UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF THE SUSPENSION SYSTEM FOR THE AGRICULTURAL SMART MOVER WITH USING TOTAL DESIGN METHOD.

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

by

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I hereby, declared this report entitled "Design and Analysis of Suspension System for Agricultural Smart Mover with using Total Design Method" 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 degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

………………………………

(Project Supervisor)

ABSTRAK

Agricultural Smart Mover adalah sebuah kereta sorong biasa yang sudah dimodifikasi di mana padanya terdapat sistem enjin, sistem brek, dan sistem suspensi. Sistem suspensi memberikan banyak kebaikan kepada sesuatu kenderaan. Ia juga memastikan tayar dan jalan sentiasa bersentuhan seterusnya dapat mengekalkan keseimbangan kenderaan. Tajuk projek ini ialah rekabentuk dan analisis sistem suspensi untuk Agricultural Smart Mover. Antara langkah dalam penghasilan projek ini adalah mereka bentuk sistem suspensi yang sesuai dengan keadaan muka bumi di dalam ladang kelapa sawit supaya ia dapat mengurangkan impak yang diterima oleh Agricultural Smart Mover. Rekabentuk yang tepilih akan dianalisis dengan menggunakan CATIA V5 bagi menguji kekuatan rekebentuk itu sendiri.

ABSTRACT

Agricultural Smart Mover is an ordinary wheelbarrow that have been modified where it has engine system, brake system and suspension system. The suspension system provides many benefits to a vehicle. It also ensures the tire and the road is always in contact to maintain the balance of the vehicle. The title of this project is to design and analyze the suspension system for Agricultural Smart Mover. Among the steps in the production of this project is to design a suspension system in accordance with the state of the earth in the palm oil so that it can reduce the impact received by the Agricultural Smart Mover. The design will be choose with using the results obtained from CATIA V5. Then the selected design will go through another analysis in SolidThinking.

DEDICATION

To my beloved parents all the ones who supported me.

ACKNOWLEDGEMENT

I would like to thanks to all who participated in making this report and project a made believe.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

According to Lewis (1994), wheelbarrow is a small hand-propelled vehicle, usually with just one wheel, designed to be pushed and guided by a single person using two handles at the rear, or by a sail to push the ancient wheelbarrow by wind. Wheelbarrow term itself contains two words, which are 'wheel' and 'barrow'. The derivation of bearwe(old English) produced 'barrow'. Bearwe was a carrying loads device during that time.

Wheelbarrow is designed to ease the operator moving of something to another location. The design of the wheelbarrow makes the weight of its load between the wheel and the operator distribute evenly. As such it is a second-class lever. However, Needham (1965) states that, a traditional Chinese wheelbarrow supports the whole load with using a central wheel. The use of wheelbarrow is common and still being used in today's industry work, plantation site and even gardening.

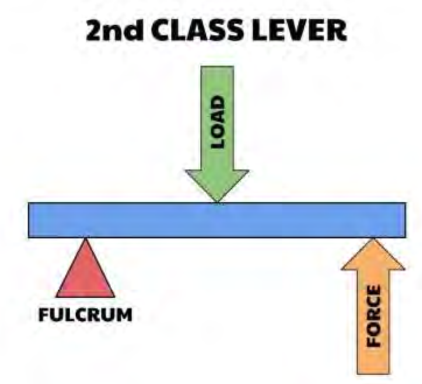

Figure 1.1: 2nd class lever.

The Agriculture Smart Mover actually is the improvised version of the typical wheelbarrow which it has suspension system to support the loads in the carriage. For it to be more applicable in the plantation, suspension is also added aside from braking system and engine powertrain.

Gillespie (1992) states that suspension system consists of spring, damper and structural components carrying the sprung mass (car chassis). The suspension system serves two main purposes that contributes to the car's handling and braking. It also protecting the vehicle itself and any cargo from damage at the same time.

In line with this project title, this project focuses on designing the suspension part for the Agriculture Smart Mover with using total design technique. The drawing of the design will use the CATIA software while the analysis will use some simulation tool to proof that the design meets the stiffness, strength, and stability. The designed suspension will be assemble with the body of the mover.

1.1 Problem Statement

Demand in palm oil is relatively high nowadays. It even started to make huge profit and contribution to Malaysia's economy in 2009 where as stated in Utusan Online. Tan Sri Bernard Dompo, Minister of Plantation Industries and Commodities, said that the profit increases from RM52.7b in 2009 to RM125b in 2011.

In yesteryear's February 9th, Irawati Hamdany reported in kelapasawitnews.com that Malaysia's palm oil production is expected to increase. While oil production in the world today is more than 55 million tons, Malaysia produces more than 21 million tonnes. Malaysia and Indonesia become a country that controls the world's palm oil production.

These two news shows that the high need in palm oil. Developments in palm oil industry should be able to fill the demands. The use of normal wheelbarrow has been applied for over the years in order to move the collected fruits from the tree to fruit collection point before the fruit transports to factory.

