MODAL ANALYSIS ON FLEXIBLE PLATE STRUCTURE USING FINITE ELEMENT ANALYSIS

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VERIFICATION

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of degree of Bachelor Mechanical Engineering
(Structure & Material)"

Signature	:…………………………………
Supervisor's Name	:…………………………………
Date	: ………………………………...

SPECIALLY DEDICATED TO MY FATHER, MOTHER , FAMILY MEMBERS AND TO ALL MY FRIENDS…..

DECLARATION

I hereby declare that this project report entitled

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USING FINITE ELEMENT ANALYSIS

is written by me and is my own effort except the ideas and summaries which I have clarified their sources.

Signature :………………………………….

Author :………………………………….

Date : ………………………………...

ACKNOWLEGEMENT

All praise to Allah, that give me blessing to finish and complete this research. Furthermore, my thanks also for my family because of their support and encouragement’

I also would like to express greatest thankfulness and appreciation to my supervising lecturer, Pn. Rainah Ismail of which we had a good working relationship, and who had offered me a wonderful help and encouragement. She also gives me full of support and advice.

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ABSTRACT

Flexible structures are commonly use in aircraft manufacturing as a main part of the plane structure. Plane structure plays an important role in producing a safety for the plane. Due to the safety, dynamic behaviors of the structure mostly are the first to analyze. Modal analysis is the method that be used to determine dynamic characteristics of the structure. In modal analysis studied, modal parameter like frequency, damping ratio and mode shape of the structure will be defined. These parameters are known as dynamic characteristics. It very significant to know the dynamic characteristics of the structure because dynamics load acting on an aircraft during flight will be encourages the onset of the structure damage such as flutter and resonance. This paper will discuss about finite element analysis on flexible rectangular plate structure using finite element analysis software that is MSC NATRAN PASTRAN. This software will apply finite element method analysis to the plate then the data will compare with experimental value and finite difference method analysis that have been done by other researcher.

ABSTRAK

Struktur yang fleksibel digunakan secara meluas dalam industri pembuatan pesawat sebagai bahan utama untuk struktur pesawat. Struktur pesawat memainkan peranan penting dalam menghasilkan sebuah pesawat yang selamat. Berdasarkan keselamatan pesawat, sifat dinamik sesebuah struktur pesawat adalah yang paling utama perlu dikaji. Analisis modal adalah satu kaedah yang digunakan untuk menentukan sifat dinamik sesebuah struktur. Penggunaan modal analisis adalah untuk mendapatkan parameter modal iaitu frekuensi, nisbah redaman, dan bentuk kala. Parameter ini dikenali sebagai sifat dinamik bagi sesuatu struktur. Adalah amat penting bagi menentukan parameter ini kerana daya dinamik yang bertindak pada pesawat sewaktu penerbangan akan menghasilkan satu keadaan yang akan memusnahkan struktur pesawat seperti kepakkan dan resonan. Kajian ini akan membincangkan tentang analisis modal yang menggunakan analisis unsur terbatas pada plat segi empat yang fleksibel. Perisian analisis unsur terbatas akan digunakan iaitu MSC NATRAN PASTRAN. Perisian ini akan mengapplikasikan kaedah unsur terbatas ke atas plat, dan data yang diperoleh akan dibandingkan dengan nilai daripada kaedah eksperimen dan analisi beza terhingga yang dilakukan oleh pengkaji lain.

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m	-	mass system
c	-	damping
k	-	stiffness
x	-	displacement
$\dot{x}$	-	velocity
$\ddot{x}$	-	acceleration
ω_n	-	natural frequency
ξ	-	damping ratio
$[\mathrm{m}]$	-	structural mass matrix
$[\mathrm{c}]$	-	structural damping matrix
$[\mathrm{k}]$	-	structural stiffness matrix
$\{\mathrm{X}\}$	-	the node displacement vector
$\{\dot{\mathrm{X}}\}$	-	the node velocity vector
$\{\mathrm{f(t)}\}$	-	the time function
$\mathrm{H}(\omega)$	-	input force function
$\mathrm{Y}(\omega)$	-	response function
f	-	frequency
T, t	-	time
ρ	-	pressure
h	-	volume density
Q_x, Q_y	-	dynamic shear force per unit length
$M_{x,} M_y$	-	moments per unit length
M_{xy}	-	twisting moment per unit length

E	-	modulus of elasticity
μ	-	Poisson ratio
G	-	shear modulus
D	-	flexural rigidity

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CHAPTER 1

INTRODUCTION

1.1 Research Background

This simulation will cover on modal analysis of flexible plate structure. Thus result and data will compare to actual and experimental value. We had decided to use aluminum for the flexible plate. Modal analysis is the study of the dynamic properties of structures under vibration excitation.

