UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF SUSPENSION SYSTEM FOR EXTREME BUGGY

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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I hereby, declared this report entitled "Design And Analysis Of Suspension System For Extreme Buggy" 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 fulfilment of the requirements for the Bachelor Degree of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

....

(ADNAN BIN KATIJAN)

ABSTRAK

Tajuk projek ini adalah "Merekabentuk Dan Menganalisis Sistem Suspensi Untuk Buggy Lasak". Sistem suspensi untuk buggy lasak akan direka dan lukisan terperinci setiap komponen akan disediakan dengan menggunakan perisian CATIA V5R19. Kemudian, analisis struktur dilakukan menggunakan perisian yang sama. Ia dilakukan bagi mengetahui titik kelemahan dan kekuatan setiap komponen yang dibuat. Selepas itu, satu analisis pematuhan dan kinematik dijalankan untuk mengkaji pergerakan setiap komponen dalam sistem suspensi buggy. Kajian ini merangkumi bahagian hadapan dan belakang sistem suspensi. Seperti yang diketahui, buggy adalah sebuah kenderaan yang lasak dengan roda yang besar dan lebar. Ia direka khusus untuk memandu melalui permukaan jalan yang lasak. Oleh itu, adalah penting untuk merekabentuk sebuah sistem suspensi yang kuat dan kukuh. Sistem suspensi yang baik memainkan peranan yang penting untuk mendapatkan kestabilan semasa memandu mendaki gunung dan melalui laluan yang sukar.

ABSTRACT

The title of this project is “Design and Analysis of Suspension System for Extreme Buggy”. A suspension system for Extreme Buggy will be design and details child part drawing will be prepare by using CATIA software. Then, a structure analysis will be done by using same software. This analysis is done to determine strength and weakness point for each fabricate components. After that, a kinematics and compliance analysis will be run to study the movement of each components in buggy suspension. The study will cover on both front and rear suspension system. As known, extreme buggy is an off-road vehicle with large wheels and wide tires that was designed for use on extreme terrain. That why it is important to design a strong and tough suspension system. It plays an important role to get stability during extreme driving like climbing a mountain and drive thru tough off-road track.

DEDICATION

For my beloved parents

Mr. Samsudin Bin Baharum

Mrs. Fatimah Binti Mohd. Yussof

For my respected supervisor

Mr. Adnan Bin Katijan

And to all my treasured friends from

4^{th} years BETA class

Thank you very much for all your care, support and believe in me.

ACKNOWLEDGEMENT

First of all, I am really grateful to almighty Allah S.W.T because the strength that he give to me, I finally have finished my Bachelor Degree Project without any delay and major problem. I am also very grateful to him for granting me a wisdom and strength to face and overcome the challenges and obstacle to accomplish this project.

I also thank to my respected supervisor, Mr. Adnan Bin Katijan for his supervision and her passion to lead me through the period of my project and without him, my project will be nothing. His guidance and help though this period helped me to understand better on working this report. It has been truly memorable and educative being student under his supervision.

Gratitude is also to all my friends in 4^{th} years BETA class for their sharing ideas and moral support that truly have helped me during this project. The experiences and knowledge I gained throughout the process of completing this project would prove invaluable to better equip me for challenges in the future.

Last but definitely not least to my parents, I can never thank you for your love and for supporting me throughout my studies in Universiti Teknikal Malaysia Melaka (UTeM).

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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
4WD	-	4 Wheel Drive
SLA	-	Short Long Arm
K&C Analysis	-	Kinematic and Compliance Analysis

CHAPTER 1

INTRODUCTION

1.1 Background

The suspension system of an automobile is located between the rigid frame and wheel. The frame is attached to the rear and front axle as suspension system mean. All equipment and the passengers on this rigid frame should not feel the impact, shock loads and unequal loads to which the vehicles moving. The suspension system absorbing these shock loads and makes a comfortable riding. This load however cannot be allowed to pass upwards into the frame in order to protect structural stability, equipment safety and passenger comfort. The suspension system serves the purpose of absorbing impact and shock loads during extreme driving. For this purpose, the suspension for any automobile is constructed with a set damping and shock absorbing devices, torsion bars, coil spring and linkages.

In this project, a suspension system for front and rear suspension will be design and child part drawing will be prepare by using CATIA software. Then, a structural and kinematic analysis will be done. As known, kinematics analysis is a study about mechanics that describes the motion of component without consider causes from the motion. While a structural analysis can be interpreted as effects of loads on physical structures or component. For this project, only design and analysis will be made and there will no manufacturing process due to limitations of budget and duration of project. This project will be done by follow the schedule as plan.