. The existing wheelbarrow are not durable due to the maximum weight of the palm oil fruit. The wheelbarrow will receive the force exerted on it and the high force will damage the wheelbarrow. The uneven or bump on off-road surface condition in the plantation also will affect the wheelbarrow durability.

With the installation of the suspension system in the smart mover, it will reduce the damage done on the wheelbarrow and reduce the maintenance and replacing cost. Vehicle suspension system consists the springs that support the weight of the vehicle, maintain ride height, and absorb road shock. The suspension system should meet the earth condition in palm oil plantation in order to deliver positive result

1.2 Objective

The objective of this project is:

1. To design a suspension for the agriculture smart mover with using total design method.
2. To analyse the suspension system with using suitable simulation software.

1.3 Work Scope

i) This project will cover only in designing and selecting the suspension, and then the design will go through further fabrication work.

ii) Analyse the suspension using CATIA V5 and SolidThinking software.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction.

In this chapter, a brief history of suspension will be cited. Various types of suspension are available in the market nowadays. The suspension that will be covered in this chapter ranging from motorcycle's to car's suspension system.

Gillespie (1992) states that suspension system consists of spring, damper and structural components carrying the sprung mass (car chassis). The springs provide cushioning with absorbing impacts when a wheel hits a bunp in the road. It also keep the control of vehicle by keeping the wheels in contact with the road while resisting wheel's movement and rebounds, pushing the wheel back down.

Shock absorbers (dampers) perform two functions. They absorb any larger than average bumps in the road so that the upward velocity of the wheel over the bump is not transmitted to the car chassis. They also keep the suspension at full as much as possible during the travelling for the given road conditions, in brief, they keep the wheels planted on the road, according to Nasir (2006).

2.1 History of Suspension.

According to Subramani (2016) an early form of suspension on ox-drawn carts had the platform swing on iron chains attached to the wheeled frame of the carriage. Until the turn of the 19th century, this system remained the basis for all suspension systems, although the iron chains were replaced with the use of leather straps by the 17th century.

Automobiles were initially developed as self-propelled versions of horse-drawn vehicles. However, horse-drawn vehicles has relatively slow speeds, and their suspension was not well suited to the higher speeds permitted by the internal combustion engine. That is why the earlier suspension systems are not suitable for modern vehicles.

Adam (1837) said that in is writing that Obadiah Elliott registered the first patent for a spring-suspension vehicle; - each wheel had two durable steel leaf springs on each side and the body of the carriage was fixed directly to the springs, which were attached to the axles. Within a decade, most British horse carriages were equipped with springs; wooden springs in the case of light one-horse vehicles to avoid taxation, and steel springs in larger vehicles. These were often made of low-carbon steel and usually took the form of multiple layer leaf springs.

Coil springs first appeared on a production vehicle in 1906 in the Brush Runabout made by the Brush Motor Company. Today, coil springs are used in most cars.

2.2 Main Components of Modern Suspension System.

At this point, it is important to understand that the main components of a moving vehicle suspension system are the struts, shock absorbers, springs, and tires, Reza (2008). The springs support the weight of the vehicle, maintain ride height, and absorb road shock. Springs are the flexible links that allow the frame and the body to ride relatively undisturbed while the tires and suspension follow the bumps in the road.

Springs are the compressible link between the frame and the body. When an additional load is placed on the springs or the vehicle meets a bump in the road, the springs will absorb the load by compressing. The springs are a very important component of the suspension system that provides ride comfort. Shocks and struts help control how fast the springs and suspension are allowed to move, which is important in keeping tires in firm contact with the road.

During the study of springs, the term bounce refers to the vertical (up and down) movement of the suspension system. The upward suspension travel that compresses the spring and shock absorber is called the jounce, or compression. The downward travel of the tire and wheel that extends the spring and shock absorber is called rebound, or extension.

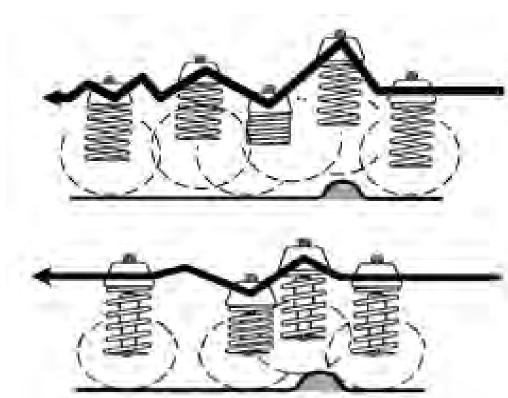

Figure 2.1 Spring extensions and compression.

When the spring is deflected, it stores energy. Without shocks and struts the spring will extend and release this energy at an uncontrolled rate. The spring's inertia causes it to bounce and overextend itself. Then it re-compresses, but will again travel too far. The spring continues to bounce at its natural frequency until all of the energy originally put into the spring is used.

