

ANTIROLL SUSPENSION SYSTEM FOR SPORT UTILITY VEHICLES

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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**A report submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Automotive**

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DECLARATION

I declare that this project report entitled “Anti Roll Suspension System for Sport Utility Vehicles” is the result of my own work excepts as cited in the references.

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Date : *15.6.2017*

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive).

Signature :

Name :

Date :

DEDICATION

To my beloved mother and father

ABSTRACT

Suspension system is the connector between the tire and the body of a vehicle. The main aim of suspension system is to isolate a vehicle body from the road irregularities. There are 3 suspension systems have been met in this research which is passive, semi active, and active suspension system. All of this suspension systems affects the performance and stability of a vehicles, include sport utility truck. Passive and active suspension have been test in this simulation MATLAB software to determine which suspension is better to achieve anti rollover of vehicles. This report is developed an active suspension for the half car model of a sport utility truck to improve the performance by using actuator force and proportional integral derivative (PID) controller. All the parameters of 3 different sport utility truck has been taken to analyzed through simulation in MATLAB Simulink. We will be studied by comparing the passive and active suspension system graph. In order to modelling this simulation, the equation of motion has been draft by half model car so we can analyze the data or rollover and vertical displacement of vehicles by comparing the passive and control suspension system.

ABSTRAK

Sistem suspensi adalah penyambung diantara tayar dan badan sesebuah. Tujuan utama system suspensi ialah untuk mengelakkan kenderaan dari jalan penyelewangan. Terdapat 3 jenis suspensi sistem yang diketemukan dalam penyelidikan ini dimana ia ialah pasif, separuh pasif, dan aktif suspensi. Kesemua sistem suspensi ini akan memberi kesan kepada kecekapan dan kesetabilan sesebuah kenderaan, termasuk sport utility vehicle. Suspensi aktif dan pasif akan dicuba dalam simulasi perisian MATLAB untuk menentukan suspensi mana yang sesuai dan bagus untuk mencapai anti bergolek. Kajian ini akan menghasilkan suspensi aktif untuk model separuh kereta untuk meningkatkn lagi kecekapan dengan menggunakan daya penggerak dan system PID. Kesemua 3 kereta ini mempunyai parameter yang berbeza dan akan diambil untuk di analisis melalui simulasi perisian MATLAB Simulink. Kami akan mengkaji dengan membandingkan graph yang dihasilkan oleh pasif dan aktif suspensi. Untuk menghasilkan model simulasi ini, persamaan perlu di draf pada separuh model kereta supaya kami boleh analisis data kenderaan bergolek dan anjakan menegak kereta dengan membandingkan suspensi aktif dan pasif.

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LIST OF SYMBOLS

DOF	degree of Freedom
t	track
COG	centre of Gravity
m_b	mass of Body
m_w	weight of Vehicle
l_w	distance Between Front Both Tire
ϕ	roll of Vehicle
k_{tr}	stiffness of Right Spring
k_{sl}	stiffness of Left Spring
m_w	mass wheel both side
Z_r	road displacement
g	gravity
K	spring
C	damper
m_{wr}	mass wheel right
m_{wl}	mass wheel left
k_t	tyre spring
w_b	wheelbase
C_{sr}	damper Right Spring
C_{sl}	damper Left Spring

k_{sr} stiffness of Right Spring

k_{sl} stiffness of left spring

CHAPTER 1

INTRODUCTION

1.1 Background

Vehicles is a most important to the all user and its function as to move from one destination to another destination. All vehicles have their suspension which is one of the tire system that includes springs, shock absorbers and linkage and it connects a vehicle to its wheel. Suspension is a main role to provide the vehicle good ride and better handling. Besides that, it also to ensure that steering control is maintained during maneuvering, and to provide isolation from high frequency vibration from tire excitation. Sport utility vehicles are always have problem on their suspension due their factor of centre of gravity. It mostly will affect to the vehicle stability when driving through irregularities road, turning the wheel, stability of car and rollover of the vehicle during driving.

