



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DEVELOPMENT OF MAGNETORHEOLOGICAL DAMPER  
TEST RIG MACHINE FOR AUTOMOTIVE SUSPENSION**

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

By

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## DECLARATION

I hereby, declared this report entitled “Development of Magnetorheological Damper Test Rig Machine for Automotive Suspension” 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**

Magnetorheological perendam adalah salah satu mekanisme teknologi baru penggantungan dalam industri automotif. Sistem gantungan terdiri daripada pegas dan perendam. Mesin ujian pelantar untuk 1DOF telah dihasilkan untuk mengenal pasti ciri MR perendam. Reka bentuk dan proses fabrikasi dirujuk dari analisis dan pengoptimuman data. Projek ini memberi tumpuan kepada reka bentuk dan fabrikasi magnetorheological ujian perendam mesin rig untuk kegunaan industri automotif. Proses reka bentuk megambil kira fungsi dikehendaki seperti ketahanan, kekuatan, bahan, rupa dan ergonomik. Proses pembangunan mesin rig MR ujian perendam, teknik asas dalam bidang kejuruteraan telah digunakan seperti menyertai, memotong, dan pendawaian asas. Oleh itu, pada akhir projek ini mesin magnetorheological ujian pelantar sedia untuk digunakan untuk pembelajaran dan projek penyelidikan.

## **ABSTRACT**

Magnetorheological Damper is one of new technology mechanisms of suspension in automotive industry. Suspension system consist of the spring and damper. The test rig machine for single degree of freedom was produced to identify the MR damper characteristic. The design and fabrication process are referred from analysis and optimization data. This project focusing on design and fabrication of magnetorheological damper test rig machine for automotive industry usage. The design process was considered function as per desired such as durability, strength, material, appearance and ergonomic. In MR damper test rig machine development proses, the basic technic in engineering were used such as joining, cutting, and basic wiring. Therefore, at the end of this project magnetorheological damper test rig machine is ready to use for learning and research project.

## **DEDICATION**

To my parents especially and friends, also for whom with their effort to support me in order for me to pursue study in higher education, and also in order to complete this project and project report to fulfil the requirement for Bachelor Degree in Mechanical Engineering Technology (Automotive Technology) award.

To my supervisor too, Mr. Ir. Mohamad Hafiz bin Harun and all the Mechanical Department Staff with their helpful suggestions, guidance and assistance in order for me complete this Bachelor Degree Project course.

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## LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

%	=	Percentage
$\dot{Z}_{in}$	=	Input Velocity
$\dot{Z}_s$	=	Output Sprung Velocity
$\ddot{Z}_s$	=	Output Sprung Acceleration
$\dot{Z}_u$	=	Output Unsprung Velocity
$\ddot{Z}_u$	=	Output Unsprung Acceleration
°C	=	Degree Celsius
°F	=	Degree Fahrenheit
2D	=	2 Dimension
3D	=	3 Dimension
AC	=	Alternate Current
AISI	=	American Iron and Steel Institute
Al	=	Aluminium
A	=	Ampere
Ar	=	Argon
BIM	=	Contemporary Building Data Demonstrating
C	=	Carbon
CAD	=	Computer Aided Design
CATIA	=	Computer Aided Three-dimensional Interactive Application
cm	=	Centimetre
$C_s$	=	Damper Coefficient
DC	=	Direct Current
DCS2000	=	Digital Integrated System Manager
FBD	=	Free Body Diagram
$F_d$	=	Disturbance Force
Fe	=	Ferum