If the struts or shock absorbers are worn and the vehicle meets a bump in the road, the vehicle will bounce at the frequency of the suspension until the energy of the bump is used up. This may allow the tires to lose contact with the road.

Struts and shock absorbers that are in good condition will allow the suspension to oscillate through one or two diminishing cycles, limiting or damping excessive movement, and maintaining vertical loads placed upon the tires. This helps keep the tires in contact with the road.

By controlling spring and suspension movement, components such as tie rods will operate within their design range and, while the vehicle is in motion, dynamic wheel alignment will be maintained.

Bushings.

Bushings are used in many locations on the vehicle suspension system. Most bushings are made with natural rubber. Bushings made of natural rubber offer high tensile strength and excellent stability at low temperatures. Natural rubber is an elastomeric material. Elastomeric refers to the natural elastic nature of rubber to allow movement of the bushing in a twisting plane. Movement is controlled by the design of the rubber element. Natural rubber requires no lubrication, isolates minor vibration, reduces transmitted road shock, operates noise free, and offers a large degree of bushing compliance. Bushing compliance permits movement without binding. Natural rubber resists permanent deflections, is water resistant and very durable. In addition, natural rubber offers high load carrying capabilities.

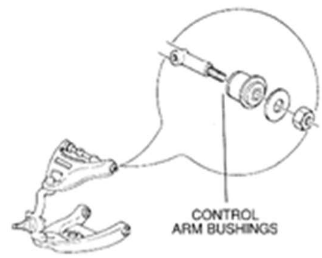

Figure 2.2: Bushings.

As with all suspension system components, control arm bushings are dynamic components, meaning that they operate while the vehicle is in motion. Control arms act as locators because they hold the position of the suspension in relation to the chassis. They are attached to the vehicle frame with rubber elastomeric bushings. During suspension travel, the control arm bushings provide a pivot point for the control arm. They also maintain the lateral and vertical location of the control arm pivot points, maintain dynamic wheel alignment, and reduce transmitted noise, road shock, and vibration, while providing resistance to suspension movement.

During suspension travel the rubber portion of the bushing must twist to allow control arm movement. Control arm bushings that are in good condition act as a spring; that is, the rubber will spring back to the position from which it started. This twisting action of the rubber will provide resistance to suspension movement.

As previously stated, control arm bushings are dynamic suspension components. As the control arm travels through jounce and rebound, the rubber portion of the bushing will twist and stretch. This action transfers energy into the bushing and generates heat.

Excessive heat tends to harden the rubber. As the rubber bushing hardens, it tends to crack, break, and then disintegrate. Its temperature determines the life of a rubber bushing. Rough road conditions and/or defective shock absorbers or struts will allow excessive suspension movement creating more heat, which shortens the life of the bushings.

Rubber bushings must not be lubricated with petroleum-based oil. A petroleum-based product will destroy the bushings. Instead, use a special tire rubber lubricant or a silicone based lubricant.

Worn suspension bushings allow the control arm to change positions. This results in driveline vibration (primarily rear wheel drive rear control arm bushings), dynamic alignment angle changes, tire wear, and handling problems. Control arm bushing wear (looseness) will create a clunking sound while driving over rough roads.

2.3 Spring Design

Before discussing spring design, it is important to understand sprung and unsprung weight. Sprung weight is the weight supported by the springs. For example, the vehicle's body, transmission, frames, and motor would be sprung weight. Unsprung weight is the weight that is not carried by springs, such as the tires, wheels, and brake assemblies.

The springs allow the frame and vehicle to ride undisturbed while the suspension and tires follow the road surface. Reducing unsprung weight will provide less road shock. A high sprung weight along with a low unsprung weight provides improved ride and also improved tire traction.

2.3.1 Type of Springs

Coil Springs

The most commonly used spring is the coil spring. The coil spring is a length of round spring steel rod that is wound into a coil. Unlike leaf springs, conventional coil springs do not develop inter-leaf friction. Therefore, they provide a smoother ride.

The diameter and length of the wire determine the strength of a spring. Increasing the wire diameter will produce a stronger spring, while increasing its length will make it more flexible.

Spring rate, sometimes referred to as deflection rate, is used to measure spring strength. It is the amount of weight that is required to compress the spring 1 inch. For example: If it takes 100 lbs. to compress a spring 1 inch, it would take to 200 lbs. to compress the spring 2 inches.

Some coil springs are made with a variable rate. This variable rate is accomplished by either constructing this spring from materials having different thickness or by winding the spring so the coil will progressively compress at a higher rate. Variable rate springs provide a lower spring rate under unloaded conditions offering a smoother ride, and a higher spring rate under loaded conditions, resulting in more support and control.

Coil springs require no adjustment and for the most part are trouble-free. The most common failure is spring sag. Springs that have sagged below vehicle design height will change the alignment geometry. This can create tire wear, handling problems, and wear other suspension components. During suspension service, it is very important that vehicle ride height be measured. Ride height measurements not within manufacturer's specifications require replacement of springs.