UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF MULTIBODY DYNAMICS (MBD) METHOD FOR UTeM FV MALAYSIA RACING CAR SUSPENSION SYSTEM

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

by

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DECLARATION

I hereby, declared this report entitled " Development Of Multibody Dynamics (MBD) Method for UTeM FV Malaysia Racing Car Suspension System " is the results of my own research except as cited in references.

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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 Bachelor Degree of Mechanical Engineering Technology (Automotive Technology) with Honors. The member of the supervisory is as follow :

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(**MUHAMMAD ZAIDAN BIN ABDUL MANAF**)

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LIST OF ABBREVIATIONS

CATIA	-	Computer Aided Three-dimensional Interactive Application
BDP 1	-	Bachelor Degree Project 1
BDP 2	-	Bachelor Degree Project 2
UTeM	-	Universiti Teknikal Malaysia Melaka
SLA	-	Short Long Arm
K & C Analysis	-	Kinematic and Compliance Analysis
MBD	-	Multibody Dynamics

ABSTRACT

This paper is entitled 'Development Of Multibody Dynamics (MBD) Method for UTeM FV Malaysia Racing Car Suspension System'. This paper presented the suspension analysis on UTeM's FV Malaysia racing car by using Multibody Dynamics method that modeled with MotionView Software. The analysis is focus on Kinematic and Compliance analysis for both front and rear suspension system design. This analysis commonly use to analyze the static and dynamic suspension performance parameter on vehicle. To predict and produced accurate dynamics response, Multibody Dynamics (MBD) was used in order to get the data before suspensions prototypes are available. It also 98% accurate with actual suspension data that measured using Suspension Performance and Measurement Machine (SPMM). In this study, Double Wishbone suspension was used. In this simulation, the suspension performance data can be estimated to get a few data such as ride test, roll test and forces on wheel data. This data used as an input to analyze chassis structure integrity later on. Data that get from the simulation can be use as guidelines to look on the actual performance of the car and comparison can be done between the performances of different suspension systems that suitable to the racing car.

ABSTRAK

Kertas kerja ini bertajuk 'Pembangunan Kaedah Multibody Dynamics (MBD) Untuk Sistem Suspensi Kereta Lumba UTeM FV Malaysia. Kertas kerja ini membentangkan analisis sistem suspensi pada kereta lumba UTeM FV Malaysia dengan menggunakan kaedah Multibody Dynamics yang dimodelkan dengan menggunakan perisian MotionView. Analisis memberi tumpuan kepada kinematik dan analisis untuk kedua-dua reka bentuk sistem suspensi depan dan belakang. Analisis ini biasanya digunakan untuk menganalisis parameter prestasi suspensi statik dan dinamik pada kenderaan. Untuk meramalkan dan menghasilkan tindak balas dinamik yang tepat, Multibody Dynamics (MBD) telah digunakan untuk mendapatkan data sebelum prototaip sebenar sistem suspensi boleh dihasilkan. Ia juga 98% tepat dengan data suspensi sebenar yang diukur menggunakan Prestasi Penggantungan dan Mesin Pengukuran (SPMM). Dalam kajian ini, Wishbone penggantungan Double digunakan. Dalam simulasi ini, data prestasi suspensi boleh dianggarkan untuk mendapatkan data beberapa seperti ujian perjalanan, ujian roll dan daya pada data roda. Data ini digunakan sebagai input untuk menganalisis integriti struktur casis di kemudian hari. Data yang dapat daripada simulasi boleh digunakan sebagai garis panduan untuk melihat kepada prestasi sebenar dari kereta dan perbandingan boleh dilakukan yang sesuai untuk kereta lumba UTeM FV.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The suspension framework for Formula Varsity (FV) dashing auto is situated between the inflexible edge and wheel of vehicle. The inflexible edge is joined to the front and back hub as suspension framework mean. Driver on this unbending casing ought not feel the effect, stun burdens and unequal burdens when vehicles moving. The suspension framework retaining these stun loads and makes an open to riding. This heap however can't be permitted to pass upwards into the edge with a specific end goal to ensure auxiliary security and driver solace. The suspension framework fills the need of retaining effect and stun burdens amid amazing driving. For this reason, the suspension for any vehicles is built with a set damping and stun retaining gadgets, torsion bars, loop spring and linkages.

