UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMISATION OF MAGNETORHEOLOGICAL DAMPER TEST RIG FOR AUTOMOTIVE SUSPENSION

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

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours The member of the supervisory is as follow:

…….

(Project Supervisor)

ABSTRACT

Optimisation of magnetorheological damper test rig for vehicle suspension system analysis is the innovative idea to support our industry primarily in automotive field. The technology that will be employ is not high technology however the conceppt of using the lower technology to produce the neccesary result is the main importance that we had to evaluate. Writing in this report is the introduction of this project for the start. It consists of introduction, literature review to fabricate the project and some methodology for design analysis and drawing to complete the prototype and actual drawing. The analysis of the prototype involves in the design and material type to test the best design on the damper mount cross member which testing on the 3500N of force .The magnetorheological damper mount cross member design is to be tested and validated with the aids of two simulation software which are CATIA and BasicFEA simulation static analysis. By the end of this project, we achieved the result and fulfill the objective of this research project that to design and optimised a small scale magnetorheological damper test rig for easier comprehension to the magnetorheological damper characteristic.

ABSTRAK

Pengoptimuman magnetorheological ujian peredam pelantar untuk analisis sistem suspensi kenderaan adalah idea inovatif untuk menyokong industri kita terutamanya dalam bidang automotif. Teknologi yang akan bekerja dengannya bukan teknologi tinggi namun konsep menggunakan teknologi yang lebih rendah untuk menghasilkan keputusan yang diperlu adalah kepentingan utama yang kita terpaksa menilai. Menulis dalam laporan ini adalah pengenalan projek ini untuk permulaan. Ia terdiri daripada pengenalan, kajian literatur untuk mereka projek dan beberapa kaedah untuk analisis reka bentuk dan lukisan untuk melengkapkan prototaip dan lukisan yang sebenar. Analisis prototaip terlibat dalam reka bentuk dan bahan jenis untuk menguji reka bentuk yang terbaik di peredam gunung silang anggota yang menguji pada 3500N daya .The peredam magnetorheological gunung reka bentuk ahli salib adalah untuk diuji dan disahkan dengan bantuan dua simulasi perisian yang CATIA dan simulasi BasicFEA analisis statik. Pada akhir projek ini, kami telah mencapai keputusan dan memenuhi objektif projek penyelidikan ini yang untuk mereka bentuk dan dioptimumkan skala kecil peredam magnetorheological ujian pelantar untuk pemahaman lebih mudah untuk ciri peredam magnetorheological.

DEDICATIONS

To my beloved parents, I would like to thank them for the supporting character throughout my project. I also would like to thank my supervisor for his continuing support throughout the fabrication of the project. Lastly, I would like to thank all the staff involved in aiding me to finish the project

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LIST OF SYMBOLS AND ABBREVIATIONS

AISI	=	American Iron and Steel Institute
2D	=	2 Dimension
3D	=	3 Dimension
CATIA	=	Computer Aided Three-dimensional Interactive Application
DOF	=	Degree Of Freedom
NVH	=	Noise, Vibration and Harshness
ADAMS	=	Automated Dynamic Analysis of Mechanical Systems
BSR	=	Buzz, Squeak and Rattle
MIMO	=	multi-input/multi-output
SISO	=	single-input/single-output
MDV	=	mechatronics development and validation
TIG	=	Tungsten Inert Gas
MIG	=	Metal Inert Gas
G	=	Giga
Pa	=	Pascal
cm^3	=	Grams
%	=	cubic centimetres
mm	=	millimetres
℉	=	Degree Fahrenheit
℃	=	Degree Celsius
e	=	Exponential function

CAD	=	Computer Aided Design
N	=	Newton

CHAPTER 1
INTRODUCTION

1.0 Introduction

Automotive industry is a symbol of technical marvel by human kind. Being one of the fastest growing sectors in the world its dynamic growth phases are defined by nature of competition, product life circle and consumer demand. Today, the global automotive industry is concerned with consumer demands for styling, safety, and comfort. The industry is at the crossroads with global mergers and relocation of production centres' to emerging developing economies. Due to its deep forward and backward linkages with several key segments of the economy, the automobile industry is having a strong multiplier effect on the growth of a country and hence is capable of being a driver of economic growth.

