UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND OPTIMIZATION OF AUTOMOTIVE SUSPENSION TEST RIG

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

By

MUHAMMAD FAIZ BIN AHMAD FISAL
B071310270
910613-02-5431

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I hereby, declared this report entitled “Design and optimization of automotive suspension test rig” 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 Degree of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRAK

Bagi sebuah kenderaan, sistem gantungan dianggap sebagai salah satu komponen kritikal, kerana sistem ini memberi kestabilan ketika memandu dan mengendalikan sesebuah kenderaan, selain daripada memberi penahan atau sokongan kepada kenderaan. Sebuah mesin ujian untuk sistem gantungan automotif adalah seuah mesin yang sangat penting kerana ia dapat mengukur ketahanan dan ciri-ciri sistem gantungan automotif. Ciri-ciri bagi sesebuah penyerap hentak amat berguna ketika hendak mereka bentuk dan membina sebuah kenderaan kerana ia dapat membantu untuk membekalkan keselesaan kepada penumpang ketika menaiki kenderaan, dan juga untuk menentukan ketahanan penyerap hentak tersebut setelah digunakan dan juga untuk mengelakkan sistem gantungan daripada rosak.

Mesin ujian sistem gantungan automotif terdapat dalam berbagai bentuk. Tumpuan projek ini adalah untuk mereka bentuk sebuah mesin ujian yang sesuai dan mempunyai struktur yang baik. Mesin ujian yang telah direka bentuk akan diuji dengan daya yang tinggi, iaitu sebanyak 5000N dan diberikan kepada pemegang penyerap hentak mesin tersebut. Tujuan dan matlamat projek ini adalah untuk mereka bentuk mesin uijan untuk sistem gantungan kenderaan yang mana ia mempunyai keupayaan untuk menahan daya yang dikenakan kepadanya. Seterusnya, proses optimisasi dibuat terhadap bahagian-bahagian mesin ujian tersebut untuk mengetahui sama ada reka bentuk yang lain adalah lebih sesuai untuk digunakan pada mesin ujian itu.

ABSTRACT

In a vehicle, suspension is considered as one of the most crucial component because this system provide stability when handling or maneuvering, and also providing support to the vehicle. An automotive suspension test rig is an important machine as it measures the toughness and characteristic of the automotive suspension. The characteristic of the shock absorber is very useful when designing and building a vehicle because it helps in providing the comfort for the passenger while riding the vehicle, determining how long the shock absorber can be used after some period of usage, and to prevent the suspension system from damage.

There are many types of design existed for the suspension test rig, but the design is complicated and complex. This project focuses on designing a suitable test rig with a proper structure. The designed test rig will be provided with a high force, which is 5000N and is projected to the damper mount. The aim of the project is to design a suspension test rig machine where it able to withstand the force given to it by conducting analysis towards the critical parts. Then, and optimization towards the its parts is done, to know whether other type of design is suitable to be used.

DEDICATIONS

A lot of thanks to my beloved family for their continous supports and encourages me in my life. Thank you for my supervisor, Ir Mohamad Hafiz Bin who has help me a lot by sharing, giving his opinions and knowledge towards me to finish this project. Not to forget my fellow friends, staffs and lecturers of Mechanical Engineering Technology Department from Engineering Technology Faculty who also help and guided me to finish this project. All of your involvement and contributions will always be remembered.

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LIST OF SYMBOL AND ABBREVIATIONS

2D	=	2 Dimensions
3D	=	3 Dimensions
AC	=	Alternating Current
AISI	=	American Iron and Steel Institute
AL	=	Aluminum
CAD	=	Computer Aided Design
CAD/CAM	=	Computer Aided Design / Computer Aided Machining
CAE	=	Computer Aided Engineering
CATIA	=	Computer Aided Three-dimensional Interactive Application
DCS	=	Distributed Controls System
F_d	=	Force disturbance
FEA	=	Finite Element Analysis
FEM	=	Finite Element Method
GSA	=	Generative Structural Analysis
Hz	=	Hertz
ICS	=	Industrial Control System
km/h	=	Kilometer per hour
kVA	=	Kilo Volt Amp
KW	=	Kilo Watt
LAN	=	Local Area Network
Lb	=	Pound
LVDT	=	Linear Variable Differential Transformer
MIMO	=	Multi-input/Multi-output
mm	=	millimeters
MR Damper	=	Magnetorheological Damper
N	=	Newton
Pa	=	Pascal
SDOF	=	Single Degree of Freedom
UDL	=	Uniformly Distributed Load