According to (Wikipedia, 2009), Modal analysis is the field of measuring and analyzing the dynamic response of structures and or fluids when excited by an input. Examples would include measuring the vibration of a car's body when it is attached to an electromagnetic shaker, or the noise pattern in a room when excited by a loudspeaker.

For this research, modal analysis will be done by using Finite Element Method(FEM),so that we can determine the mode shape and frequency of the structure.

According to (Wikipedia, 2009), it is common to use Finite Element Method(FEM) to perform this analysis because, like other calculations using the FEM, the object being analyzed can have arbitrary shape and the results of the calculations are acceptable. The types of equations which arise from modal analysis are those seen in eigensystems. The physical interpretation of the eigenvalues and eigenvectors which come from solving the system are that they represent the frequencies and corresponding mode shapes.

So in calculating FEM, Finite Element Analysis (FEA) software have been choose, that is MSC NASTRAN/PATRAN.

1.2 Problem Statement

The current trends of space aircraft design are to use the large, thin and lightweight structures. The design must be consider on many factors such as, cost, safety and mechanical parts. A heavy structure, make the higher vibration on the structure. This study is to determine the frequency of the vibration of the flexible structure that is aluminum using in aircraft manufacturing and to get their dynamic behaviors. The data get will be help to design the aircraft body.

Therefore, this research will do simulation analysis to identify the dynamic characteristics of the flexible plate, and compare it with experimental work so that the data will useful for aircraft manufacturing

1.3 Objective

The objectives of this study are to obtain dynamic characteristic that is frequencies and mode shape of the flexible structure using FEA analysis software MSC NASTRAN/PATRAN and also to verify the results with the analytical finite element model and experimental result that has been done by other researcher.

1.4 Research Scope

The scopes of this study are:

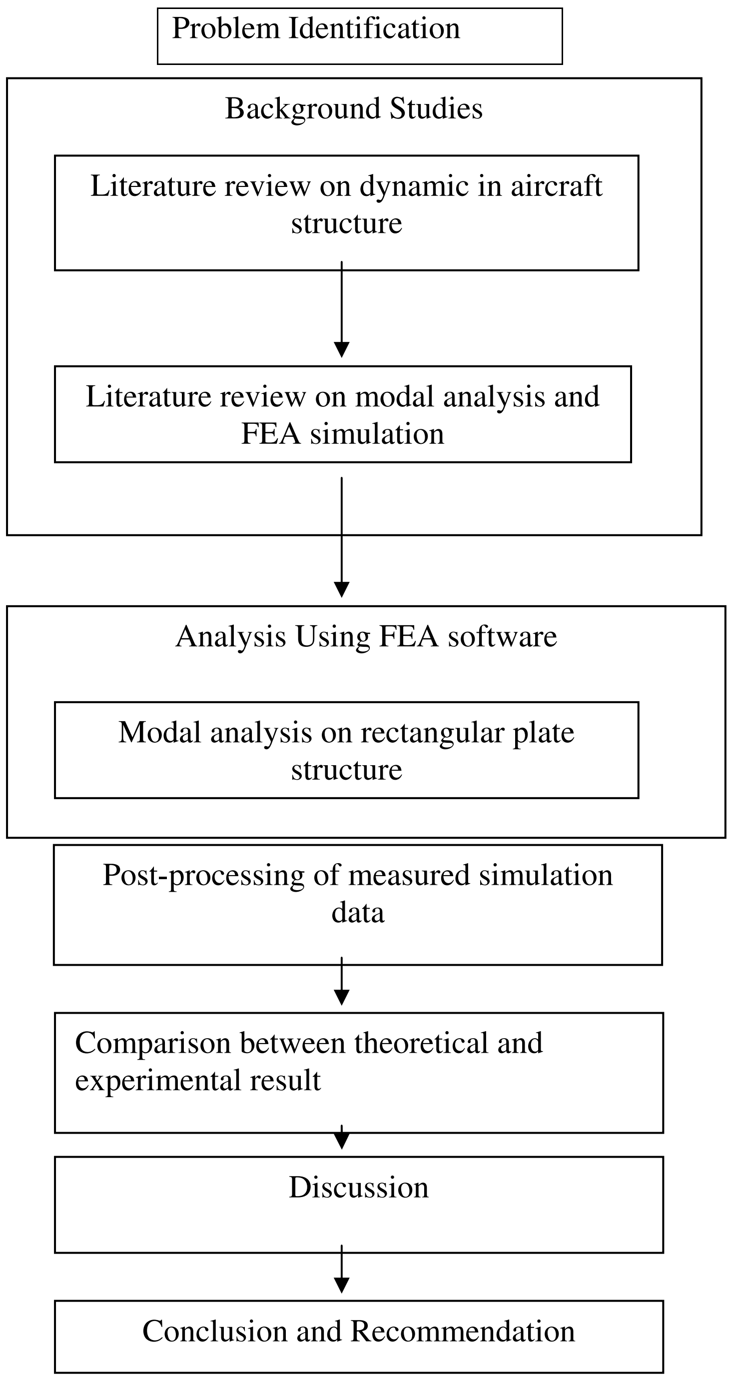
(a) To do literature study on modal analysis

