UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF LOW COST SHOCK ABSORBER TEST RIG FOR SUSPENSION PARAMETER STUDY

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) with honours

by

MUHAMAD AZWAN BIN AZIZ

B071210243

930406-14-6095

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DESIGN AND ANALYSIS OF LOW COST SHOCK ABSORBER TEST RIG FOR SUSPENSION PARAMETER STUDY**

SESI PENGAJIAN: **2015/16 Semester 1**

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....

MUHAMMAD ZAIDAN BIN ABDUL MANAF

(Project Supervisor:)

MUHAMMAD ZAIDAN BIN ABDUL MANAF
Pensyarah
Jabatan Teknologi Kejuruteraan Mekanikal
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ABSTRACT

This report emphasizes three main things which is the basis for the whole project consists of introduction passive, semi active and active suspension system. Main scope of this project is to study the parameter for low cost shock absorber test rig machine though existed model consists of high end system by adapting expensive part to generate a shock absorber testing model. Shock absorber test rig for this project emphasizes design phase integrated for this project by determining the specific components and specifications to be adapted to model the design using CATIA V521 software. Afterwards, declaration of components identified to be implemented into the real model test rig. The test rigs then undergo analysis by the Generative Structural Analysis by static case to be observed the capability of the machine to accommodate the force applied on specific part. The result shows deflection of middle plate region including lower mounting for 1400 N in rebound force applied. It can be seen form the result whether material used or the force applied under circumstances need to be considered for a better result in designing phase before inspected to be fabricated or used for future study.

ABSTRAK

Laporan menekankan tiga perkara utama yang merupakan asas bagi keseluruhan projek yang terdiri daripada pengenalan pasif, semi sistem gantungan aktif dan aktif. Skop utama projek ini adalah untuk mengkaji parameter untuk kejutan kos rendah ujian absorber mesin pelantar walaupun model yang sedia ada terdiri daripada sistem mewah dengan menyesuaikan bahagian yang mahal untuk menjana ujian model penyerap kejutan. Penyerap kejutan ujian pelantar untuk projek ini menekankan fasa reka bentuk bersepadu untuk projek ini dengan menentukan komponen dan spesifikasi khusus untuk disesuaikan dengan model reka bentuk menggunakan perisian CATIA V521. Selepas itu, pengisytiharan komponen yang dikenal pasti untuk dilaksanakan ke dalam ujian model sebenar pelantar. Pelantar ujian kemudian menjalani analisis oleh Analisis Struktur Generative oleh kes statik yang perlu dipatuhi keupayaan mesin untuk menampung daya yang dikenakan pada bahagian tertentu. Hasil kajian menunjukkan pesongan rantau plat pertengahan termasuk pemasangan yang lebih rendah untuk 1400 N berkuat kuasa pemulihan digunakan. Ia boleh dilihat membentuk keputusan sama ada bahan yang digunakan atau daya yang dikenakan di bawah keadaan yang perlu dipertimbangkan untuk keputusan yang lebih baik dalam bentuk fasa sebelum diperiksa akan direka atau digunakan untuk kajian masa depan.

DEDICATIONS

To my beloved parents, Aziz Bin Hassan and Faridah bt Junoh,

My supportive family members,

And friends those give me motivation and encourage me in finishing the task,

Thanks you so much.

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For all person that contributed for my Final Year Project, especially to Mr. Muhammad Zaidan bin Abdul Manaf who is my final year project supervisor. Your time spent for me is the unforgettable moments that will be lighten up my inspirational to keep on going and continue until the end of the project

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF SYMBOLS AND ABBREVIATIONS

SBM	=	Shape-Based Matching
TDC		Top Dead Center
BDC		Bottom Dead Center
CAD		Computer Aided Software
RPM		Revolution Per Minute
HP		Horsepower
Ips		Inch Per Second
Lbs		pound

CHAPTER 1
INTRODUCTION

1.0 Introduction

Suspension consists of the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. In other meaning, suspension system is a mechanism that physically separates the car body from the car wheel. The main function of vehicle suspension system is to minimize the vertical acceleration transmitted to the passenger which directly provides road comfort.