In this undertaking, a suspension framework for front and back suspension will be demonstrate by utilizing Multibody Dynamics (MBD) technique. The improvement of FV dashing auto suspension model utilizing Multibody Dynamics (MBD) will in light of recreations manages reenactments including huge relocations. "Multi-body" infers that numerous bodies connect in the reproduction. "Elements" infers that the reenactments decide the powers and minutes acting in the middle of bodies and register relocations of the bodies in view of these and different limitations connected on the bodies. Movement View in the Hyper Works suit of configuration devices is the Multi-body Dynamics pre-processor while Motion Solve is the multi-body progress solver. In the vehicle models in Multi-body flow include, it displaying the distinctive "moving" parts as bodies and the associations between them as joints or compels.

Half auto models as far as Multi-body motion include the demonstrating of the accompanying sub-frameworks of the vehicle:

- Suspension
- Steering (front)
- Drive shafts (if driven wheels)

These sub-frameworks are regularly characterized by what are known as the suspension "hard focuses". These are 3 dimensional directions in space where the distinctive suspension segments associate with the frame, haggles another. They characterize the geometry of the suspension you pick which in the long run decide the kinematics and the elements of the suspension frameworks.

The break down suspension execution of hustling auto is the imperative things that must been done to get the suspension execution information of the FV dashing auto. By utilizing Kinematic and Compliance estimation machine, it can gives an information to suspension execution. Be that as it may, because of the lacking of this machine due to exceedingly cost, this investigation should be possible by utilizing multibody progress (MBD) suspension examination. A couple of examination that should be possible by utilizing this multi body motion (MBD) suspension investigation :

- Kinematic & Compliance Analysis
- Ride test analysis
- Roll test analysis
- Forces on wheel analysis

From this multibody dynamics (MBD) suspension investigation, the examination of breaking down information for vehicle elements and suspension execution should be possible. This information utilized as a data to investigate suspension for FV Racing Car. Information that gather from the recreation can be use as rules to look on the real execution of the suspension dashing auto. By doing this, the execution of suspension framework for FV Racing Car can be progressed.

1.2 Problem Statement

The UTeM's FV Racing Car has been created to withstand a race that requires an elite suspension framework. Because of this, the taking care of execution must be precisely outline. The taking care of is specifically include suspension qualities of the auto itself. At the point when utilizing a Mathematical model of 4-DOF dynamic suspensions with single body motion, it can't anticipate flow reaction while utilizing Kinematic and Compliance estimation machine, it can gives an information to suspension execution yet it profoundly cost. On the other hand, to anticipate and created precise motion reaction, we can utilize Multibody Dynamics (MBD) that can demonstrating construct, fathom, comprehend and enhance framework plans even before equipment models are accessible. By configuration of trials, the general element reproduction and element reaction expectation should be possible by utilizing utilization of Multibody Dynamics (MBD). The suspension framework for FV Racing Car that break down with this Multibody Dynamics (MBD) Method, can foresee and created precise motion reaction and consequently build execution of suspension framework.

1.3 Objective

In view of the title, “Development of FV racing car suspension model using Multibody Dynamics (MBD)”, the targets to be accomplish toward the end of this task are as beneath :

1) To model racing car suspension using Multibody Dynamics (MBD) method.
2) To analyze the suspension performance of racing car.
3) To compare the performance of different suspension systems that suitable to the racing car.

1.4 Scope

In this study, the extension for this task are to choose vehicle level targets. Outline necessity of the vehicles level targets most extreme consistent state parallel quickening (in understeer mode), move solidness (degrees per g of horizontal increasing speed), ride frequencies, sidelong load exchange rate circulation front to back, move minute conveyance front to back, ride statures at different conditions of burden, understeer inclination, turning circle, Ackermann, jerk travel and bounce back travel. Other degree that included in this study is vehicle level necessity and the breaking down the suspension framework. Before investigating information for vehicle elements of coming about configuration should be possible, the area of hard point for suspension part must be distinguished.

Reenactment can be proceeded by picking joint and CG areas as examination parameters. Execution additions may be acknowledged by incorporating these parameters in the framework distinguishing proof procedure. By applying these conformities, the non-direct model's precision may be progressed. The examination of breaking down information for vehicle progress and suspension execution can been done after settled the investigation working. Future examination can be embraced by utilizing the non-direct model for its horde of potential applications. Applications incorporate configuration of tests, general element recreation, and element reaction expectation. The scope of potential applications is broad.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section exhibits a writing audit identified with McPherson strut suspension history and applications, multibody motion and quarter-auto demonstrating, and recreation. A few sources were sought in conjunction with apropos catchphrases. Since both Macpherson and McPherson strut are prevalent spellings for this sort of suspension, both were utilized as a part of this hunt. (Andersen, Sandu, & Kasarda, 2007)

2.2 Multibody Dynamics

A multibody dynamic (MBD) framework is one that comprises of strong bodies, or connections, that are associated with one another by joints that confine their relative movement. The investigation of MBD is the examination of how instrument frameworks move affected by powers, otherwise called forward flow. An investigation of the reverse issue, i.e. what powers are important to make the mechanical framework move in a particular way is known as opposite progress. Movement examination is imperative on the grounds that item outline often requires a comprehension of how numerous moving parts cooperate with one another and their surroundings. From vehicles and air ship to clothes washers and sequential construction systems - moving parts create loads that are regularly hard to foresee. Complex mechanical congregations present configuration challenges that require a dynamic framework level examination to be met.

