UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF THE UTEM FV MALAYSIA RACE CAR SUSPENSION SYSTEM DESIGN TO REDUCE ROLLING EFFECT

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

by

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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:

…….

(Mr Nor Azazi bin Ngatiman)

ABSTRACT

One of the most important factors that affect the performance of the racing cars are the behaviour and responses of the car suspension. Rolling can reduce the performance of the car due to unnecessary motion that occur such as rolling. This study will help to improve the suspensions of the UTeM FV Malaysia race car so that the car will experience more confidents handling especially while enter and exit from the corner by doing some improvements on the rolling centre of the suspensions. By using current UTeM FV Malaysia racing car as a reference and FSAE rules as our guidance, an improvement on suspension has taken place using related CAD software through simulation. Most of racing car use double wishbone suspension link as their suspension system due to its advantages. The current suspension design is analysed using Altair Multi Body Dynamic – Motion View, and the result will be used for optimization. In conclusion, the result from optimization must be better compared to existing to ensure the objective to reduce rolling on the car is achieved.

ABSTRAK

Salah satu faktor penting yang perlu diambil kira dalam memastikan prestasi kereta lumba dalam keadaan yang terbaik adalah kelakuan atau tindakbalas sistem gantungan kereta tersebut ketika dipandu. Ini sangat menyumbang kepada penurunan prestasi kereta lumba dengan kehadiran pergerakan yang tidak diperlukan seperti gulingan. Kajian ini akan membantu untuk meningkatkan lagi kebolehan sistem gantungan kereta lumba UTeM FV Malaysia untuk menahan kesan gulingan ketika mengambil selekoh dengan melakukan pengubahsuaian pada "roll centre" sistem gantungan. Kereta lumba sedia ada UTeM akan digunakan sebagai rujukan dan peraturan oleh FSAE dijadikan sebagai petunjuk dalam melakukan penaiktarafan ini yang dijalankan secara simulasi oleh perisian CAD yang berkenaan. Kebanyakan kereta lumba menggunakan sistem gantungan jenis "Double Wishbone" disebabkan oleh kelebihan-kelebihan yang dimiliki olehnya. Sistem gantungan semasa akan dianalisis menggunakan perisian Altair Multi Body Dynamic – Motion View, dan keputusan analisis akan dijadikan panduan untuk melakukan penaiktarafan. Kesimpulannya, keputusan daripada penambahbaikan yang dibuat perlulah lebih baik berbanding keputusan sistem gantungan sedia ada supaya objektif untuk mengurangkan kadar gulingan itu dapat dicapai.

DEDICATIONS

This thesis is dedicated to my parents for their love, support and encouragement. And to my Supervisor, Mr Nor Azazi Bin Ngatiman for has been my constant source of knowledge and inspiration.

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LIST OF SYMBOLS AND ABBREVIATIONS

FSAE	=	Formula SAE(Society of Automotive Engineer)
FV	=	Formula Varsity
SLA	=	Short-Long Arm
CAD	=	Computer Aided Design
CG	=	Center of Gravity
MBD	=	Multi Body Dynamic
KPI	=	Kingpin Inclination
UBJ	=	Upper Ball Joint
LBJ	=	Lower Ball Joint
OTRB	=	Outer Tie Rod Ball Joint

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter covers all the informations of the thesis starting from the background of the project, problem statement, objective and scope.

1.1 Background

Suspension system in race car is one of the most crucial part in which it will influence the performance of the car and provide rigidity, stability and speed while entering and exit from corner or in straight run. The suspension system consists of springs, shock absorber, struts, control arms and spindle or axle as well as the bushing that allow the necessary motions. These parts should hold the tire firmly and wheel in correct alignment with the car and the road. The suspension is the main mechanisms that separates the bump between vehicles and the roads. It also the device connecting the body with wheels. Irrelative motion on the body between the wheels, the motion is constrained by the suspension. In fact, all forces, moment exerted between the wheels and the ground passing through the suspension (Sun, Deng, & Zhang, 2014).

