MODELING AND FORCE TRACKING CONTROL OF BOUC-WEN MR DAMPER MODEL

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This report is submitted
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DECLARATION

I declare that this project report entitled “Modeling and Force Tracking Control of Bouc Wen MR Damper Model” is the result of my own work except as cited in the references

Signature : .....

Name of Supervisor : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature :. .....

Name of Supervisor : .....

Date : .....

DEDICATION

To my beloved mother Rosnida Binti Ramli and my father Sanusi Bin Che Abdullah

ABSTRACT

The modeling of magnetorheological (MR) dampers is essential in understanding the operation, working principles and behavior of the suspension. The models of MR dampers divided into two type which are parametric and non-parametric model. Parametric model consists of Bouc-Wen and modified Bouc-Wen model which have been study and compared to understand the performance of both models. The verification method is used for this study to compare the performances for both models using MATLAB Simulink. The structure of the force tracking control for the proposed MR damper model uses as a continuous state control to achieve the desired force. The performance of the proposed controller is evaluated by simulation using sinusoid, square and sawtooth signal to represent several classes of continuous and discontinuous functions. Analysis through experiment and non-parametric model should be developed in future works.

ABSTRAK

Pemodelan magnetorheologi (MR) adalah penting dalam memahami operasi, prinsip kerja dan tingkah laku penggantungan. Model pembawa MR terbahagi kepada dua jenis iaitu model parametrik dan bukan parametrik. Model parametrik terdiri daripada Bouc-Wen dan model Bouc-Wen diubahsuai yang telah dikaji dan dibandingkan untuk memahami prestasi kedua-dua model. Kaedah pengesahan digunakan untuk kajian ini untuk membandingkan prestasi kedua-dua model menggunakan MATLAB Simulink. Struktur kawalan pengesanan daya untuk model peredam MR yang dicadangkan digunakan sebagai kawalan keadaan berterusan untuk mencapai daya yang dikehendaki. Prestasi pengawal yang dicadangkan dinilai oleh simulasi menggunakan isyarat sinusoid, persegi dan gergaji untuk mewakili beberapa kelas yang berterusan dan tidak berterusan fungsi. Analisis melalui model percubaan dan tidak parametrik perlu dibangunkan pada masa akan datang.

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MR	:	Magnetorheological
BW	:	Bouc-Wen
MBW	:	Modified Bouc-Wen
ER	:	Electrorheological
LQG	:	Linear-Qudratic Control
NN	:	Neural Network
NNC	:	Neural Network Controller
NNI	:	Neural Network Identifier
PSM	:	Projek Sarjana Muda

LIST OF SYMBOLS

F	:	Damping force
c_0	:	Damping coefficient
c_1	:	Damping coefficient
k_0	:	Spring stiffness coefficient
k_1	:	Spring stiffness coefficient
x	:	Displacement
$\dot{x}$	:	First derivatives of x
$\ddot{x}$	:	Second derivatives of x
y	:	Secondary displacement y
$\dot{y}$	:	First derivatives of y
$\ddot{y}$	:	Second derivatives of y
z	:	Hysteretic deformation
$\dot{z}$	:	First derivatives of z
γ	:	Fluid properties
β	:	Fluid properties
α	:	Fluid properties
A	:	Fluid properties
n	:	Number of orders

v	:	Applied current
u	:	Filtered current
η	:	Frequency
Fc	:	desired damping force
Fd	:	actual damping force
G	:	feedback gain
B.	:	proportional gain

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CHAPTER 1

INTRODUCTION

1.1 Background

Semi-active damping system is one of the most important system for automotive suspension system. This damping device can minimize the response of the unwanted motion and external disturbance by adjusting the properties of the device. There semi-active devices that can generate forces from viscous fluid which is magnetorheological (MR) damper (Spencers, Dyke et al. 1997).