In this project, double wishbone suspension had been selected to use by extreme buggy. This due to advantages of this suspension system and it compatibility with extreme buggy chassis. This suspension usually attaches to front or rear wheel where hub assembly attach to the single point and chassis with two points. This will maintain a straight tire during driving and prevent wheel from turn to the side.

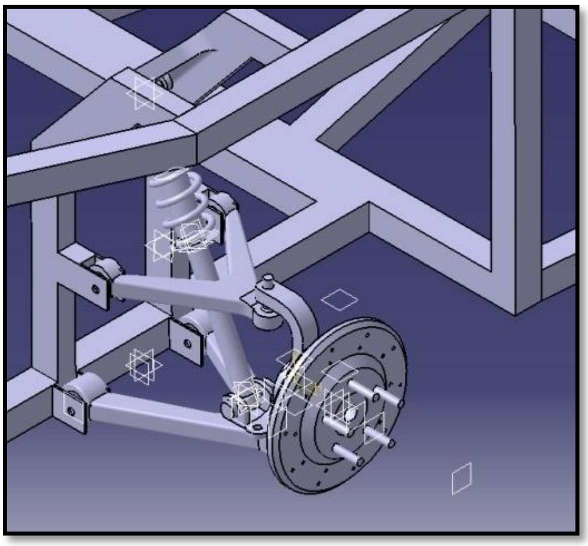

Figure 1.1: Double Wishbone Suspension (Speedcunt, 2012)

This suspension system had many advantages. One of them is it lends well to calibration of each moving joint in system because of load is more spread between parts. With variations in double wishbone suspension systems, design loads can be tuned for different load and more simple. Part design weights can be customized and reduced since load factors for each part are more readily known. More importantly, this suspension allows for a more complete negative camber gain through maximum bouncing.

1.2 Problem Statement

Suspension system is the most important thing when designed an extreme buggy car. In recent years, handling stability and ride with a comfort is a very important features when design an off-road vehicle. In off-road terrain, the track consists of all kinds of obstacles that could easily bind up suspension of any buggy car. Thus, to make the buggy more compatible with extreme terrain, it is necessary to design a suspension system that can handle the roughest of bump without affecting vehicle stability and at the same time it provide a smooth ride to the driver and passenger. This mean a strong and tough suspension is needed to build an extreme buggy that suitable for all challenging terrain.

1.3 Objective

Based on the title "Design and Analysis of Suspension System for Extreme Buggy", the objectives to be achieve at the end of this project are as below :-

- To design and analysis suspension system for extreme buggy.
- To produce detail child part drawing for all components in extreme buggy suspension system.

1.4 Scope & Limitation

This extreme buggy will be design with two seats for driver and passenger. It must be suitable and practical to be use on a rough and extreme terrain. This buggy will use 1.3 Litre engine from Perodua Kembara. It is 4WD with front mounted engine. This project will use CATIA V5R19 software to design suspension system and produce details child part drawing. Then, by using same software, a structure analysis will be done to analysis it strength and weakness point. After that, a kinematics and compliance analysis will be run to study the movement of each component in buggy suspension. This analysis will done using HyperWorks Motion View. A raw material that will be use is A4 paper for details child part drawing. The requirement that needed to do this project is student must be able to use CATIA V5 and HyperWorks software and know how to run analysis using both software.

- To study and design a suitable suspension system for extreme buggy.
- To produce details child part drawing for all component in extreme buggy suspension system.
- To perform a kinematic and structure analysis for suspension system.

CHAPTER 2

LITERATURE REVIEW

2.1 Suspension System

Suspension system is a term given to the set of spring, shock absorber and linkage that connect vehicle to it wheel and allow relative motion between them. Suspension system has two main purpose such as contributing to the vehicle road holding and braking for a good active safety. It also protect the vehicle itself and it cargo from shock load. According to Ramakrishna, K. (2012), suspension system of an automobile is located between the rigid frame and the travel wheels. The frame as well as the body of the vehicle is attached to the front axle and the rear axle. It does the job by absorbing these shock loads and make the ride more comfortable.

2.2 Sprung And Un-Sprung Mass

Ramakrishna, K. (2012) say that suspension support all weight that come above it. The rear axles, wheel assemblies including tyres and brake are below the suspension and they are not supported by the suspension. The total of all these un-supported parts is called the un-sprung mass. The un-sprung mass when deducted from the total weight of the vehicle loaded or unloaded will gives the sprung mass of the vehicles. In other word, weight that controlled by the suspension and usually below the suspension, where the weight force it to contact with the road surface and other components, is call un-sprung mass. While, a weight that support by suspension and commonly above the suspension, which separate from other component and road surface is call as sprung mass.