In other meaning, suspension system is a mechanism that physically separates the sprung mass (car body) from the unsprung mass (car wheel). Vehicle suspension system main function is to provide minimum vertical acceleration transmitted to the passenger which directly provides road comfort. Also to prevent the vehicles to experience extreme body rolling, pitching and yawing. An excessive wheel travel will result in non-optimum behaviour of tyre to the road that will lead to poor adhesion and handling. Besides that, to maintain good vehicle handling, the optimum tyre to road contact must be maintained on all wheels. (Hadi, 2007)

Load disturbances include the variation of loads induced by accelerating, braking and cornering. Therefore, a good suspension design is concerned with disturbance rejection to the outputs. Roughly speaking, a conventional suspension needs to be “soft” to insulate against road disturbances and “hard” to insulate against load disturbances. This make a suspension design is an art of compromise between these two goals (Wang 2001). Therefore, design of the suspension system is an important part of the overall vehicle design, which determines the performance of the racing car (Sun et al., 2014).

1.2 Classification of Suspension System

Suspension system have variety of type and designs which each of the design have their own advantages and disadvantages. There are two main categories of suspension system;

i. Dependent suspension (i.e. Rigid axle, semi rigid axle, trailing arm)

ii. Independent suspension (i.e. Macpherson, Double wishbone, Multilink)

For dependent suspension system, the motion of a wheel on one side is dependent on the motion of wheel on the other side. When one wheel of the vehicle strikes a pothole, the effect is transmitted directly to wheel on the other side. This has a harmful effect on ride and handling of the vehicle. With independent suspension system, the motion of wheel is independent of the other wheel, so that a disturbance at one wheel is not effecting to a wheel on the other side. This leads to better ride and handling capabilities.

Among all the design, there is two popular design that been used by the car manufacturer that is Double Wishbone Suspension and MacPherson Strut. Both of this suspension is regularly can be seen on vehicles suspension system due to its performance (Sh., J., N., a., & R., 2010).

1.2.1 Double Wishbone

The most common design for the front suspension of American car following World War II used two lateral control arms to hold the wheel. Each wishbone has two mounting points to the chassis and one joint at the knuckle. The shock absorber and coil spring mount to the wishbones to control vertical movement. Design of the geometry for a SLA requires careful refinement to give good performance. The camber geometry of an unequal-arm system can improve camber at the outside wheel by counteracting camber due to body roll, but usually carries with it less-favourable camber at the inside wheel (equal-length parallel arms eliminate the unfavourable condition on the inside wheel but at the loss of camber compensation on the outside wheel). At the same time, the geometry must be selected to minimize tread change to avoid excessive tire wear. The compact design of a coil spring makes it ideal for use in front suspension systems (Güler, 2006).

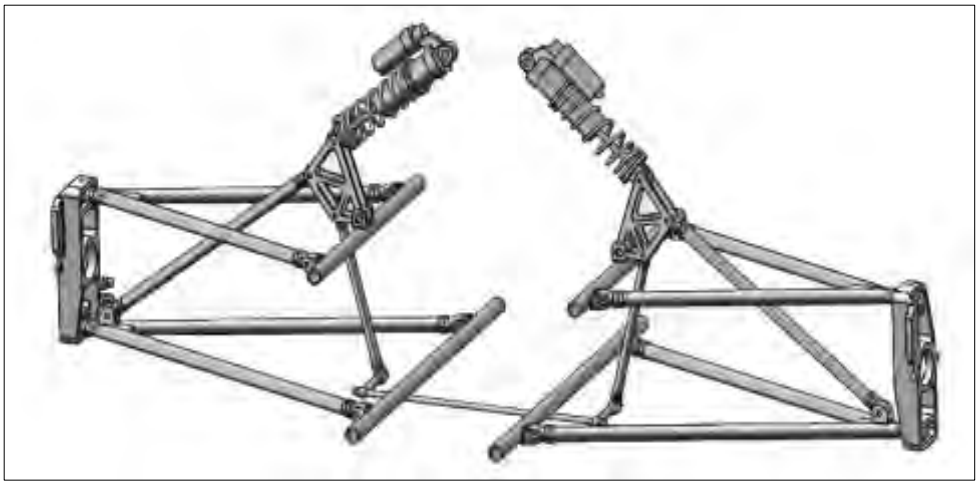

Figure 1.1: Example of race car Double Wishbone (Akhmadeen, 2008).

