

ACTIVE CONTROL OF VIBRATION IN STIFFENED STRUCTURES

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CONTENTS

Abstract	x
Statement of originality	xiii
Acknowledgments	xiv
CHAPTER 1. INTRODUCTION AND LITERATURE REVIEW	1
1.1 Introduction	1
1.2 Literature review	7
1.2.1 Analysis of vibration in continuous structures	7
1.2.1.1 The differential equations of motion	7
1.2.1.2 Treatment of termination impedences in theoretical analysis	8
1.2.1.3 Analysis of vibration in rectangular plates	10
1.2.1.4 Analysis of vibration in cylindrical shells	13
1.2.2 Active vibration control	16
1.2.2.1 The origins of active noise and vibration control	16
1.2.2.2 Development of feedback vibration control methods	17
1.2.2.3 Actuators for active vibration control	18

Contents

1.2.2.4	Error sensors for active vibration control	22
1.2.2.5	Feedforward active control of vibration in beams	23
1.2.2.6	Feedforward active control of vibration in plates	27
1.2.2.7	Feedforward active control of vibration in cylinders	29
1.3	Summary of the main gaps in current knowledge addressed by this thesis	31
CHAPTER 2.	FEEDFORWARD ACTIVE CONTROL OF FLEXURAL VIBRATION IN A BEAM USING A PIEZOCERAMIC ACTUATOR AND AN ANGLE STIFFENER	32
2.1	Introduction	32
2.2	Theory	34
2.2.1	Response of a beam to a harmonic excitation	34
2.2.2	Boundary conditions at the beam ends	36
2.2.2.1	Beam boundary impedance	36
2.2.2.2	Equivalent boundary impedance of an infinite beam	39
2.2.2.3	Impedance equations	41
2.2.3	Equilibrium conditions at the point of application ($x = x_0$) of a force or moment	42
2.2.3.1	Response of a beam to a point force	42
2.2.3.2	Response of a beam to a concentrated moment	43
2.2.4	Mass loading of the angle stiffener	44

Contents

2.2.5	Minimising vibration using piezoceramic actuators and angle stiffeners	45
2.2.5.1	One control source and one angle stiffener	45
2.2.5.2	Two control sources and two angle stiffeners	51
2.2.5.3	Two error sensors	52
2.3	Numerical results	54
2.3.1	Acceleration distributions for controlled and uncontrolled cases	55
2.3.2	Effect of variations in forcing frequency, stiffener flange length and control source location on the control force	57
2.3.3	Effect of variations in forcing frequency, control source location and error sensor location attenuation of acceleration level	62
2.3.4	Effect of a second angle stiffener and control source on the attenuation of acceleration level	67
2.4	Experimental procedure	70
2.4.1	Impedance of an experimental termination	70
2.4.2	Relating control signal and control force	78
2.4.3	Test procedure	82
2.5	Experimental results	90
2.6	Summary	94

Contents

CHAPTER 3. FEEDFORWARD ACTIVE CONTROL OF FLEXURAL VIBRATION IN A PLATE USING PIEZOCERAMIC ACTUATORS AND AN ANGLE STIFFENER	
STIFFENER	98
3.1 Introduction	98
3.2 Theory	100
3.2.1 Response of a plate to a harmonic excitation	100
3.2.2 Boundary conditions at the plate ends	103
3.2.2.1 Free end conditions	103
3.2.2.2 Infinite end conditions	104
3.2.3 Equilibrium conditions at the point of application ($x = x_0$) of a force or moment	105
3.2.3.1 Response of a plate to a point force	105
3.2.3.2 Response of a plate to a distributed line force parallel to the y-axis	106
3.2.3.3 Response of a plate to a distributed line moment parallel to the y-axis	106
3.2.4 Modelling the effects of the angle stiffener	107
3.2.5 Minimising vibration using piezoceramic actuators and an angle stiffener	109
3.2.5.1 Control sources driven by the same signal	115
3.2.5.2 Control sources driven independently	118
3.2.5.3 Two angle stiffeners and two sets of control sources	119

Contents

3.2.5.4	Discrete error sensors	119
3.3	Numerical results	121
3.3.1	Acceleration distributions for controlled and uncontrolled cases	122
3.3.2	Effect of variations in forcing frequency, control source location and error sensor location on the control forces	127
3.3.3	Effect of variations in forcing frequency, control source location and error sensor location on the attenuation of acceleration level	130
3.3.4	Number of control sources required for optimal control	136
3.3.5	Effect of a second angle stiffener and set of control sources on the attenuation of acceleration level	136
3.3.6	Number of error sensors required for optimal control	139
3.4	Experimental procedure	140
3.4.1	Modal analysis	140
3.4.2	Active vibration control	141
3.5	Experimental results	148
3.5.1	Modal analysis	148
3.5.2	Active vibration control	150
3.6	Summary	152

