transmitted to the opposite wheel. It is widely used in rear suspension of many cars and truck as well as on the front of many 4WD trucks because the advantageous of solid axle which wheel camber is not affected by body roll.

The most significant advantageous for solid axle is as mentioned above. The body roll of a vehicle is no affecting the wheel camber and it gives easy adjustment and refinement. The major disadvantageous of solid axle is their susceptibility to tramp-shimmy steering vibrations.

2.2.2 Semi rigid crank axle

The combined crank suspension could be described as the new rear axle design of the 1970 and it is still used in today's small and medium-sized front-wheel drive vehicle (Reimpell, Stoll, Betzler, 2001). It consists of 2 trailing arms that are welded to a twistable cross-member and fixed to the body via trailing links. This member absorbs all vertical and lateral force moments and, because of its offset to the wheel centre, must be less torsionally stiff and function simultaneously as an anti roll bar.