1.2.2 MacPherson Strut

It was created by Earl Macpherson in 1949 for the ford company. Due to its light weight and size compatibility this kind of suspension is widely used in different vehicles. Moreover this kind of vehicle is more popular to be found in the front of the

car even though it was also used as a rear suspension. This system is uses the axis of a telescopic damper as the upper steering pivot. It is widely used in modern vehicles. MacPherson struts consist of a wishbone or a substantial compression link stabilized by a secondary link which provides a bottom mounting point for the hub or axle of the wheel (Purushotham, 2013).

1.3 Problem Statement

Suspension has become the big issues now when it comes to car performance. Whether the car is for road use or track use, suspension always become the main things to be discussed. For road use, the comfort of the suspension always be the priority. Different things happened for track used, the vehicle must be able to keep the maximum tire to road contact while in and out from cornering, braking and accelerating which the result will minimizing the comfort.

In this research, the student is responsible to study and improve the design of the suspension system for UTeM FV Malaysia race car. For beginning, overview on current UTeM FV Malaysia race car will help to look for the optimization and redesign opportunities to obtain better quality of suspension design, which will result in better ride and handling also rolling effects. The design should meet the technical performance and safety for the driver and car. The designed suspension system will be analysed virtually using related CAD software. The aim is the suspension system is fit enough in term of quality and safety, and will reduce the rolling on the vehicles while cornering which can enhance the car performance.

1.4 Objective

In this project, the objectives of the research are as follows:

1. To analyse the suspension system of UTeM FV Malaysia race car by simulation using related CAD software.
2. To optimize the design of Double Wishbone suspension for UTeM FV Malaysia race car to reduce rolling effect.

1.5 Scope

To achieve the objective of this project, analysis is focused on following scope:

1. This project will focus on Double Wishbone suspension system.
2. The CAD software that is used to generate the design is Hyperwork by using Multi Body Dynamic (MBD). Analysis also will be done using Hyperwork.
3. Current design of Double Wishbone suspension system on FV Malaysia car is improved in order to obtain optimum performance subject to rolling effect of the car.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

In the literature review the primary functions of the suspension systems in vehicles and their effect in ride and handling are discussed. A dynamic simulation software is reviewed through this chapter. Finally the effective techniques to reduce the rolling effect of the car are discussed.

2.2 History

Early stage of transportation required suspension of some kind. With the limited technology at that time, simple wrought-iron beam springs were combined in several layers to obtain the required combination of compliance with strength. These design became known simply as leaf springs. To increase the compliance, a pair of leaf springs were mounted back-to-back. They were curved, and so then known as elliptical springs. Single ones were called semi-elliptic. (Dixon, 2009)

In early age of road transportation, leaf springs is the most practical design of suspension ever had at that time. At the front, the leaf spring was not bring satisfaction to the driver, because of the effects in steering geometry difficulties (bump steer, roll steer, brake wind-up steering effects, and shimmy vibration problems).

In 1920s, the rigid axle at the front was increase in problem. With increasing engine power and vehicle speeds, this was becoming increasingly dangerous. Hard front springs were used to solve the problem. It is limiting the axle movement, but this results in very poor ride comfort and allowing much softer springs and greater

comfort. Around 1930, Sloan considered the problem of ride quality as one of the most important and most crucial in automotive engineering, and the problem was getting worse as car speeds increased. By 1933 Rolls-Royce already had an independent front suspension. After that, most vehicles started using hydraulic shock absorbers and balloon (low-pressure) tyres (Dixon, 2009).

2.3 Suspension Fundamental

2.3.1 Unsprung weight

The unsprung weight of a vehicle is the fraction of the total weight that is not supported by the suspension springs and will usually consist of the wheels, tires, hubs, hub carriers, brakes (if mounted outside the car's chassis), and lastly, roughly 50% of the weight due to drive shafts, springs and shocks as well as the suspension links (Farrington, 2011).

2.3.2 Sprung weight

This is basically the opposite of the mentioned definition above. Sprung weight is the portion of total car weight which is supported by the suspension springs. This weight is much larger than the unsprung weight as it consists of weight from the majority of car components which would include the chassis, engine, driver, fuel, gearbox and other components housed in the chassis (Farrington, 2011).

2.3.3 Wheelbase

Wheelbase is defined as the distance between the front and rear axle centrelines. It also influences weight transfer, but in the longitudinal direction. Large wheelbase will experience less 'pitch' motion and short wheelbase is effective in