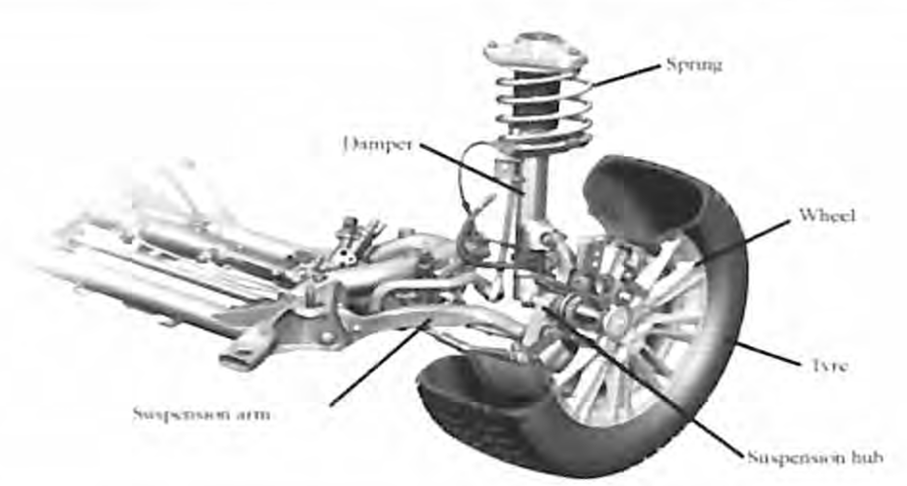

Figure 1-1: Automotive suspension system major components

The vehicle suspension system is used to improve the ride comfort and road handling by controlling the relative position and motion between the vehicle body and the wheel mass.

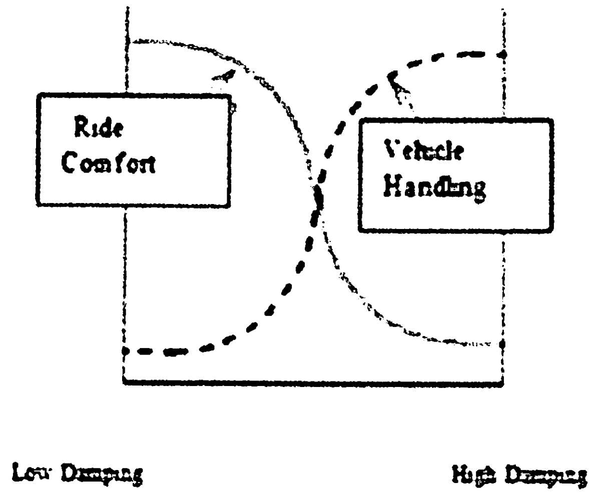

Figure 1-2: Conflict in ride and handling

Generally, vehicle suspension systems can be classified into three categories, passive, semi-active and active suspension systems for vehicles. Passive suspension system, it can only temporarily dissipate perturbation by spring and damping, without energy supplied by the suspension system. Therefore, a fixed suspension setting has to cope with a wide variety of road conditions.

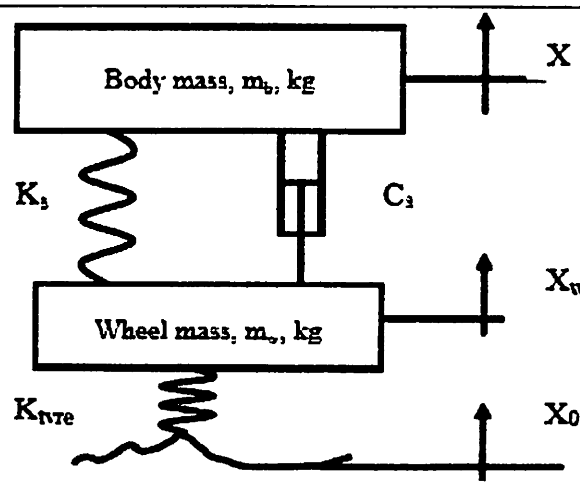

Figure 1-3: Passive suspension system based on quarter car model

A test rig is used to study the behaviour of vehicle due to the variation of the road profile which is commonly known as the ride vehicle analysis. The performance criteria in designing suspension system are body acceleration, suspension travel and spring acceleration. Performance of the suspension system is characterized by the ability of the suspension system in reducing those three performances of criteria effectively. The test rig should be developed in such a way that closely resembles the real vehicle and have ability to mount several different designs of actual suspensions, able to perform a wide range of tests which include variation on body loads, frequency of road disturbance, and have an ability to expend for future developments.