Rollover is a major problem of vehicle. There are 3 type of suspension system in vehicles which is passive, semi active and active suspension. Active suspension system uses hydraulic actuator to reduce the amount of external power necessary to achieve the desired performance characteristics and able to exert an independent force on the suspension to improve the riding characteristics. Semi active suspension is the damping force of the damper is controlled by changing the combination of throttle holes that pass the working fluid with quick electromagnetic valves. Both suspension have their own pro and cons.

There are 3 basic translational motions of vehicle axis system in **Figure 1.1** which are the roll motion through x-axis where front direction of vehicle is the positive value, the pitch motion through the y-axis where the direction to left side is positive value, and lastly is the motion through z-axis is yaw where the clockwise direction is positive value.

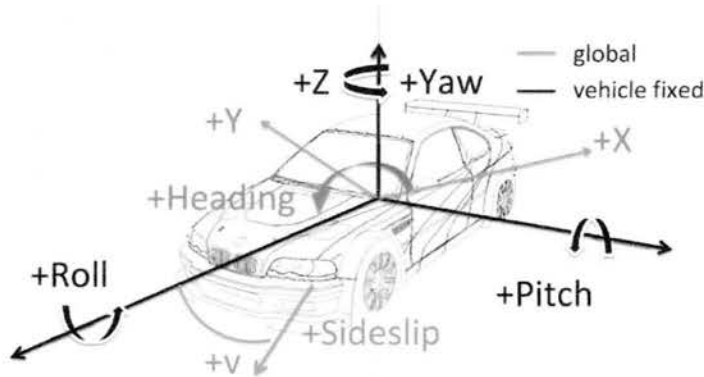


Figure 1.1: Vehicle pitch, yaw and roll

1.2 Problem Statement

From the theory, we all know that all the vehicles have pitch, yaw and roll and all of that have their own movement. Vehicles need a good suspension to avoid from rollover because suspension can improve the vehicle to the better handling and absorb the vibration when through the irregularities road. In order to achieve the good suspension and better comfort during ride, parameter need to change to make sure the isolation of vibration is lower so that the natural frequency become low and the stability of the vehicles is increase. Simulation from Matlab software can control the parameter and design the anti-rollover suspension control system.

1.3 Objective

The research focuses on sport utility truck which to control the suspension of the vehicles and avoid it from rollover. The main objective of this study are:

- a) To understand working principles of suspension in vehicle, component and theories through a literature study.
- b) To control and improve sport utility truck vehicles to the better handling, safety and comfort.
- c) To provide complete analysis and modelling about suspension.
- d) To tune suspension parameters and analyse the rollover of sport utility vehicle using Matlab software.

1.4 Scope of Project

The scope of this project is:

- a) To analysis the sport utility vehicle rollover by changing the parameter of vehicle such as mass, stiffness, and damping.
- b) To study and investigate the parameter of suspension to the comfort handling and avoid rollover.
- c) Using Matlab and Simulink to analysis the suspension of vehicles.
- d) Degree of freedom will be used for this project.

1.5 General Methodology

The methods that need to be carried out to success the objectives in this project are:

a) Literature review

Journals, articles, or any materials that related with the project will be reviewed.

b) Matlab/Simulink

Control and modelling the vehicle dynamic and change the suspension parameter to analyse the factor of vehicle's rollover.

c) Research

Research about the criteria of suspension in vehicle and type of suspension such as semi active/active suspension

d) Simulation

The suspension will be tested by changing the value of mass, spring stiffness and damping coefficient which influence the rollover of vehicles

e) Report Writing

We need to do a report for this research.

CHAPTER 2

LITERATURE REVIEW

2.1 History

The early years of automotive development were an interesting time for the engineers where the period of development without established practice and virtually all ideas were new one and worth trying. As is well known, automobile was initially developed as self-propelled horse carriages. The special of horse at that time is it have its own suspension system with double leaf springs and dead axles but the speed of horse is low. A car is much of complex system and have a high speeds and high possibilities. The innovation of automotive suspension at the beginning of the twentieth century. At 1903, Mors from Germany fitted a car with shock absorbers. In 1920, Leyland used torsion bars at suspension system. In 1922, construction and independent front suspension were pioneered on the Lancia Lambda, independent front suspension become more popular which it had wheel drive, unitary Minor with torsion bar independent front suspension. At 1949, Triumph Mayflower created the combined coil spring/damper unit and strut-type telescope damper. From 1950 to 1962, Citroen car used hydropneumatic suspension in its DS 19 model while BMC used independent rubber suspension and improved it in its 110 model using hydrostatic suspension. **Figure 2.1** shows the early model of suspension system which is use leaf spring and have two tyre with one connector made on the year 1900.

