UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MODELLING AND VALIDATION OF RIDE MODEL COMMERCIAL VEHICLE

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

by

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I hereby, declared this report entitled “Modelling and Validation of Ride Model Commercial Vehicle” is the results of my own research except as cited in references.

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Name **:** MOHAMAD SHUKRI FAIZ B SHAARI

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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) (Hons.). The member of the supervisory is as follow:

AHMAD ZUL HUSNI BIN CHE MAMAT
(Project Supervisor)

ABSTRACT

There are many vehicle models that have been developed for the study of the vehicle dynamics specifically for the ride and handling behavior. This thesis describes the development of commercial vehicle ride model to study the behavior of the vehicle after improvement with semi-active suspension system. The derivation of a 7 DOF vehicle model consists of ride is presented. The most accurate combination of controller and actuator which follows the comparing result of the Matlab/Simulink with Carsim software was chosen to be coupled with the 7 DOF model. All the assumptions made for the 7 DOF with semi-active system vehicle model is stated. The 7 DOF vehicle model will then be validate using Carsim software. The results discuss such as pitch rate, lateral acceleration and roll angle of the vehicle body.

ABSTRAK

Terdapat banyak model kenderaan yang telah dibina untuk kajian dinamik khususnya tingkah laku perjalanan dan pengendalian. Tesis ini menerangkan pembangunan model kenderaan untuk mengkaji tingkah laku kenderaan jenis "Commercial Vehicle" selepas peningkatan dengan sistem suspensi semi-aktif. Model kenderaan 7-DOF terdiri daripada perjalanan yang telah dibina berdasarkan model terbitan. Pemilihan kombinasi yang tepat diantara pengawal dan penggerak akan dibuat berdasarkan keputusan perbandingan diantara Matlab/Simulink dan Carsim untuk dipadankan dengan model 7-DOF. Semua andaian yang dibuat untuk 7-DOF dengan kenderaan semi-aktif sistem model dinyatakan. 7-DOF model kenderaan akan disahkan menggunakan perisian Carsim. Keputusan yang dibincangkan adalah kadar rewang, pecutan sisi, sudut gulungan badan kenderaan.

DEDICATIONS

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Dedicated to my advisor, Ir. Mohamad Hafiz bin Harun and Mr. Ahmad Zul Husni bin Che Mamat for guidance and encouragement while doing this project. To my friends Nurrul Hikmah binti Muhammad Mahayuddin, Abdullah bin Omar, Nurhan bin Ayub and my friends, I would like to thank you that has help me in giving ideas and opinion for completing this final year project. For all your care, support and believe in me.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

m_s = Sprung mass

m_u = Unsprung mass

K = Stiffness

L = Wheelbase

I_{zz} = Vertical axis moment of inertia

$\ddot{\theta}$ = Pitch angular acceleration

$\ddot{\emptyset}$ = Roll axis angular acceleration

k_{sfl} = front left suspension spring stiffness

k_{sfr} = front right suspension spring stiffness

k_{tfl} = front left tire stiffness

k_{tfr} = front right tire stiffness

c_{sfl} = front left damping stiffness

c_{sfr} = front right damping stiffness

z_{sf} = front displacement of the sprung mass

z_{ufl} = front left displacement of the unsprung mass

z_{ufr} = front right displacement of the unsprung mass

z_{rfr} = rear right displacement of the unsprung mass

z_{rfl} = rear left displacement of the unsprung mass

$\ddot{\theta}$ = pitch acceleration at body center of gravity

I = moment of inertia

CHAPTER 1
INTRODUCTION

1.1 Introduction

This paper studies on vehicle dynamics technology based on vehicle model with selected parameter to simulated driving characteristics and vehicle control. It involves development of commercial vehicle dynamic equation model. The dynamics equation model consists of seven degree of freedom(DOF) where four DOF generate from unsprung mass, body rolling, body pitching, and body vertical direction. It also involves development of commercial vehicle dynamics equation rollover model. All these equations then will be modelled in Matlab Simulink Software. The response generated in Matlab Simulink software then will be validated using CarSim software. The purposes of this study are to identify the rollover characteristics of the vehicle and to improve the vehicle ride comfort by using appropriate controller.

1.2 Problem Statement

Commercial vehicle is the one of economic development mechanism. Good quality product delivered by the commercial vehicle will determined the performance of the transportation company. Nevertheless, there are a lots of good rejected upon delivered. It's because suspension system is not capable to withstand the vehicle load. The factors contribute to this problem are goods overloading and not properly arranged. Significantly this problem will have affected the driver, passenger and consumers. To overcome this problem semi active suspension system will be proposed because it offers better possibility to improve the dynamics performance of commercial vehicle compared to conventional passive solution (M. Hafiz Harun et al. 2016).

1.3 Objective

i. To develop the commercial vehicle, ride model.
ii. To validate the commercial vehicle, ride model.
iii. To improve the commercial vehicle suspension system by using the appropriate controller.

1.4 Scope

i. Develop the commercial vehicle ride model using Matlab Simulink software.
ii. Validate the commercial vehicle ride model using Carsim software.
iii. Improve the commercial vehicle ride comfort using a semi-active suspension system.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

A car is a wheel and production of automotive industry skidding across the road. Truck, or vehicle or self-powered motor vehicle used to move people or goods. Modern car is considered the modern year of 1886. It also has various restrictions used for driving, parking, passenger facility and safety, and a variety of light controllers. Section 4-13 of New York City Transport Rules, vehicles or a mixture of vehicles designed to transport the following properties:

i. two axles and six tires
ii. three or more axles

2.0.1 Passenger Car

Passenger cars as shown in **Figure 2.1** are at least four wheels, motor vehicles used for passenger transport, and do not have eight seats in addition to the driver's seat.

