UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY OF FRICTION CONTROL FOR DAMPING SYSTEM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotic and Automation)

by

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: A Study of Friction Control for Damping System

SESI PENGAJIAN: 2010/11 Semester 2

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation). The member of the supervisory committee is as follow:

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ABSTRAK

Projek ini adalah tentang pengawalan geseran pada sistem redaman. Selain itu, projek ini tertumpu kepada strategi pengendalian kajian geseran dan memahami tentang sistem redaman. Projek ini bertujuan untuk menyediakan pengawalan geseran dalam sisem redaman. Untuk melengkapkan projek ini, model untuk geseran, sistem redaman dan hubungan antara geseran dan sistem redaman di fahami. Kepentingan projek ini adalah untuk memahami tentang ciri-ciri tenaga dan aplikasinya. Selain itu, model untuk geseran dan sistem redaman juga dikaji untuk memahami tentang semua model yang ada. Objektif projek ini adalah untuk mengkaji tentang strategi pengawalan geseran dan sistem redaman. Amnya, projek ini lebih fokus kepada kesesuaian peredam geseran di bangunan. Jadi, bangunan di reka dengan sistem peredam geseran dan tanpa sistem peredaman geseran ini yang kemudiannya di bandingkan antara ke dua-dua jenis rekaan tadi. Hasil dan perbincangan projek ini digambarkan di dalam simulasi dengan menggunakan perisian SAP2000. Hasil yang di harapkn daripada projek ini adalah perbandingan yang lengkap antara rekaan bangunan yang mengaplikasikan dengan yang tidak mengaplikasikan sistem redaman geseran.

DEDICATION

For all of the advice and encouragement, this thesis for my study project is gratefully dedicated to my father, mother and to all of my family members. Not forgotten to all of my friends. Thank you very much for continuous support and effort towards the publication of this thesis.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

PSM	-	Projek Sarjana Muda
FYP	-	Final Year Project
UTeM	-	Universiti Teknikal Malaysia Melaka
DOF	-	Degree Of Freedom
SBC	-	Slotted Bolted Connection
EDR	-	Energy Dissipating Restraint
VE	-	Visco-elastic
ADAS	-	Added Damping and Stiffness
DBE	-	Design Basis Earthquake
MCE	-	Maximum Credible Earthquake
B	-	Damping factor
FD	-	Friction damper
2D	-	2 Dimensional
3D	-	3 Dimensional
SAP	-	Structural Analysis Program
CAx	-	Computer-aided Technologies
CAD	-	Computer Aided Design
CAM	-	Computer-aided Manufacturing
CAE	-	Computer-aided Engineering
API	-	Application Programming Interfaces
KBE	-	Knowledge-based engineering
RSA	-	Response Spectrum Analysis
MPF	-	Modal Participation Factors
LB	-	Library Building

CHAPTER 1

INTRODUCTION

1.1 Background

The friction model has 3 categories which are Classical static models, Mechanics and fluid dynamics and Empirical phenomenological models. The classical static models are Coulomb friction, viscous friction, stiction. The Mechanics and fluid dynamics models are First principles, Microscopical contact and Viscosity. The Empirical phenomenological models are The Dahl model, The Bliman-Sorine model and LuGre model. (K. J. Åström TDU, October 2005). However this project will discuss 2 friction models. They are the Classical static models and Empirical phenomenological models only.

Friction is often considered by engineers as detrimental to the design of mechanism with moving parts, but it has long been established that it can also provide an efficient means of damping out vibrations in elastic structures. In applications such as turbo machinery bladed disks, where structural damping is negligible, dry-friction damping has been widely used to reduce the resonant response of the blades so as to limit the occurrence of wear and premature failure. In such systems, friction is obtained either by appending special passive devices (friction dampers) to selected locations of the elastic structure to be damped, or by direct frictional interaction between two or more of its constitutive parts. Once properly modelled, the parameters describing these frictional interfaces can be optimized so as to maximize the benefits of friction damping are namely as reducing the vibratory response. (Olivier J. Poudou, 2007)

There are different types of damping models such as modal or proportional damping, Rayleigh damping, viscous damping and structural or hysteresis damping.

Each of these models has their specific characteristics. This is accomplished by searching for equivalent parameters for the damping constants, so that the damping levels in the various damping models are more or less comparable. Differences and similarities between the different damping models are explored. Damping can be velocity and displacement dependent. (D.J. Rijlaarsdam, April 2005)

For this study project, Pall friction damper (FD) device have been selected for example to make the comparison of designing building with and without this friction device. The building especially tall buildings are subjected to vibrations. These vibrations can be due to wind forces, earthquake excitations, machine vibrations, or may other sources. In some cases, especially under strong earthquake excitations, these vibrations can cause the structural damage or even collapse of structure. For the structures that have high inherent or natural damping, the likelihood of damage will be decreased. However, for structures subjected to strong vibrations, the inherent damping in the structure is not sufficient to mitigate the structural response. In many situations, supplemental damping devices may be used to control the response of structure. (Abdollah Vaez Shoushtari, 2010).