(b) To develop FEM analytical simulation method and produce a result to compare with experimental and theoretical

(c) To study on FEA software MSC NASTRAN PATRAN in doing simulation work

1.5 Research Methodology

Methodology of this study is summarized in the flow chart below



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, theory of vibration, modal analysis and description about the Finite Element Analysis (FEA) software will discuss according to journal and thesis done by other person.

2.2 Vibration Theory

There are two general classes of vibrations - free and forced. Free vibration takes place when a system oscillates under the action of forces inherent in the system itself, and when external impressed forces are absent. The system under free vibration will vibrate at one or more of its natural frequencies, which are properties of the dynamic system established by its mass and stiffness distribution.

L.S Chan, (2001) said that, Vibration that takes place under the excitation of external forces was called forced vibration. When the excitation was oscillatory, the system was forced to vibrate at the excitation frequency. If the frequency of excitation coincides with one of the natural frequencies of the system, a condition of resonance was encountered, and dangerously large oscillations may result. The failure of major structures such as bridges, buildings, or airplane wings is an awesome possibility under resonance. Thus, the calculations of the natural frequencies are major importance in the study of vibrations.

C. F Beards (1996), state that, the analysis of structural vibration is necessary in order to calculate the natural frequencies of a structure, and the response to the expected excitation. In this way it can be determined whether a particular structure will fulfill its intended function and, in addition, the results of the dynamic loadings acting on a structure can be predicted, such as the dynamic stresses, fatigue life and noise levels. Hence the integrity and usefulness of a structure can be maximized and maintained. From the analysis it can be seen which structural parameters most affect the dynamic response so that if an improvement or change in the response is required, the structure can be modified in the most economic and appropriate way. Very often the dynamic response can only be effectively controlled by changing the damping in the structure. There are many sources of damping in structures to consider and the ways of changing the damping using both active and passive methods require an understanding of their mechanism and control. For this reason a major part of the book is devoted to the damping of structural vibrations.

2.2.1 Single degree of Freedom (SDOF)

A basic understanding of structural dynamic is necessary for successful modal testing. It is important to have a good grasp of the relationship between frequency response function and modal parameter. In this research, we took SDOF system for its application. Figure 2.1 shows a simple undamped spring-mass system, which is assumed to move only along the vertical direction. It has single degree of freedom (SDOF), because its motion is described by a single coordinate x.

When placed into motion, oscillation will take place at the natural frequency which is a property of the system. We now examine some of the basic concepts associated with the free vibration of systems with one degree of freedom.

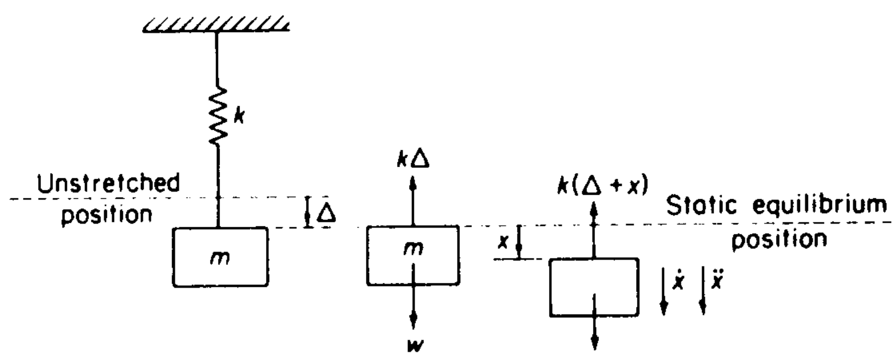


Figure 2.1 Spring-Mass System and Free-Body Diagram

Newton's second law is the first basis for examining the motion of the system. As shown in Figure 2.1 the deformation of the spring in the static equilibrium position is D , and the spring force kD is equal to the gravitational force w acting on mass m

By measuring the displacement x from the static equilibrium position, the forces acting on m are $k(\Delta+x)$ and w. With x chosen to be positive in the downward direction, all quantities - force, velocity, and acceleration are also positive in the downward direction.