Choice of the direction framework is the initial phase in multibody motion demonstrating. De-Jalon examines the execution, favorable circumstances, and detriments connected with relative, reference point, and characteristic 2D arranges. Relative directions depict the relative movement between two abutting components. For instance, a revolute joint would be portrayed by the point between the components it interfaces and a translational joint by the separation between associated components. Imperative comparisons are produced from the vector mathematical statements that nearby kinematic circles. This framework utilizes a low number of directions and is particularly well-suited at portraying open-chain designs. Be that as it may, scientific plan can be tricky, and albeit few directions are utilized the mathematical statements of movement they make can be computationally costly. Also, pre-and post-handling is required to decide every joint's supreme movement.

Reference point directions indicate component position and introduction by inserting a nearby facilitate framework in that component, determining the X-Y position of the neighborhood coordinate root, and introduction edge between a nearby pivot and the worldwide inertial hub. Regularly neighborhood tomahawks are meant with a prime, for instance x′ or y'. Requirement mathematical statements are composed in light of the kind of movement every joint permits between nearby components. For instance, a revolute joint would oblige both X and Y interpretation. Since the position and introduction of every component is straightforwardly indicated, little pre-and post-preparing are important to decide every joint's supreme movement. The principle drawback of this framework is that the vast number of directions it requires can extend reenactment time.

Common directions indicate two focuses on a body to decide its position and introduction in space. Requirements are composed by inflexible body condition (that is, the separation between two focuses on an unbending body is consistent) or by joint limitations. This framework is favorable on the grounds that it disposes of rakish directions, and little pre-or post-preparing is required. On the other hand, this framework requires a bigger number of directions than relative directions would. For this postulation, reference point directions are utilized due to their preferences.

PC based quarter-auto test models are regularly utilized in vehicle flow thinks about as streamlined and surely knew frameworks for such uses as testing new control techniques, outlining new suspension frameworks, and breaking down ride progress. Whenever accessible, quarter-auto apparatuses are utilized to get pertinent trial information. A quarter-auto test apparatus is a trial stage which endeavors to duplicate the progress of one corner of an auto. Having an exact PC model of the test apparatus utilized is exceptionally significant since it gives the specialist more adaptability in trying different things with different situations in the virtual world, plans examinations, and performs broad investigation. In this study the emphasis was on demonstrating and performing framework recognizable proof on a quarter-auto fix that, not at all like common quarter-auto apparatuses, contains a full suspension framework.

The suspension under study is a McPherson strut suspension, however the quarter-auto test rig, as it was planned, is equipped for obliging a large number of distinctive suspensions. All things considered, consideration must be taken so that a suspension that is fit for delivering element loads higher than that which the quarter-auto test rig's straight heading are appraised for is not utilized. This heap, termed here as the ordinary burden, is what is connected to the sprung mass plate's direct orientation opposite to the side which the suspension joins to. Multibody motion models are equipped for assessing the dynamic ordinary burdens connected to the quarter-auto rig's sprung mass, which gives extra inspiration to the present study. It is predictable that diverse suspensions will be utilized on the quarter-auto test rig. It is normal that a non-straight quarter-auto elements show that precisely reproduces the first framework and records for its limitations will give more exact results and offer expanded capacities contrasted with conventional direct single-hub quarter-auto models. The term non-direct alludes to the way that, notwithstanding reenacting its straight movement, the non-direct model records for the suspension's precise removals. To exploit its expanded exactness and extraordinary abilities, the quarter-auto model must be obviously characterized and simple to adjust to future changes in the framework. (Andersen et al., 2007)

2.3 Suspension System

Suspension framework is a term given to the arrangement of spring, safeguard and linkage that unite vehicle to it haggle relative movement between them. Suspension framework has two fundamental reason, for example, adding to the vehicle street holding and braking for a decent dynamic security. It additionally secure the vehicle itself and it freight from stun load. As indicated by Ramakrishna, K. (2012), suspension arrangement of a vehicles is situated between the inflexible edge and the travel wheels. The casing and the body of the vehicle is connected to the front hub and the back hub. It does the occupation by retaining these stun loads and make the ride more agreeable.