Atray and Roschke (2003), said that an MR damper is relatively damping device, during which the magnitude of the resisting force acting upon a mechanical structure will be adjusted in real time. There are two main categories of MR damper which is parametric and non-parametric (Metered, Bonello et al. 2010). Parametric model consists of some mechanical element such as linear viscous, friction and spring, Parameter model associated with this mechanical part are determined by examination the models with experimental results.

Next, non-parametric model establish between measured quantities and the occurring parameters does not have an instantaneous physical. Even though, the non-parametric model can represent MR damper behavior effectively, they are slightly complex and require additional experimental dataset. MR damper has major disadvantage lies within the non-linear and hysteretic force–velocity response. To employ the MR damper the design of a controller usually needs a model of the actuator. The Bouc-Wen model was initially proposed by Bouc early in 1971 and

generalized by Wen in 1976 and since then it has been called the Bouc-Wen model. The general Bouc-Wen model predicts the force displacement behavior of the damper well, and it possesses force velocity (İ, Engin et al. 2010).

1.2 Problem statement

In order to fulfill the objective of this project, which is to analyze MR damper model and to design force tracking control of MR damper. In order to analyze the MR damper model, it is necessary to select the best method and model to analyze. Parametric model has been chosen to conduct this study compare to non-parametric model. This is because non-parametric model has more complicated steps to conduct which is non-parametric model has to conduct the experiment first before the simulation to get the accurate result. It will consume more time and cost more money to undergo this study using non-parametric model. Thus, parametric model has been used to conduct this study.

1.3 Objective

The objectives of this project are as follows:

1. To analyze MR damper model based on parametric modeling method.
2. To design force tracking control of MR damper.

1.4 Scope of Project

The scope of this project is:

1. MR damper mathematical model is developed based on Bouc-Wen and Modified Bouc-Wen model which are in the class of parametric model.

1.5 Thesis Outline

Chapter 1: Introduction

In this chapter, there are four section that will be covered which is background of the study, problem statement, objective and scope of project for this study.

Chapter 2: Literature Review

This chapter provide a basic description of the various mechanism of MR damper. Parametric model of MR damper was explored and presented in this chapter. The mathematical model for Bouc-Wen and Modified Bouc-Wen also been covered in this chapter. The theory and the type of controller in MR damper system were study and presented.

Chapter 3: Methodology

Methodology present the method and steps that were used in this study. The content of this chapter is step of project, flowchart of this project, MATLAB Simulink Model and the parameter identification for Bouc-Wen and Modified Bouc-Wen Simulink model.

Chapter 4: Result and Discussion

For this chapter included all the result from the MATLAB Simulink simulation of MR damper have been analysed and compared between Bouc-Wen and Modified Bouc-Wen model.

Chapter 5: Conclusion and Recommendation

This is the last chapter which conclude all the result that have been achieved along this project and give the recommendation for future study.

1.6 Summary

The main objective of this project is to develop MR damper model based on parametric modeling method and to design force tracking control of MR damper. MR damper mathematical model is developed based on Bouc-Wen and Modified Bouc-Wen model which are in the class of parametric model and simulate both models using MATLAB Simulink.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will be present a complete literature review to sum up the previous work related to this thesis was introduced in Chapter 1. This section starts by giving background of MR damper then follow up by a review of parametric model of MR damper which is Bouc-Wen and Modified Bouc-Wen models. Next, this chapter continue by showing the MR damper mathematical model that have been developed based on Bouc-Wen and Modified Bouc-Wen method. Finally, the system controller for MR damper will be covered.

2.2 Magnetorheological damper background

MR fluids ever since it was discovered by Jacob Rabinow in the 1940's have in recent years has been identified to the researchers as a multi-functional fluid for its property of obtaining attractable on the applying of magnetic field. When magnetic field is applied, MR fluid has the unique ability to change its properties (Carlson and Jolly 2000). Application of MR damper is important among numerous applications of MR fluids (Carlson and Jolly 2000, Choi, Nam et al. 2000, van Kasteel, Cheng-guo et al. 2003, Lee, Sung et al. 2011) .