V	=	Volt
VH	=	Vibration and Harshness
ω	=	Omega
%	=	Percent

CHAPTER 1
INTRODUCTION

1.1 Background

There are various kind of test rig machine for part testing in car industry. At the point when creating new vehicle, a few test must be directed so as to accomplish a comfort and toughness for the vehicle. In a vehicle, suspension is additionally considered as a crucial and significant part since this part give stability when handling of car or moving, furthermore giving support to the vehicle. To test the suspension toughness, an in-door testing for the street vehicle suspension system is conducted, which is using the car suspension test rig. A quarter vehicle suspension test rig used to test the magnetorheological shock absorber which is assembled to the test rig.

The magnetorheological shock absorber then is put with load to be analyzed and recognize the feature for the shock absorber while applying the stress. The typical for the shock absorber is extremely important when making and creating a vehicle since it will help in giving the comfort for the passenger while riding the vehicle, choosing to what degree the shock absorber can be used after some season of utilization, and to keep away the suspension system from problems while functioning at the variety kind of road or scene passed by the vehicle. An auto suspension test rig machine structure furthermore have to be strong because there are an impressive measure of force applied when performing the test to the magnetorheological shock absorber.

In case the structure of the test rig assembly is not suitable, it lead the test rig machine to failure when executing the test or some part of the test rig machine will have some displacement or bending after a number of test had been executed. Therefore, the load that

will be given when conducting test should also be considerate, whether a center point load or an evenly distributed load. Finally, the vehicle suspension test rig machine should have the ability to lead test for variable extent of size of the absorber. This is to ensure that other size of the shock absorber feature be examined as a way to develop and produce a better shock absorber for the road vehicle usage.

1.2 Objectives

The objectives of this study are as stated below:

i. To design a suspension test rig machine.
ii. To conduct an analysis for the designed suspension test rig machine.
iii. To optimize the part of suspension test rig machine.

1.3 Project Work Scope

The scope of this project are:

- Designing a suitable suspension test rig machine.
- The designed suspension test rig is conducted with analysis towards the structure of the test rig machine, and its critical parts.
- Comparison of analysis result between two models. (Base model and models with optimized parts.)

1.4 Problem Statement

Suspension test rig machine used to identify the automotive suspension characteristic. This machine is important for research, teaching and learning purpose. However, the critical part of the suspension test rig which is the damper mount bended after long term usage. Hence, a proper test rig should be designed. The design then is optimized to know whether some part of the test rig can be reduce it size or material. After the design is finalized, it should be conducted with analysis to know the test rig durability.

1.5 Project Management

The management of the project is the most important part of the structure of the project. Project management can be represented in Gantt Chart form. The whole flows of the project are exhibited in Figure 1.1 and 1.2 respectively.