The most feared effects of earthquake are collapse of structures especially tall building structures due to high displacement of stories. One of the key problems with this explanation is to reduce the structural response by increasing the dissipation of input energy due to earthquake. In other words, if the amount of energy getting into the structure can be controlled and a major portion of the energy can be dissipated mechanically independent of primary structure, the seismic response of the structure and damage control potential can be considerably improved. It can be achieved by adopting new techniques of base isolation and energy dissipation devices. Damper devices are the most popular instruments for increasing the dissipation of input energy. (Abdollah Vaez Shoushtari, 2010).

The application of damper system at the building is important for the designing of building at now days. The goal of this project is to studying the friction control for damping system.

1.2 Problem Statement

Various problems have been found during this project, the question about what is friction and what is damping already answered at this project. The friction is the force opposing the relative motion of solid surfaces, fluid layers, or material elements sliding against each other and the damping is the energy dissipation properties of a material or system under cyclic stress. The damping has different types of damping models and will be useful for energy dissipation during motion. This energy dissipation may depend on velocity (general viscous damping), displacement (hysteresis damping) or a combination of both. (D.J. Rijlaarsdam, April 2005). The function of elastic deformations in the friction damping system is to give behavior and clear from this that the elastic deformations may eliminate the energy dissipation in the damping system. (Leif O. Nielsen, Imad H. Mualla, 2002)

The significance doing friction control in damping system is to understand about the energy dissipation characteristics of friction dampers and what application in which they can successfully be used. Besides, the model of friction and damping are studied to understand all of existing model. Now days, the natural phenomenon can cause the large effect to the country and it is depend on how that country solve that problem. The one example of natural phenomenon is earthquake. Although, Malaysia is not include as one of place that earthquake may happen but it is wrong if preparation is made for any possibilities. How far the application of damper system can dissipate energy during earthquake? This study project will discuss in term of simulation by applying the computer software to interpret data.

1.3 Objectives

The objectives of this study are:-

i. To study friction control strategies
ii. To study about damping system
iii. To provide study for friction control in damping system

1.4 Scope of the project

The project will focus to study about friction control for damping system. The friction and damping was described in mathematical model then damping system will be modeled. The simple design of building that will be applying with and without friction damper device will be comparing by using SAP2000 software student version. Then, the result and discussion of the project is described in term of simulation of the building. The detail of the analysis to be prepared and compared each other. The relationship about the friction and damping system also will be covered. Besides, several existing damper will be modeling by using CATIA V5R16 software and will be discuss especially in term of friction. The SAP2000 software student version have limitation that a simple design only can be applied because the purpose of this student version software is for learning process and cannot be commercial.

1.5 Organization of the Report

Basically these reports have 6 chapters that will represent this project for first semester and will continue to the second semester in fourth year. There are the simple explanations about the chapter in this project.

Chapter 1 – Introduction

The overall review of this research study is mentioned in this chapter. The basic explanation about friction and damping, objectives and scope of the project are also described in this chapter.

Chapter 2 – Literature Review

This chapter will explain about the friction and damping with more detailed. Then, continue with explanation about the modelling damper. The explanation will represent in table and figure to make more understanding. The techniques and tools used in this project also mentioned in this chapter.

Chapter 3 – Methodology

This chapter shows the completion of modelling damper by using CATIA V5R16 software. The process flowchart for the research study that will be done also recorded in this chapter. Besides, the design of building by using software SAP2000 also will be representing in this chapter. The ways of analysis data also covered at this chapter.

Chapter 4 – Results

This chapter shows the simulation result from SAP2000 software in form of figure or table. The result will be display by comparing the building with and without friction damper device based on 20 mode of analysis. All of the result at this chapter is come from SAP2000 software.

Chapter 5 – Discussion

This chapter described all analysis; the results will be interpreted in form of graph to see the comparison more clearly. Besides, this chapter also will explain more about the result and then the problems occurred in finishing this study project.

Chapter 6 – Conclusion

The last chapter of this study is explained about the final finding the project whether all the objectives for this research are achieved or not. The limitation for current study project and the suggestion for further study project also covered at this chapter.

1.6 Gantt Chart of Project for PSM I and II

The table 1.1 and 1.2 are showing the activity for semester one and semester 2 in order to complete this study project successfully. Only important activity is described to finish up this study project.