Figure 2.1: Passenger Car

(Source: http://www.automotive-fleet.com)

2.0.2 Commercial Vehicle

Light commercial vehicles are at least four wheels' motor vehicles. A range between light commercial vehicles and heavy trucks is divided into mass or tons.

2.1 Road Truck

Truck classifications are usually based on the maximum loaded weight of the truck using the Total Vehicle Weight Value (GVWR) or Total Truck Weight Value (GTWR). There are three main categories is light truck, medium truck and heavy trucks on the road. In every country, the driver needs to have a license to drive the vehicle safely.

2.1.1 Light truck

Light truck or light-duty truck as shown in **Figure 2.2** is a United States classification of trucks with ability to payload for (1,815 kg). Similarly, the EU is known as light commercial vehicles.

Figure 2.2: Light Truck Ford Ranger
(Source: http://www.motoring.com.au)

Based on Federal regulations, light-duty truck has Gross Vehicle Weight Rating (GVWR) not more than 3,855.5 kg curb weight plus payload. Light trucks includes vans, pickups, and sport utility vehicles. Light trucks have fewer energy standards than cars, and that these vehicles are used for useful purposes rather than for personal transport.

2.1.2 Medium trucks

Medium trucks as shown in **Figure 2.3** are larger than light trucks but smaller than heavy trucks. In the United States, its Gross Vehicle Weight Rating (GVWR) is between 6351-11793 kilograms are defined. In North America, a medium-duty truck is larger than a heavy-duty pickup truck or full-size van.

Figure 2.3: Medium Truck Chevrolet Low Cab

(Source: http://www.gmfleet.com)

2.1.3 Heavy trucks

Heavy trucks as shown in **Figure 2.4** are heavier than medium trucks. It Gross Vehicle Weight Rating (GVWR) is between is from 11794 to 14969 kg. There is no high road classification.

Figure 2.4: Heavy Truck Isuzu Trailer

(Source: https://www.123rf.com)

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2.2 Suspension System

Suspension system an important role in isolating vehicle body from road shocks and vibrations. The aim of suspension system is to improve ride comfort, road handling and stability of vehicles (Bharali and Buragohain,2016). The main of suspension system is to isolate a vehicle body from road irregularities in order to maximize passenger ride comfort and retain continuous road wheel contact in order to provide road holding.(Renn and Wu, 2007). Basically, the suspension connects a vehicle with its wheels, features springs system, shock absorbers and connections. Performance and driving is the most common part for use of suspended systems is to controlling tire defensing or wheel hops to handle the body deficit and passenger riding facility.

In recent years, much research has been carried out in the design of active and semi-active suspensions of vehicles for better vehicle response (Yan and Shaojun, 2009). Suspension system can be classified into three type which are passive suspension system, semi-active suspension system and active suspension system. The control objective of suspension systems is to provide superior ride comfort and stabilize the attitude of the vehicle within the suspension's travelling range(Jue and Jing, 2015).

Passive suspension system is a regular suspension system with an uncontrolled spring. Semi-active suspension has the same elements, but there are two or more selective spring. A system controlled by drivers that provide additional performance is for active suspension. Several performance characteristics have to be considered in order to achieve a good suspension system (Sam *et al*., 2004).

2.2.1 Passive Suspension System

An early design for automobile suspension systems focused on unconstrained optimizations for passive suspension system which indicate the desirability of low suspension stiffness, reduced unsprung mass, and an optimum damping ratio for the best controllability(Sam *et al*., 2004). Passive suspension system a regular suspension system has unconstraint spring and shock-absorbing damage. Passive suspension is a system that contains an element, damaging, energy-saving and spring. This is called suspended suspension because these two elements cannot form the structure of the system.

Passive suspension has the ability to save energy in the spring, and it is capable of exhausting it through the barrier. Its parameters are generally determined, and a certain amount of compromise is determined with road handling, load and driving facility. **Figure 2.5** shown in below show diagram of passive suspension system.

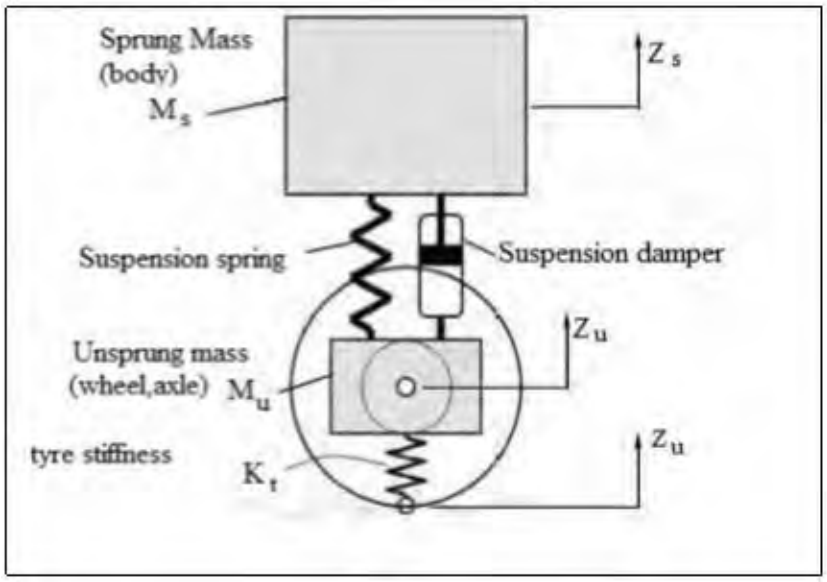

Figure 2.5: Passive suspension system

(Adopted from C.M.Isa (2015))