FTK	=	Fakulti Teknologi Kejuruteraan
g	=	Gram
GMAW	=	Gas Metal Arc Welding
GTAW	=	Gas Tungsten Arc Welding
h	=	Hour
He	=	Helium
Hz	=	Hertz
ICEM	=	Integrated Computer Engineering and Manufacturing Computing
ICS control	=	Industrial Control System
IGES	=	Initial Graphics Exchange of Product Data
in	=	Inch
kg	=	Kilogram
km	=	Kilometre
KW	=	Kilo Watt
lb	=	pound
LVDT	=	Linear Variable Differential Transformer
m	=	Meter
MIG	=	Metal Inert Gas
MIMO	=	Modern Multi-Input / Multi-Yield
mm	=	millimetre
MR	=	Magnetorheological
M <sub>s</sub>	=	Mass Sprung
M <sub>u</sub>	=	Mass Unsprang
N	=	Nitrogen
Pa	=	Pascal
SDOF	=	Single Degree of Freedom
Si	=	Silicon
SMAW	=	Shielded Metal Arc Welding
STEP	=	Standard for the Exchange of Product
TIG	=	Tungsten Inert Gas
UTeM	=	Universiti Teknikal Malaysia Melaka
V	=	Volt

VH	=	Vibration and Harshness
$Z_{in}$	=	Input Displacement
$Z_s$	=	Sprang Displacement
$Z_u$	=	Unsprang Displacement
$\omega$	=	Omega

# CHAPTER 1

## INTRODUCTION

### 1.0 Background

A growing technology in automotive industry nowadays has expanded and lot requirement from customer in order to fulfil life style, safety and human comfort. Today, manufacturer in automotive industry have done lot of research to provide best system in vehicle. Technology in absorber or vibration reduction today expand by study, researcher and testing. The testing machine that be used for test study must strong in structure to produce accurate result.

A vehicle have the many systems to maintain for ensure every part the vehicle function very well. The vehicle suspension is one of the important system that provide good ride comfort, vehicle handling and stability characteristic. (Balamurugan, Jancirani, & Eltantawie, 2014). As common know suspension system consist of the spring and damper. This project being focus to design and fabricate magnetorheological damper test rig machine for automotive industry usage.

A magnetorheological damper or generally known as magnetorheological shock absorber use the magnetorheological fluid to produce controllable dampers. Magnetorheological (MR) fluids are controllable fluids belonging to the elegance of lively substances which have the specific potential to change dynamic yield strain while acted upon through an electric powered or magnetic subject, at the same time as preserving viscosity incredibly regular. (Ashfak, Saheed, Rasheed, & Jaleel, 2009).

In complete the development proses, the basic technic in engineering were use such as joining, cutting, and basic wiring. Therefore, at the end of this project magnetorheological damper test rig machine is ready to use for learning and research project.

## 1.2 Problem Statement

The magnetorheological (MR) damper test rig machine are used to test the damping force of magnetorheological damper and important to study the performance and durability. The development of magnetorheological damper test rig machine is for prove the result from the simulation software.

Besides that, the fabrication of this machine will show the side factor that may occur during running the test. As example, the movement of magnetorheological repeatedly will cause fiction then form the heat. The coeffician of magnetorheological will reduce from that effect.

Other factor this machine develop for usage of the faculty because this machine doesn't exist for learning purpose for FTK. Today, FTK student only use the simulation in studying the damping of the suspension and does't know practically how the suspension test in industry.

So, to solve this problem the FTK should have this machine because it will help the lecturer in teaching and show the real test to student, and student will learn on how the damping occur. The solution for them to solve this problem is produce this machine to FTK with fabricate the machine base on design given.

### **1.3 Project's Objective**

The main objectives are as following:

- i. To design magnetorheological damper test rig machine.
- ii. To fabricate the magnetorheological damper test rig machine.
- iii. To assemble the magnetorheological damper test rig machine with experimental components.

### **1.4 Project's Scope**

This project development the magnetorheological damper test rig machine that apply in automotive industry. The design process start by using CATIA software and for fabrication process using basic engineering technique such as cutting, welding, and grinding. This machine will complete with install component and ready to test.

### **1.5 Project Planning**

To achieve the date line, the proper time schedule management must be prepared to make the working flow smoothly. The Gantt chart attach in appendix consist of Bachelor Degree Project 1 and 2.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.0 Introduction**

This chapter present a general literature review of current machine use in test rig and technical concept that will apply in development process.