1.1 Problem Statement

In this new modern technology, most of the car manufacturing industries have their own types and calibration of test rig to determine suspension parameter such as damper coefficient and spring stiffness to suit their own specification. Most of the commercial test rigs are complex and quite expensive. By simplifying the test rig, there would be slightly changes from the actual data and the result based on component used. Eventually at the last procedure, the experiment data achieved needed to be repeated to obtain real performance and get average data because of some experimental error in design or noise that disturb the measurement parameter. Basically, a new test rig needs to run repeatedly to overcome shortcoming of the existing test rig.

1.2 Objectives

There are three main objectives includes in overall project:

1) To design shock absorber testing machine model for parameter study
2) To analyse the performance of the testing machine.
3) To validate the limitation of testing machine

1.3 Scope of Research

The project scope of the development of shock absorber parameter measurement machine for suspension systems are consists of selected equipment and process by following the procedure to manage modelling of the test rig.

The scope of this research is limited to the following items so that the research could be focused to achieve the stated objectives.

1.4 Thesis Arrangement

This project is organized in 5 chapters by regarding the steps involved to design and develop the shock absorber testing machine model. The development process is divided into each category by the chapter.

The first chapter introduces the ride vehicle analysis and behaviour of the passive suspension system by its components. Progresses continued to the objective by assuming deficiency of the system and were stated in the problem statement.

Chapter two briefs the literature about suspension test rig, passive suspension system by diagram and examples of test rigs model that was used in determining the shock absorber parameters by showing various results by plotted graph, tabulated data, and calculation

Chapter three proposed a method of design of the system by focusing on the steps integrated by the flow chart using CATIA software to design the test rig by its parameter and analysis of the test rig such as Von Mises Stress.

After that, the test rig machine then analysed and observed by running the test rig design to observe the performance of the machine followed by the specification of the actual data from the calculation performed in chapter 3. The progress continued until the validation achieved by the characteristic of the test rig in chapter four.

A compressive summary of the project efforts and the conclusions derived from the results are presented in chapter five. Constraints and future research that can be improved by the test rig and suspension system are also included in the final stages of the project,

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This review provides an overview of the published work critical to the understanding of this research in the context of mechanical engineering research today. To begin, a review of mechanical system identification is presented. System identification is the process of estimating input–output dynamic systems models, and their parameters using measured data (Segla & Reich, 2007). The subject of system identification is extremely broad and much research has been published in the literature on this topic. Therefore, the topic has been broken down. Linear system identification procedures are first examined followed by a review of popular nonlinear system identification techniques. Examples from the literature on the application of linear and nonlinear system identification methods to both experimental and simulated data are also presented (Alexandru & Alexandru, 2011).

Focus then turns to the identification of vehicle suspension systems. The existing literature is viewed from two angles, force–response identification and response only identification, or operational identification. A critical review of research focusing on the characterization, mathematical modelling, parameter estimation and simulation of suspension systems is documented. Experimental testing setups used by other authors in the characterization and identification of vehicle suspension systems are examined along with simulation approaches. Finally the conclusions of this literature review are summarized and the objectives of this investigation outlined.

2.1 History of Suspension System

By the early 19th century, 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 made of low carbon steel and usually took the form of multiple layer leaf springs. The British steel springs were not well suited for use on America's rough roads of the time, and could even cause coaches to collapse if cornered too fast. In the 1820s, the Abbot Downing Company of Concord, New Hampshire developed a system whereby the bodies of stagecoaches were supported on leather straps called "thorough braces", which gave a swinging motion instead of the jolting up and down of a spring suspension. Automobiles were initially developed as self-propelled versions of horse drawn vehicles(Vangelou, 2003). However, horse drawn vehicles had been designed for relatively slow speeds and their suspension was not well suited to the higher speeds permitted by the internal combustion engine. In 1901 Mors of Germany first fitted an automobile with shock absorbers. With the advantage of having a dampened suspension system in his 'Mors Machine', Henri Fournier was able to win the prestigious Paris-Berlin race on June 20th 1901. Fourniers superior time was 11 hours 46 min 10 sec, while the best competitor was Léonce Girardot in a Panhard at the time 12 hours 15 min 40 sec. In 1920, Leyland used torsion bars in a suspension system. In 1922, independent front suspension was pioneered on the Lancia Lambda and became more common in mass market cars from 1932.