Table 1.1: The Gantt chart of project for semester 1 (PSM I)

Semester 1	Week															
Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Briefing about the subject and project																
Research paper preparation																
Proposal preparation																
Introduction																
Literature review																
Research methodology																
Project planning process																
Report preparation																
Presentation Preparation																

Table 1.2: The Gantt chart of project for semester 2 (PSM II)

Semester 2	Week															
Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Review about the project	■	■	■													
Design and modeling		■	■	■	■	■	■	■								
Running simulation							■	■	■	■	■	■	■			
Analyzing and Interpreting Results					■	■	■	■	■	■	■					
Discussion and conclusion							■	■	■	■	■	■	■			
Report preparation				■	■	■	■	■	■	■	■	■	■	■	■	■
Presentation Preparation										■	■	■	■	■	■	■

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will explain more detailed about friction and damping in term of mathematical model and the several example of damper will be covered in this chapter. Besides, the concept of damping will be explained in this chapter and the existing friction damper device also will be covered in this chapter. The source of references to the statement or any theory will be mention at the bottom of statement. To make more understanding, the explanation will be presented in the table. The figure and graph also will be presented to make all cleared. The software that use for simulation and modelling friction damper also will be explained (SAP2000 and CATIA V5). For this study project, Pall friction damper (FD) device have been selected as case study and this device will be modelled by using CATIA V5 software at chapter 3. The basic introduction and the theory for Pall FD are representing in this chapter.

2.2 Introduction to friction

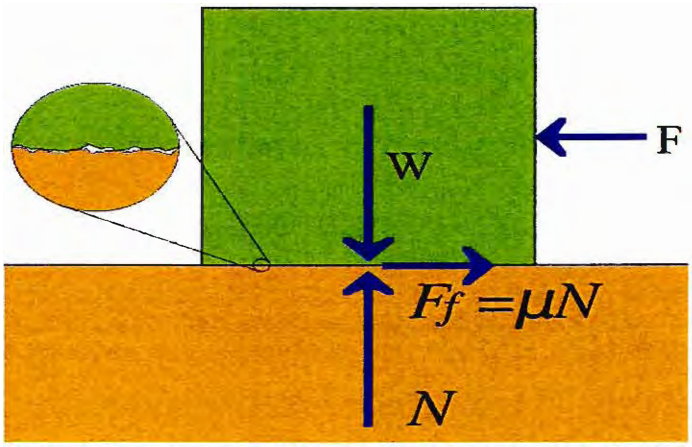

Figure 2.1: Normal friction

The friction can be described as a force that resists movement between two objects that are touching. The coefficient of friction is a dimensionless constant that takes into account the two surfaces. For normal solids, the friction force is strictly dependent on the force that's pushing the two surfaces together. The smaller cube with the same weight will have the same friction force. (Kevin C, 2009)

2.2.1 Friction phenomena

Friction occurs in all mechanical systems such as bearings, transmissions, hydraulic and pneumatic cylinders, valves and brakes and wheels. Friction appears at the physical interface between two surfaces in contact. Lubricants such as grease or oil are often used but the there may also be a dry contact between the surfaces. Friction is strongly influenced by contaminations. There is a wide range of physical phenomena that cause friction; this includes elastic and plastic deformations, fluid mechanics and wave phenomena, and material sciences. Friction is the tangential reaction force between two surfaces in contact. Physically these reaction forces are the results of many different mechanisms, which is depend on contact geometry and topology, properties of the bulk and surface materials of the bodies, displacement and relative velocity of the bodies and presence of lubrication. (H. Olsson, K.J. Åström, C. Canudas de Wit, M. Gäfvert, P. Lischinsky.)

2.2.1.1 Steady Velocity Friction

The friction force as a function of velocity for constant velocity motion is called the Stribeck curve. In particular the dip in the force at low velocities is called the Stribeck effect. The friction velocity relation is application dependent and varies with material properties, temperature, wear and others. Many friction phenomena do not appear for constant velocity experiments. (H. Olsson, K.J. Åström, C. Canudas de Wit, M. Gäfvert, P. Lischinsky)

2.2.1.2 Static Friction and Break-Away Force

Static friction is the friction when sticking. The force required to overcome the static friction and initiate motion is called the break-away force. Rabinowicz are investigated friction as a function of displacement. He concluded that the breakaway force is given by the peak seen in Figure 2.2 below.

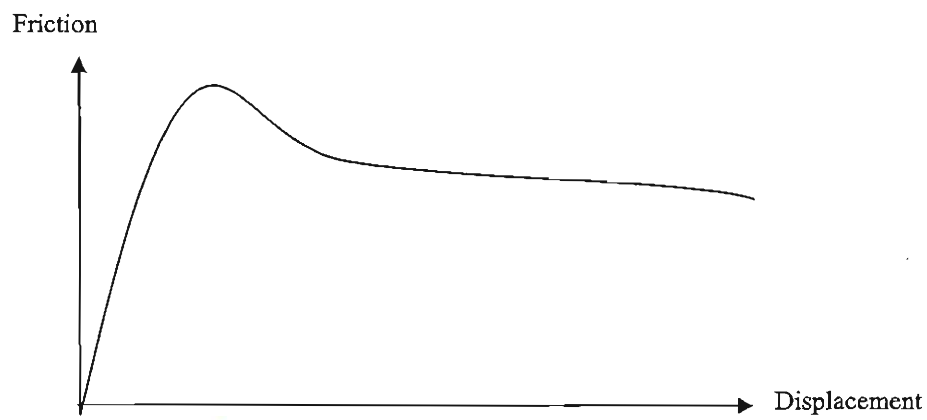

Figure 2.2: The relation between friction and displacement