1.1 Background

A magnetorheological damper or known as magnetorheological shock absorber is one of damper which filled with magnetorheological fluid. The magnetorheological fluid is controlled by magnetic field which usually produced from powering an electromagnetic. The characteristic of magnetorheological damper is critical to an automotive engineer as the design of a vehicle required all variable and constant is calculated and considered when design or building a vehicle. The usage of magnetorheological damper in vehicle suffer from the irregularities of road condition, the continuous usage of not well designed magnetorheological damper will causes strain in the component of the vehicle and the passenger. To prevent the damage to the working component of vehicle while offer riding comfort to the passenger in the vehicle. A quarter car test rig is an equipment designed to perform a

choice of test for the magnetorheological damper to study the variation of stress exerted from the magnetorheological damper. The performance requirement in magnetorheological damper design need to cater and solved before the actual magnetorheological damper is installed to it respective targeted area. Finally, the magnetorheological damper test rig system would have to be able to test a wide range of size of the magnetorheological damper. This is to ensure multiple choices of magnetorheological damper can be known and help in the future development of better magnetorheological damper.

1.2 Objective

The main objective for this research study is to optimize a new modified magnetorheological damper test rig for magnetorheological damper analysis and to rate the technology that can improve the state of the art in vehicle suspension system testing. Because this is follow up lab, an extra requirement objective is to fabricate the magnetorheological damper mount cross member to further characteristic the magnetorheological damper. More details about the design and comparison of magnetorheological damper test rig will be discussed at the next chapter.

Next, the magnetorheological damper test rig system will be improved further more to increase the fault and defect detection. The current issue of the test rig system would not be able to detect some minority fault in the magnetorheological damper and will be catastrophe to end user.

In summary, a new magnetorheological damper test rig system has been designed and optimized. The goal of characterize the magnetorheological damper and improve the fault and defect detection has been succeed.

1.3 Project Work Scope

The motivation is to design and optimize a modified full scale magnetorheological damper test rig for automotive suspension. The scope of this project focus on the structure analysis of damper mount cross member. The other part or frame of magnetorheological damper test rig are not included. The data acquisition system of test rig are not included in this project work scope. The material analysis of this project do not exceed low-carbon steel AISI 1015, other type of metal materials are not included.

1.4 Problem Statement

With the current quarter car test rig available to the public. Many of these rigs do not have the functionality required for the current and future research project, whereas the commercially available rigs are too expensive even though it does have the functionality we needed. Therefore we have to optimize the damper mount of the system on the magnetorheological dampers to measure the intended data require to study the effect of magnetorheological damper. The characteristic of magnetorheological damper need to improve in term of the magnetorheological damper test rig strength to withstand the high stress strain testing experimentation without failure such as invalid data reading due to bending effect of damper mount cross member.

1.5 Approach

To achieve the targeted goals, the following approach is taken. Current quarter-car test rig and the state parameter of quarter car testing in common are first rated. The approach is to develop a magnetorheological damper test rig that addresses most of the imperfection found with the current design while trying to reducing the cost. After the parameter of magnetorheological damper test rig is determined, the

following step is to construct a new design concept for newly modified test rig by using 3D software that known as CATIA. Having drawn the conceptual design, the next step is analyse the structure integrity of damper mount cross member by meshing. And then, the structure undergoes force actuation on surface to simulate the force produced by motor which test the characteristic of magnetorheological damper test rig. Finally, the proper design is proposed to optimize the current magnetorheological damper test rig.

1.6 Outline

Chapter 2 was presented with the information of the literature review that consists of 2DOF quarter car test rig and some of comparison previous design quarter car test rig with the newly input design. This provide a literature search that was conducted to study the past research study being done and any of related field to this project. Chapter 3 discusses in details of the methodology that being conducted to successfully complete this research project. This chapter also give an insight of the research work flow of the design and analysis magnetorheological damper test rig damper mount cross member. Chapter 4 present the result procured by BasicFEA and CATIA static analysis on damper mount cross member, further discussion of the result also being discussed at here. Chapter 5 is the conclusion chapter which finalized and draw a conclusion to the project and discuss of further recommendation toward future research project.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

In this chapter, some history of the current state-of-the-art in vehicle testing rigs and the systems they employ will be reviewed. The chapter started with a survey of the current test rig technology and some of the main issues or imperfection found within the technology or design. This will serve as the foundation for defining the new requirement of the magnetorheological damper test rig design presented in this research. Then, the chapter reviews continue with the revision of the current control algorithms in use on indoor vehicle shaker rigs. The divergent between theses current algorithms and the one used in this study are focus on. Finally the chapter review goes to the material design and the types of welding process for the fabrication of the magnetorheological damper test rigs to employ on this research.

