GUIDED WAVE PROPAGATION IN ASYMMETRICAL CORRUGATED PLATES

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To my beloved family

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ABSTRACT

Research on guided wave propagation in isotropic flat plates has been quite intensive in the past decade. However, the research on guide wave propagation in corrugated plate limited only to symmetrical type whilst the asymmetrical type has not been determined. Therefore, the behaviour of guided wave in asymmetrical corrugated plates still remains unknown. Hence, in the present study, guided wave dispersion curve for asymmetrical corrugated plates and effects of corrugated dimensions on the dispersion curves are determined. Two-dimensional and infinite plate with isotropic material is modelled by numerical method. Two parameters are affecting the results of dispersion curve which are corrugation height and half wavelength. The results show that the mode shapes are easier to identify if smaller ratio of corrugation height and half wavelength is used. The dispersion curve is reasonably well for small corrugation height but not so good for large corrugation height.

ABSTRAK

Penyelidikan bagi perambatan gelombang berpandu dalam plat isotropi adalah intensif pada dekad yang lalu. Walau bagaimanapun, penyelidikan mengenai perambatan gelombang panduan dalam plat beralun terhad bagi jenis simetri manakala bagi jenis antisimetri belum ditentukan lagi. Oleh itu, gelombang berpandu dalam pinggan beralun antisimetri masih belum diketahui. Dalam kajian ini, lengkung serakan untuk plat beralun antisimetri dan kesan dimensi beralun pada lengkung serakan ditentukan. Plat dua dimensi dan tidak terhingga telah dimodelkan dengan mengguna bahan isotropi. Dua parameter yang mempengaruhi keputusan lengkung serakan ialah ketinggian kerut dan separuh panjang gelombang. Keputusan menunjukkan bahawa bentuk mod adalah lebih mudah dikenal pasti jika nisbah bagi ketinggian kerut dan separuh panjang gelombang adalah kecil. Lengkung serakan jelas untuk dilihat bagi ketinggian kerut yang kecil tetapi tidak begitu jelas bagi ketinggian kerut yang besar.

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LIST OF ABBREVIATIONS AND SYMBOLS

NDT	-	non-destructive testing
FEM	-	finite element method
2D-FFT	-	Two Dimensional Fast Fourier Transform
h	-	half thickness
k	-	wavenumber
ω	-	circular frequency
c_A	-	velocity of asymmetric mode
c_S	-	velocity symmetric mode
c_p	-	phase velocity
c_g	-	phase velocity
E	-	Young's modulus
v	-	Poison's ratio
ρ	-	density
θ	-	angle of incidence
l	-	length of plate
d	-	thickness of plate
L_1, L_2	-	load
a	-	corrugation height
b	-	half wavelength of the periodic surface
u	-	displacement
t	-	time
n	-	number of cycles

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CHAPTER 1

INTRODUCTION

This chapter describes the background information, problem statement, research objective, scope and significance of the study.

1.1 Background Information

In general, non-destructive testing (NDT) method includes eddy current, magnetic, optical and guided wave testing. In this study, guided wave testing is chosen. The fundamental concept of the guided wave is based on the acoustic plane wave of the material, propagating along a medium that is bounded by the regular boundaries of the structure. The behaviour of the guided wave can be described using dispersion curves of wavenumber, phase velocity and group velocity. Sometimes, it is difficult to solve the propagating guided wave in complicated geometry by analytical method, thus either experimental method or numerical method is needed in order to solve the problem.

Despite its long history, finite element method (FEM) continues to be predominant strategy employed to conduct structural analysis. Therefore, a wide variety of engineering problems apply FEM. Theoretically, it cuts a structure into several elements and then reconnects the elements at nodes. The main advantage of the FEM is that there are numerous commercial finite element codes available; hence eliminating any need to develop actual code. Former researchers have used the FEM to numerically calculate the dispersion curves in a plate. Therefore, it is possible to use FEM for guided wave propagation problems.

1.2 Problem Statement

There are three methods that can be used to solve the engineering problem which are analytical, experimental and numerical method. Since the analytical method is limited to simple geometry problem and the experimental method involves high cost, researchers are increasingly looking for low cost and acceptable alternative method. This alternative method is by modelling the structure using FEM as FEM is a method for numerical solution of field problems.

There is an analytical solution for isotropic flat plate over more than a century. However, there are still many aspects of the behaviour of guided wave especially for different waveguides which remain unknown. Since there are differences between isotropic flat plates, the corrugated plates need to be investigated especially for plotting the dispersion curves.

1.3 Research Objective

The objectives of the study are:

1. to determine guided wave dispersion curves for asymmetrical corrugated plates.
2. to determine effects of corrugated dimensions on the dispersion curves.

1.4 Scope

In this study, the software that used for the numerical method is ABAQUS and MATLAB. FEM is performed in order to investigate the dispersion curves for isotropic flat and asymmetrical corrugated plate. The isotropic material properties and asymmetrical corrugated plate geometries are considered. The asymmetrical corrugated plates are built in two-dimensional and infinite (no edge reflection). The isotropic material used is aluminium.

1.5 Significance of Study

Till now, isotropic flat plate has found numerous applications in industry especially for light weight construction. For instance, aircraft wing is made using flat plate. The flat plate can be made stiffer by using corrugated profile. However, only a little study has been made on corrugated plates. Besides that, there are no analytical solutions for general corrugated plates, thus numerical method and experimental method is required.

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