2.2 Suspension System

The suspension system can be categorized into passive, semi-active and active suspension system according to external power developed input to other surrounded system. A passive suspension system can be defined as a suspension that worked without any other assist measure or not being controlled by other mechanism into the system. The semi-active suspension has the same elements but the damper has two or more selectable damping rate. An active suspension is one in which the passive components are augmented by actuators that supply additional force. (Florin & Liliana, 2013)

Beside these three types of suspension system, a skyhook type damper has been considered in the early design of the active suspension system. In the skyhook damper suspension system, an imaginary damper is placed between the sprung mass movements can be reduced without improving the tire deflection(Segla & Reich, 2007). However, this design concept is not feasible to be realized.

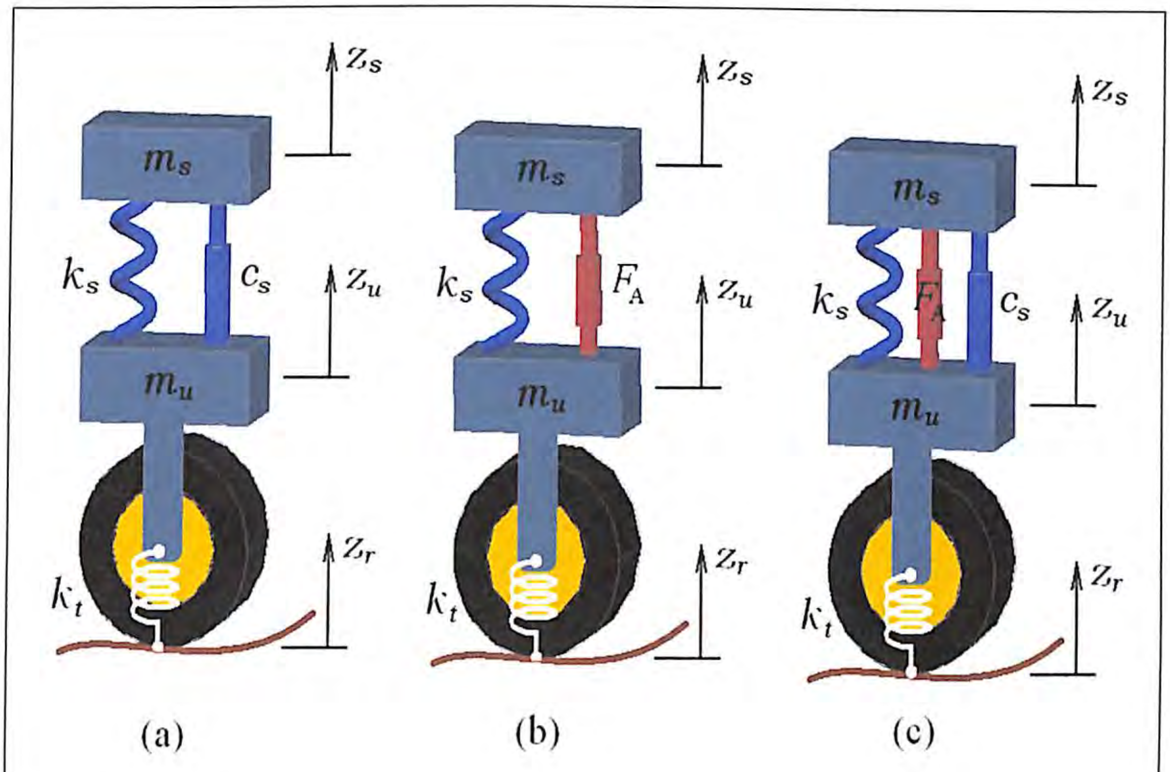

Figure 2-1: Quarter-car suspension systems: (a) Passive Suspension System, (b) Active Electromagnetic Suspension System and (c) Active Hydraulic Suspension System.