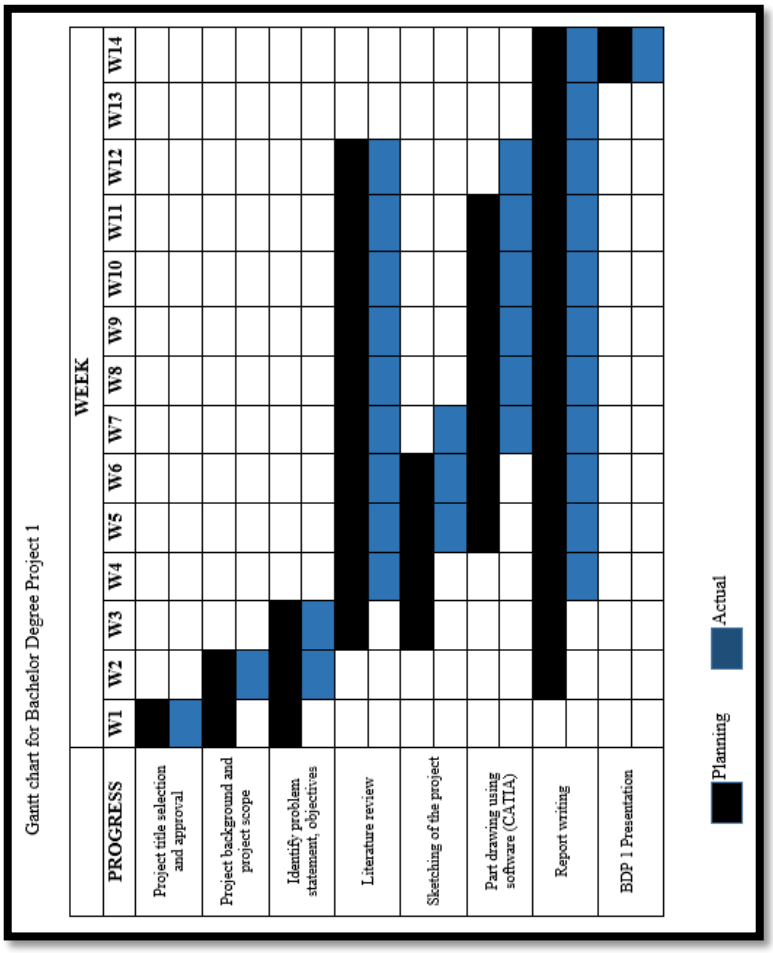

Figure 1.1: Gantt Chart for Bachelor Degree Project 1

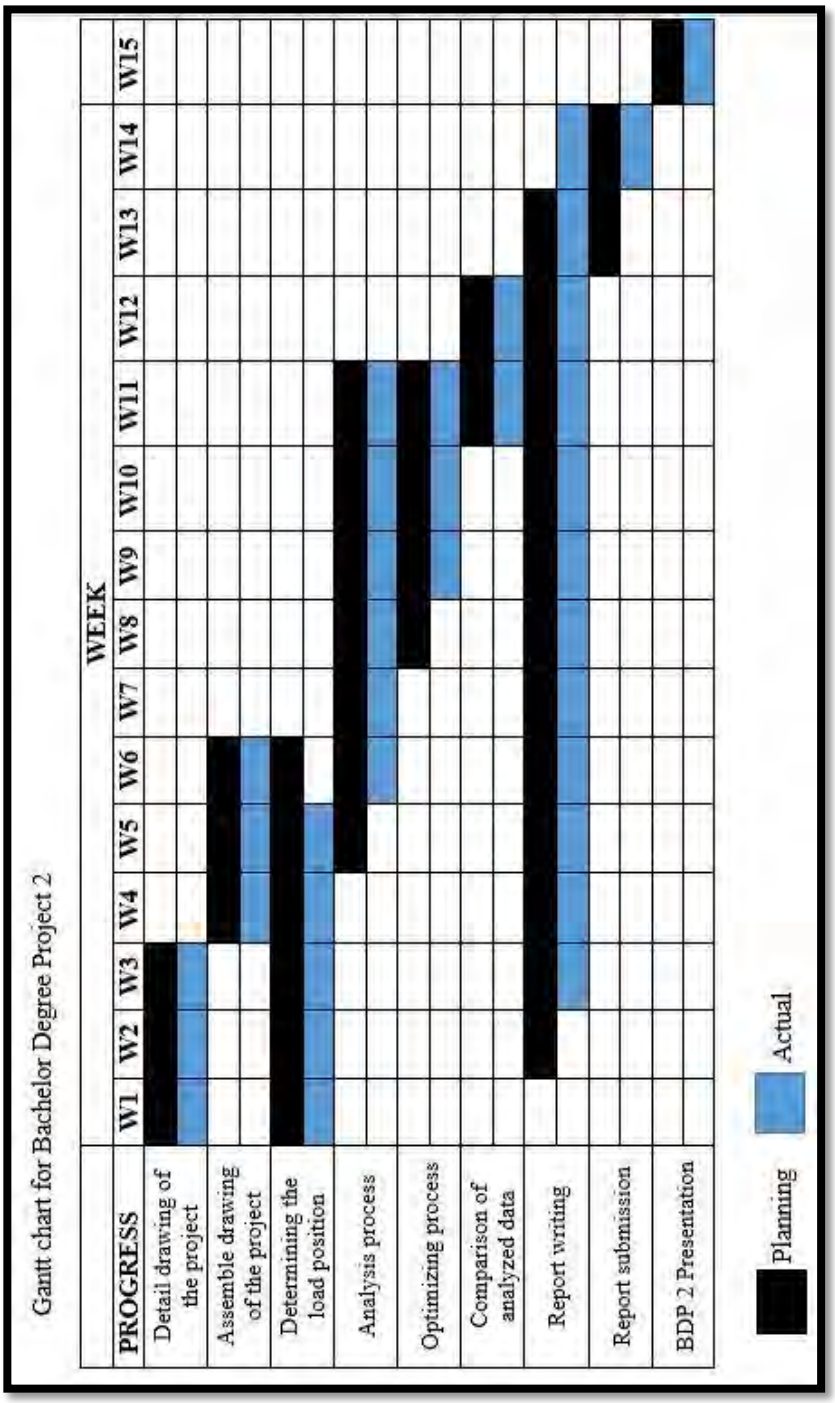

Figure 1.2 : Gantt Chart for Bachelor Degree Project 2

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

A literature review is the study that in view of a current data, information or contemplated of the analyst in a picked zone of study. This section reviews the composed work foundation identified with the organized data in this report.

2.1 Automotive Testing Rig

The test rig machine are utilized to check the execution of automotive extra parts. All the measuring instruments of the car test apparatuses are top notch advanced sort. These Test Rigs are outfitted with to a great degree convoluted of data estimation information system. They are known for their precise and substantial obligation execution for moment durability test, endurance test and environment testing. They are exceptionally tough and work friendly in nature.

2.2 Test Rig Machine Design Type

In order to acquire the suitable desired design of the suspension test rig, the current accessible test rig is reassess about its design, shape and how its functions and operate.

2.2.1 RuotaVia Test Rig

The RuotaVia analyze facility center is located at the Laboratory for the Safety of Transport of the Politecnico di Milano. Cornering, braking and moving over through obstruction test can be conducted on both full vehicle and vehicle sub-systems (e.g. tires, corners). Both consistent and transient state estimations can be performed. The RuotaVia test rig is essentially a steel drum (2.6m of diameter) that supply a running surface area to the wheel. The external ring, made in one single bit of forged steel, is attached with the central hub by means of two side disks. As a way to raise the lateral stiffness of the drum, sixteen spokes are welded to the central hub and to the two side disks..(Gobbi, Guarneri, Mastinu, Rocca, & Milano, 2008)