Contents

CHAPTER 4. FEEDFORWARD ACTIVE CONTROL OF FLEXURAL VIBRATION IN A CYLINDER USING PIEZOCERAMIC ACTUATORS AND AN ANGLE STIFFENER	156
4.1 Introduction	156
4.2 Theory	158
4.2.1 The differential equations of motion for a cylindrical shell and the general solution	158
4.2.2 Determining the wavenumbers k and constants β and γ	161
4.2.3 Boundary conditions at the cylinder ends	165
4.2.3.1 Simply supported end conditions	166
4.2.3.2 Infinite end conditions	167
4.2.4 Equilibrium conditions at the point of application ($x = x_0$) of a force or moment	168
4.2.4.1 Response of a shell to a radially acting point force	168
4.2.4.2 Response of a shell to a circumferentially distributed line force	171
4.2.4.3 Response of a shell to a circumferentially distributed line moment	171
4.2.5 Modelling the effects of the angle stiffener	173
4.2.6 Minimising vibration using piezoceramic actuators and an angle stiffener	176
4.2.6.1 Control sources driven by the same signal	184

Contents

4.2.6.2	Control sources driven independently	187
4.2.6.3	Discrete error sensors	187
4.2.7	Natural frequencies	188
4.3	Numerical results	189
4.3.1	Acceleration distributions for controlled and uncontrolled cases	189
4.3.2	Effect of variations in forcing frequency, control source location and error sensor location on the control forces	202
4.3.3	Effect of variations in forcing frequency, control source location and error sensor location on the attenuation of acceleration level	208
4.3.4	Number of control sources required for optimal control	213
4.3.5	Number of error sensors required for optimal control	213
4.3.6	Natural frequencies	214
4.4	Experimental procedure	216
4.4.1	Modal analysis	216
4.4.2	Active vibration control	217
4.5	Experimental results	225
4.5.1	Modal analysis	225
4.5.2	Active vibration control	228
4.6	Summary	231

Contents

CHAPTER 5. SUMMARY AND CONCLUSIONS	235
5.1 Summary of numerical analysis	235
5.2 Summary of experimental results	243
5.3 Conclusions	246
References	248
Publications originating from thesis work	266

Abstract

ACTIVE CONTROL OF VIBRATION IN STIFFENED STRUCTURES

ABSTRACT

Active control of vibration in structures has been investigated by an increasing number of researchers in recent years. There has been a great deal of theoretical work and some experiment examining the use of point forces for vibration control, and more recently, the use of thin piezoelectric crystals laminated to the surfaces of structures. However, control by point forces is impractical, requiring large reaction masses, and the forces generated by laminated piezoelectric crystals are not sufficient to control vibration in large and heavy structures.

The control of flexural vibrations in stiffened structures using piezoceramic stack actuators placed between stiffener flanges and the structure is examined theoretically and experimentally in this thesis. Used in this way, piezoceramic actuators are capable of developing much higher forces than laminated piezoelectric crystals, and no reaction mass is required. This thesis aims to show the feasibility of active vibration control using piezoceramic actuators and angle stiffeners in a variety of fundamental structures.

The work is divided into three parts. In the first, the simple case of a single actuator used to control vibration in a beam is examined. In the second, vibration in stiffened plates is

Abstract

controlled using multiple actuators, and in the third, the control of vibration in a ring-stiffened cylinder is investigated.

In each section, the classical equations of motion are used to develop theoretical models describing the vibration of the structures with and without active vibration control. The effects of the angle stiffener(s) are included in the analysis. The models are used to establish the quantitative effects of variation in frequency, the location of control source(s) and the location of the error sensor(s) on the achievable attenuation and the control forces required for optimal control. Comparison is also made between the results for the cases with multiple control sources driven by the same signal and with multiple independently driven control sources. Both finite and semi-finite structures are examined to enable comparison between the results for travelling waves and standing waves in each of the three structure types.

This thesis attempts to provide physical explanations for all the observed variations in achievable attenuation and control force(s) with varied frequency, control source location and error sensor location. The analysis of the simpler cases aids in interpreting the results for the more complicated cases.

Experimental results are given to demonstrate the accuracy of the theoretical models in each section. Trials are performed on a stiffened beam with a single control source and a single error sensor, a stiffened plate with three control sources and a line of error sensors and a ring-stiffened cylinder with six control sources and a ring of error sensors. The experimental

Abstract

results are compared with theory for each structure for the two cases with and without active vibration control.

Statement of originality

STATEMENT OF ORIGINALITY

To the best of my knowledge and belief all of the material presented in this thesis, except where otherwise referenced, is my own original work, and has not been presented previously for the award of any other degree or diploma in any University. If accepted for the award of the degree of Doctor of Philosophy, I consent that this thesis be made available for loan and photocopying.

Andrew J. Young

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