2.3.1 McPherson Strut

This area gives an authentic and applications point of view on the McPherson strut suspension. The McPherson strut suspension, outlined in the late 1940s by Earl Steele Macpherson, was initially utilized on the 1949 Ford Vedette. All things considered, it is a moderately new suspension arrangement. Mantaras states that most by far of current little and medium-sized autos utilize this setup. The McPherson strut suspension design comprises of a lower control arm and telescopic strut appended to the body of the auto and to the wheel bearer, which is likewise called an upright. It is regularly the case that the essential spring and damper are co-straight with the strut's line of interpretation.

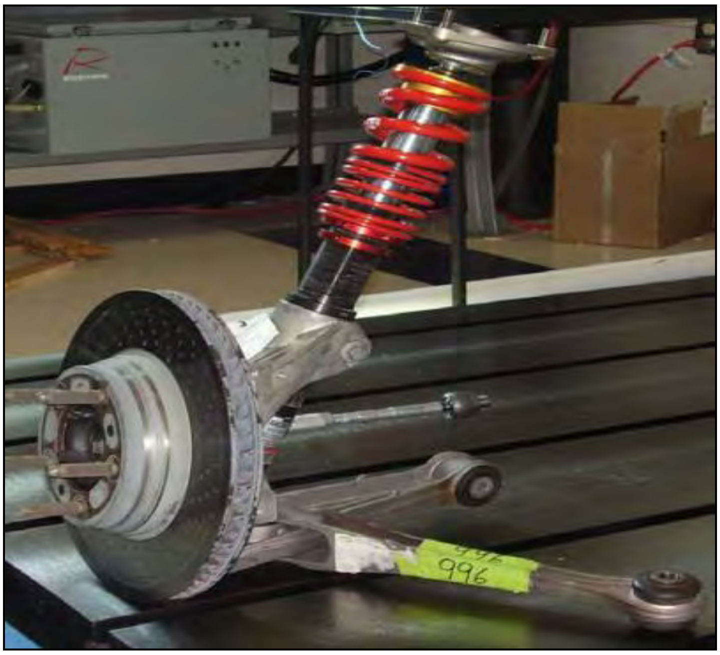

Figure 2.1 : McPherson Strut Suspension

Dynamic and semi-dynamic suspensions can possibly expand vehicular solace, execution, and security. For instance, a dynamic suspension may build solace by decreasing the speeding up experienced by the sprung mass and, thus, by the vehicle inhabitants. A dynamic suspension may expand the vehicle execution and security of its tenants by minimizing the tire-asphalt typical power change. By balancing out this power, the dunks in parallel grip connected with lower-than-regular tire-asphalt ordinary power can be maintained a strategic distance from, which encourages unsurprising, safe, and superior taking care of qualities. The adequacy of dynamic and semi-dynamic suspensions is, at times, mostly ascribed to the controller's capacity to anticipate the suspension's dynamic reaction. In this way, a precise suspension model is important for the controller to anticipate the suspension's reaction.

This design has a few points of interest. Gillespie [1] focuses out that its intrinsic L-shape helps with the bundling of transverse motors. In like manner, as Daniels [4] takes note of, its three mounting focuses can be generally separated, in this manner permitting this setup to be made basically productive. Daniels likewise noticed that camber edge change with suspension travel is little. A last favorable position is the simplicity with which the strut can be supplanted. By the by, this sort of suspension arrangement additionally has a few burdens.

From an execution point of view, Daniels takes note of that the impact of the moving power builds the further the body moves because of the move focus relocation brought about with this suspension. Daniels additionally takes note of that move focus relocation on a twofold wishbone suspension makes no difficult issue. Another execution trade off Milliken notice is that McPherson strut suspensions lose negative camber when the suspension voyages upward. In spite of these inconveniences, producers, for example, Porsche and BMW utilize this suspension to extraordinary impact in their street hustling endeavors. Similarly, purchaser auto creators, for example, Toyota and General Motors use them successfully on their traveler vehicles.(Andersen et al., 2007)

2.3.2 Wishbone Lower Arm

The Wishbone lower arm is a kind of free suspension utilized as a part of engine vehicles. The general capacity of control arms is to keep the wheels of an engine vehicle from wildly swerving when the street conditions are not smooth. The control arm suspension typically comprises of upper and lower arms. The upper and lower control arms have diverse structures taking into account the model and reason for the vehicle. By numerous records, the lower control arm is the preferable safeguard over the upper arm due to its position and load bearing limits In the car business, the riding solace and taking care of characteristics of a car are incredibly influenced by the suspension framework, in which the suspended part of the vehicle is joined to the wheels by flexible individuals keeping in mind the end goal to pad the effect of street anomalies. The particular way of connecting linkages and spring components changes generally among vehicles models. The best rides are made conceivably by autonomous suspension frameworks, which allow the wheels to move freely of one another. In these frameworks the unsprung weight of the vehicle is diminished, milder springs are reasonable and front-wheel vibration issues are minimized. Spring components are utilized for car suspension, expanding request of their capacity to store flexible vitality per unit of weight. Suspension arm is one of the fundamental parts in the suspension frameworks.