2.3 Test Rig Machine

There are some of the example of the past technology test rig machine by the various types and parameter listed. The method used by the test rig is differ for each experiment by the procedure setup and calculation until the results obtain. The data achieved will be display by the graph, tabulated data or calculation.

2.3.1 Shock Absorber Test Rig

The design of shock absorber test rig has been developed for vibration measurement system. This product actually developed to test and indicates the condition of shock absorber in automotive vehicle. As it functioning, this product can be used as a tool to verify the capability of shock absorber.

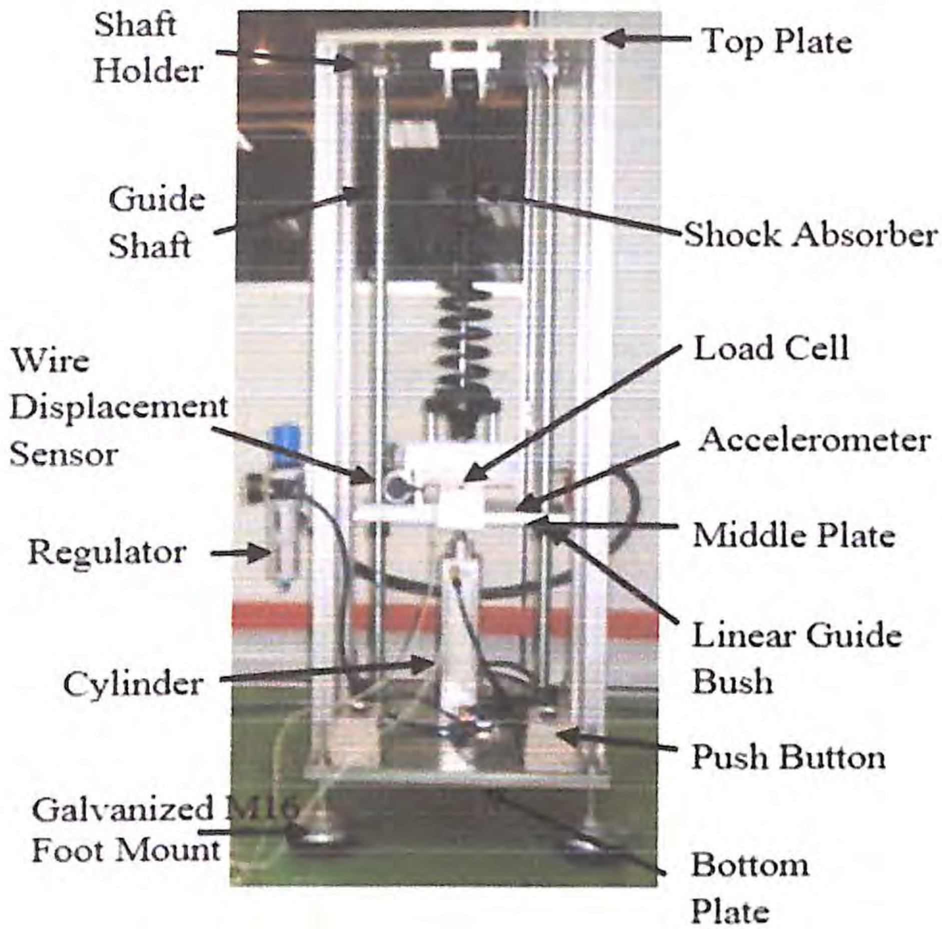

Figure 2-2: Design of shock absorber test rig

Figure 2-2 shows the complete component arrangement of the design of shock absorber test rig. This shock absorber test rig is a rigid structure with two main components connected vertical. The upper vertical is the shock absorber while the lower connection to the base structure is the pneumatic cylinder. The upper and lower component is divided by the middle plate. This middle plate is supported with two units of guide shaft for smooth movement. The shaft holder is placed at each end of the guide shaft for protecting and secures the guide shaft joints. The complete shock absorber test rig is system consist of a few important parts which are: shock absorber, guide shaft, linear guide bushes, air cylinder, air regulator and air pilot valve.