In Figure 2.1, it illustrates a line diagram model of total suspension of an automobile. The magnitude of the sprung masses and un-sprung masses are required for the analysis of suspension during the design stage. Depend on these masses, the suspension that consisting shock absorbers and spring are designed. Since the un-sprung mass will always stay as un-sprung mass, design should always to be keep the un-sprung mass as low as possible.

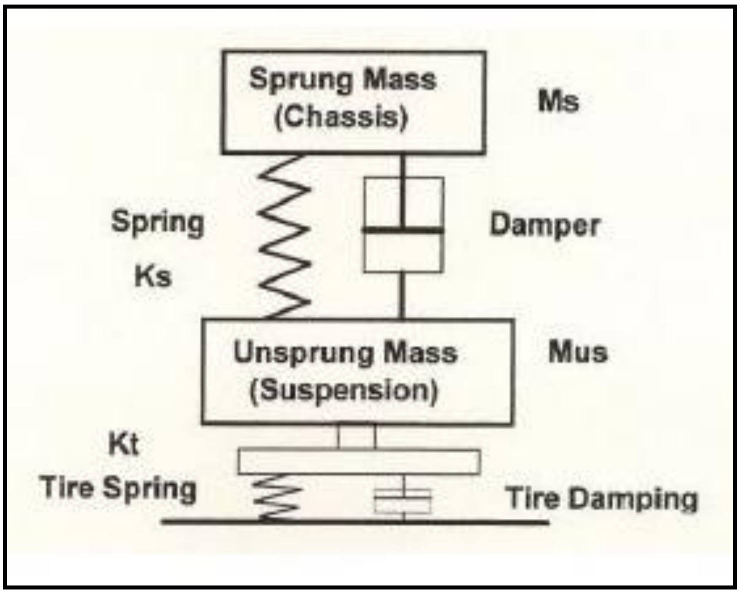

Figure 2.1: Sprung And Un-Sprung Masses (Savor, 2014)

2.3 Main Types Of Suspension

There a two main types of suspension system that can be found in vehicles. It is independent and dependent suspension. It refers to ability of other wheels to move independently from of each other. While, a dependent suspension system or also call as solid axle is move dependently based on opposite wheel. This suspension system usually found on off-road vehicle and truck. This mean that dependent suspension system wheels are linked to each other. As example, when tire on the left side hit a bump, it directly affected the right side. This will cause a larger effect from original bump. Other disadvantage of dependent system is it weight commonly more compare to independent system. This cause by number of part that require in dependent system but no need in independent system.

Independent suspension system get the name from the wheel of vehicle that independent from each other. It is cause by anti-roll bar that connect two wheels. It work by prevent the vehicle suspension from rolling when cornering. It has various type of independent suspension like double wishbone, MacPherson strut, multi-link and trailing-arm. The major difference between this system can be seen when vehicle with independent suspension system hit a bump road, it only effect the single wheel. This will produce a ride comfort, better traction and stability during driving. This aspect is critical for extreme buggy. When driving across rock terrain, an independent suspension will give a better riding stability.

2.4 Dependent Suspension

According to Gillespie, T. D. (1992), dependent suspension is located at end of the rigid beam so any movement from one wheel will transmitted to opposite wheel. This will cause wheel to steer and camber together. This system usually used by front suspension of heavy trucks that carry massive load. However, dependent suspension has it own advantage where wheel camber is not affect by body roll.

2.4.1 Hotchkiss

This suspension system is the most familiar form of the solid drive axle. The axle using semi-elliptic leaf springs as shown in Figure 2.2 and driven through longitudinal driveshaft with universal joint at transmission and axle. The spring is attach longitudinal and connect to chassis at the end while axle is attached near the midpoint. It is the simplest and least expensive of all suspensions. The Hotchkiss system use widely on the rear axle in passenger car in year 1960 and still use by mostly light and heavy truck.

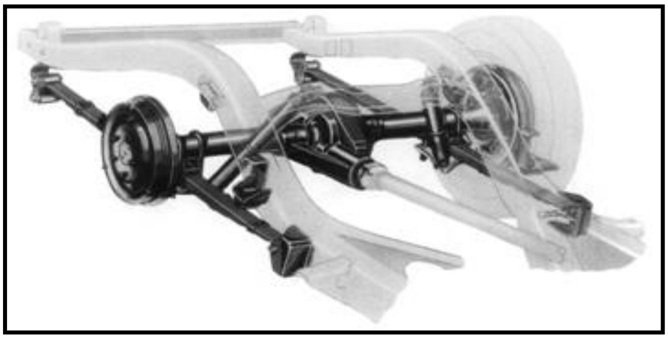

Figure 2.2: The Hotchkiss Rear Suspension (Gillespie, 1992)