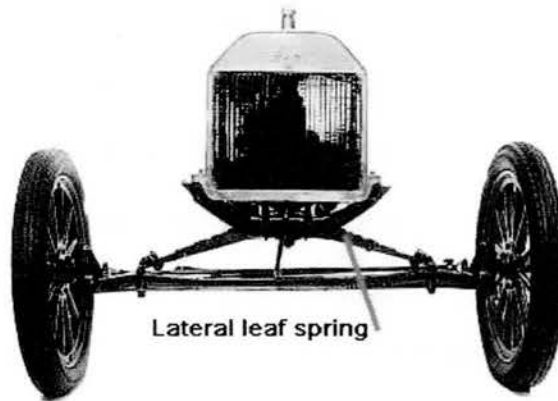


Figure 2.1: Early model of suspension system

Some of European car had tried coil spring leading by Gottlieb Daimler but most of manufactures stood fast with leaf springs. It was less costly, and be simply adding leaves or the shape are changing from full elliptic to three quarter or half elliptic, the function of spring to support weights. Leaf springs have been used since Romans era which suspended a two-wheeled vehicle on elastic wooden poles. At 18th century, the first steel spring put on a vehicle was a single flat plate installed on carriages by the French. Besides that, the venerable leaf spring who was invented by Obadiah Elliot of London in 1804 is manufacture and still use in rear suspension today. He simply piled one steel plate on top of another, pinned them together and shacked each end to a carriage.

At 1908, Henry Ford's Model T Ford featured old fashioned leaf spring and he only used one spring at each axle, mounted transversely, instead of one at each wheel. High strength vanadium steel from a French racing car make the car save weight and cut costs in many areas of the Model T Ford but not focusing their durability. Independent coil spring front suspension maintained for 25 years after the introduction of the Brush Runabout. However in 1934, General Motors, Chrysler, Hudson, and others reintroduced coil spring front suspension which each of the wheel spring independently. During that year, most of the cars started using hydraulic shock absorber and low pressure tires. At the time, not all

the cars used coil spring, some of them had independently suspended leaf springs. Then, all manufactured switch to coil spring for the front wheel after World War II.

We can say that the suspension system was revolutionized by the independent suspension system. After the cars started becomes more technology, powerful and lighter, independent front suspension helped the car in handling to keep pace with their escalating power to weight ratios. The shape of independent front suspension changed so the car can improve their ride and road holding. In addition, the disappearance of the front beam axle will make the engine moved further forward and mounted lower. The suspension assemblies were fitted almost at the same height. Today' high speed, sleek automobiles need to a lot of development that tool place like the tiny hammer blows of an artist that chisel out a piece of art.

2.2 Roll-over

2.2.1 Introduction

A rollover is a type of vehicle accident tips over onto its side or roof. Rollover on vehicles is an important to the road safety. To avoid or prevent rollover is a fundamental and significant issue for vehicle dynamics and this topic has been consideration for a long time (Palkovics, et al, 1999). There are two distinct types of vehicle rollover, tripped and un-tripped (Selim, et al, 2006). This two type of rollover is different where a tripped rollover commonly occurs as vehicles skids and digs its tire into soft soil or hits a tripping mechanism such as divider, curb or guardrail with a sufficiently large lateral velocity. Maneuver or unable to move skillful lead to un-tripped rollover which it can occur during typical driving situation and poses a real threat for the vehicles with an elevated centre of gravity. Average percentage of rollover occurrence in fatal crashes significantly higher than in other types of crashes (Chen, 2001). Rollover can occur as a direct result of the lateral wheel forces induced