It can be seen in different sorts of the suspensions like wishbone or twofold wishbone suspensions. The vast majority of the times it is called as A-sort control arm. It joins the wheel center point to the vehicle edge taking into consideration a full scope of movement while keeping up appropriate suspension arrangement. Uneven tire wear, suspension clamor or misalignment, controlling wheel shimmy or vibrations are the fundamental driver of the disappointment of the lower suspension arm. A large portion of the cases the disappointments are calamitous in nature. So the auxiliary uprightness of the suspension arm is critical from outline perspective both in static and element conditions.(Darge, Shilwant, & Patil, 2014)

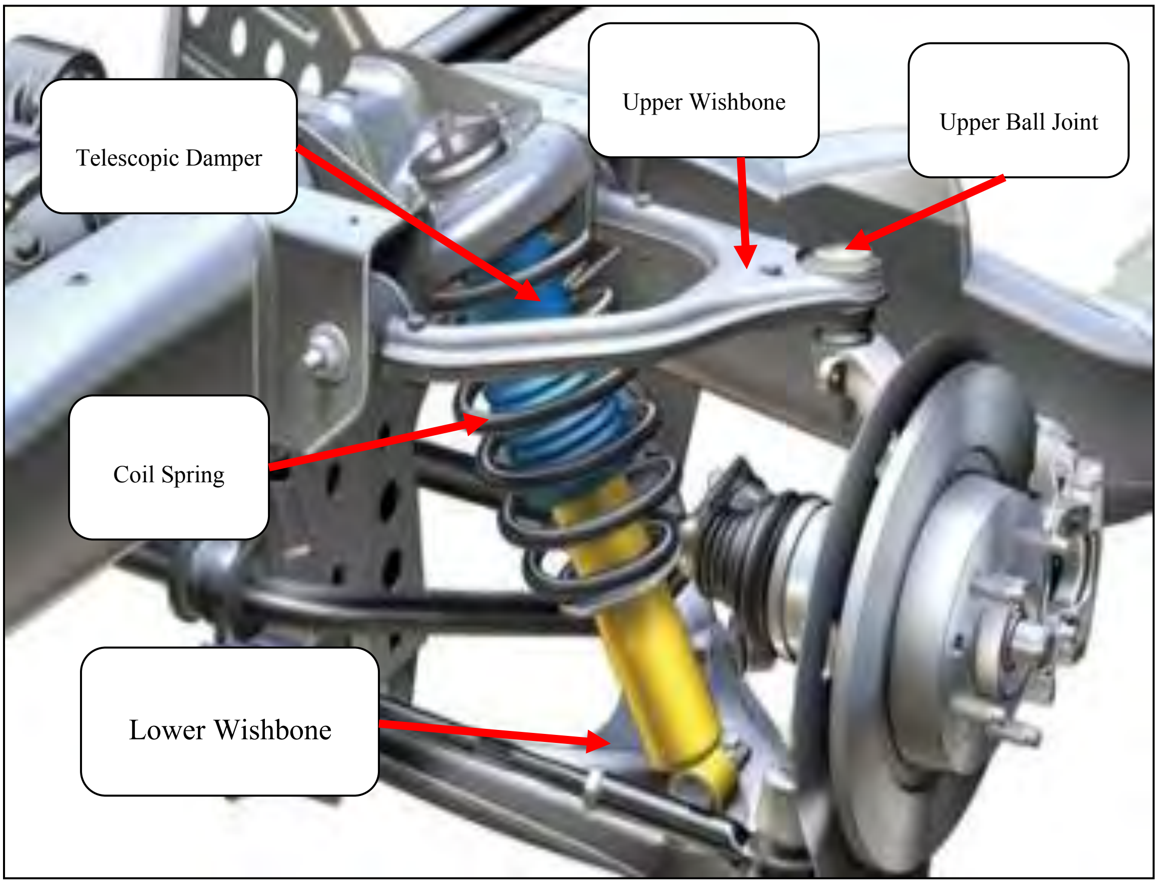

Figure 2.2 : Wishbone Lower Arm