The spokes are not welded to the outside ring in order to sustain an ideal distance from a lobe pattern distortion for the operating work surface mainly because of the centrifugal force constrain on high speed rapid testing. The driveline is formed by a non-parallel four posts electric motor with 16000 Volt amps (160 kVA), and by a two proportion gearbox. The rotational speed of the drum is measured by method for a 4096 concentrates load.(Gobbi et al., 2008)

The most optimum speed is around 440 km/h. A solid structure (140 tons) underpins the RuotaVia drum and the driveline. The entire structure has been constructed as a way to obtain a first regular rate of occurrence or frequency that is higher than 100 Hz. The frame structure substitutes the vehicle body when conducting the suspension testing. The structure of the frame is furnished with a sled which makes it possible for the suspension system to be positioned vertically.(Gobbi et al., 2008)

The sled conveys a steel plate which is intended to assist various suspensions designs (e.g. double wish-bone, McPherson). By doing these it is conceivable to position effectively the suspension system and to give the right static load (checked

by means of high exactness load cell). The goal is the VH portrayal of the suspension system and therefore the sled is secured or locked (the low recurrence methods of the vehicle body can be disregarded). It is vital that the entire framework has no regular frequencies in the recurrence scope of enthusiasm for request to keep away from parasitic vibrations.(Gobbi et al., 2008)

Figure 2.1: The RuotaVia test rig

2.2.2 Quarter Car Test Rig

The quarter auto structure (Figure 2.2) is a test-rig that been developed to duplicate the vertical dynamics of a single corner of a vehicle. It comprise of a wheel, a sliding cantilever which represent the one fourth of an vehicle body mass, and amongst these two, there is a spring and a dynamic damper with bushing. The wheel is energized at the base by a hydraulic actuator, in that way to replicate a vertical street displacement. A guide way forces a vertical movement on the beam and the wheel. (Lauwerys, Swevers, & Sas, 2005)