#### **2.1 Magnetorheological Damper.**

Today's suspension frameworks are not suitable and may not function well in diminishing vibratory loads on a wide range of terrains, subjecting consumer to vehicle vibration-cause fatigue when missions. Moreover, target pointing exactness is weakened because of over the top vehicle vibration on rough road. Conventional magnetorheological dampers quit working if a vehicle loses control, returning to a regular uninvolved hydraulic shock absorber. This could prompt to bottoming out of suspension parts and likely loss of vehicle control. With the safeguard ability, vehicles won't lose suspension even in the event of force disappointments, because of the utilization of perpetual magnets.

<<http://www.dpaonthenet.net/article/55038/Suspension-development-could-reduce-military-vehicle-vibration-induced-fatigue.aspx>>

The magnetorheological (MR) dampers are loaded with a unique measure of (MR) liquid. Once electrical current goes through the electric loop within the MR damper, the thickness of MR liquid and therefore the damping coefficient changes. In the initial segment of this section, MR liquids and their specific properties will be presented. A short time later, the MR damper structure and its application in vibration control systems will be talked about. (Geldhof, 2013)

## **2.2 Test Rig Machine.**

Test Rigs are utilized finally to check the execution of auto extra parts. Test Rigs are all around outfitted with to a great degree convoluted estimation data acquisition systems. This machine exact and heavy-duty performance for moment durability test, endurance test and environment testing. This machine exceptionally solid durable and operation inviting in nature. < <http://www.ajitenterprises.com/test-rigs.htm>>

Testing on a quarter-vehicle rig gives a cost effective intends to make precise and repeatable measurement that allow the user to implement a generally huge number of tests in a short measure of time. A survey of momentum quarter-vehicle test stages, both industrially accessible and in scholastic research labs, showed that many sought practical necessities were not accessible. (Langdon & Southward, 2007)

The need functional necessities are: convenience of an extensive variety of actual vehicle suspension parts including the tire and wheel, weight exchange because of braking and speeding up, aerodynamic strengths, and vehicle roll. The plan and execution of this new quarter-vehicle test apparatus is appeared to be an effective price for meeting the wide scope of functional needed. (Langdon & Southward, 2007)

### **2.2.1 Complex Shaker.**

These apparatuses are huge, modern multi-input/multi-yield (MIMO) frameworks and require a vast level of control learning and comprehension for appropriate utilize. Regularly because of the intricate way of these multivariable issues, disconnected emphasis is essential. Indoor testing sessions on two or four wheels vehicles can be carried on utilizing a testing rig called four-poster, illustrates in Figure 2.1. It is constituted by four servohydraulic actuators all the while controlled in position, which endorsement four vibrating plate. These can be driven by an ideal signal in the scope of frequency 0-100 Hz. (Vetturi et al., 2007).

Various types of testing are conceivable: sine test (clear in frequency); basic wave frame on every actuator; open circle test (driven by an outside pressure signal); a specific testing technique called ICS control, which permits to recreate on an auto a genuine administration environment, beginning from those information originating from the outdoor procurement sessions. The four actuators are introduced on a storm cellar made of cast-iron. This is disconnected from the beginning six pneumatic springs. The testing apparatus is finished by a power hydraulic central and a control comfort, including a PC based controller (DCS2000) and an information procurement unit. Every actuator is furnished with one displacement LVDT sensor, which is situated in the pole. The displacement control circle is made probable by these transducers. (Vetturi et al., 2007).



**Figure 2.1:** Vehicle on four poster (Vetturi et al., 2007)

### 2.2.2 Quarter Car

The characteristic machine that will focus is simple quarter car test rig machine. This is because the structure is simple which is to test magnetorheological damper in vertical condition. The simple quarter car test rig machine easy to maintainer and to handle. The working principle of Free Body Diagram (FBD) and equation show in figure 2.2 and figure 2.3.