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2.1 Vehicle Testing Rig

The main idea of the vehicle testing rig is to investigate the behaviour of vehicle due to the changing and variety in road condition which in terms of noise, vibration and harshness performance. In short, the vehicle testing rig is vital in performing test on the magnetorheological damper system have the characteristic of each damper would be identified. The automotive field greatly rely and focus on the NVH and durability of the magnetorheological damper, the field on magnetorheological damper is greatly pursued by engineer to find the best magnetorheological damper to be installed on the vehicle system. This is particularly

useful in the field of racing industry which are not likely to be interested in NVH, however durability and performance provided by the magnetorheological damper in handling and suspension tuning are critical to the driver and engineer to further develop the magnetorheological damper system.

The other form of vehicle testing rigs is known as shaker rig. The shaker rig employ the road profile system that improve the efficiency of 7-post software. However, this information is rarely known especially in the motorsport industry. As road profile is known precisely, this enable test engineer not learnt anything about other dynamics of the vehicle suffered such as inertial and aerodynamic loading. Therefore this kind of information is normally calculated based on maps, lookup tables, or vehicle models running in simulation software such as ADAMS. These type of software proved to be able working sync with the 7-post simulator system.

This section talk about the current state of the art in vehicle testing rigs. A collection of survey of magnetorheological damper test rig technology is presented which details the need for increased functionality of the new designed magnetorheological damper test rig

2.2 Complex Shaker

The types of the most complex test equipment available are the 4-post, 7-post and 8-post shakers and kinematic and compliance rigs. A typical 4-post rig is comprised of 4 servo actuators which is use to perform common test such as validation, durability, buzz, and squeak and rattle (BSR) and NVH. The 4-post test rig is known to be categorized as 2 types which is spindle-coupled and tire-coupled. The spindle-coupled work by having each spindle of the vehicle to be mounted directly to the actuator and the tire-coupled work by having each actuator post support the vehicle under each tire. Therefore the test rig can inject various signals into the vehicle to produce the responses to be measured by the engineer. The 7-post test rig on the other hand is near same to the 4-post but with the addition of 3 extra actuators or it can be 8-post test rig is the extra actuators is 4. The extra actuators is connected between the ground and the sprung mass of the vehicle. These extra actuators offer more features in the form of simulating vehicle responses from inputs such as braking, acceleration, cornering and aerodynamic loading.

Figure 2.1: Image of 7-post test rig with NASCAR race car

The above figure 2-1 represented a tire-coupled 7-post test rig with NASCAR race car. The advanced and complex test rigs provide a huge number of capability and features, but the extra features and capability come with a drawback of high maintenance issue and cost to own. This is not the only issues they causes, these test rigs are very sophisticated MIMO systems which need a high level of understanding and control knowledge to utilize the test rig properly. Moreover, the complex nature of theses multivariable complication requires multi-step iteration to produce a good drive file for instructing each of the actuators. Once the collective data is extracted from test run on theses system, it is very difficult to explain and correlate to the real-world counterpart. Some reasons for these issues with more complex test rigs are the lack of literature and other available documentation. To the authors knowledge only a handful of papers that discuss multi-post test to any detail exists. This issues is due to the lack of available information as the race teams and automotive companies are trying to protect the property infringement and keeping the competitive advantage from the competitors.

2.3 Current Quarter Car Test Rigs

To solve the high complexity and cost of the test rigs, simpler test rigs such as quarter car test rigs is being used. The concept of quarter car test rigs to reduce the high complexity greatly by emphasizing on one corner or quarter system of the vehicle. These system also can be considered as 1-post or 2-post systems and often viewed as a SISO. This kind of systems greatly cut down the computational time and complexity of understanding and often a close form of solution can be reached. This enable for much easier and clearer understanding of both the problem and results to the subject.

Many of the existing test rigs systems suffered some inherent deficiency and defect. Most of the suspension component of the vehicle had to be simplified or removed altogether. The literature also avoid discuss the test rig that able to incorporate multiple suspension design. However this can be the author decision to