



UNIVERSITI PUTRA MALAYSIA

***SECOND ORDER SHEAR DEFORMATION THEORY FOR RESPONSE
ANALYSIS ON TEMPERATURE-DEPENDENT FUNCTIONALLY
GRADED PLATES DUE TO VIBRATION AND MECHANICAL LOADING***

ALI SHAHRJERDI

FK 2011 75

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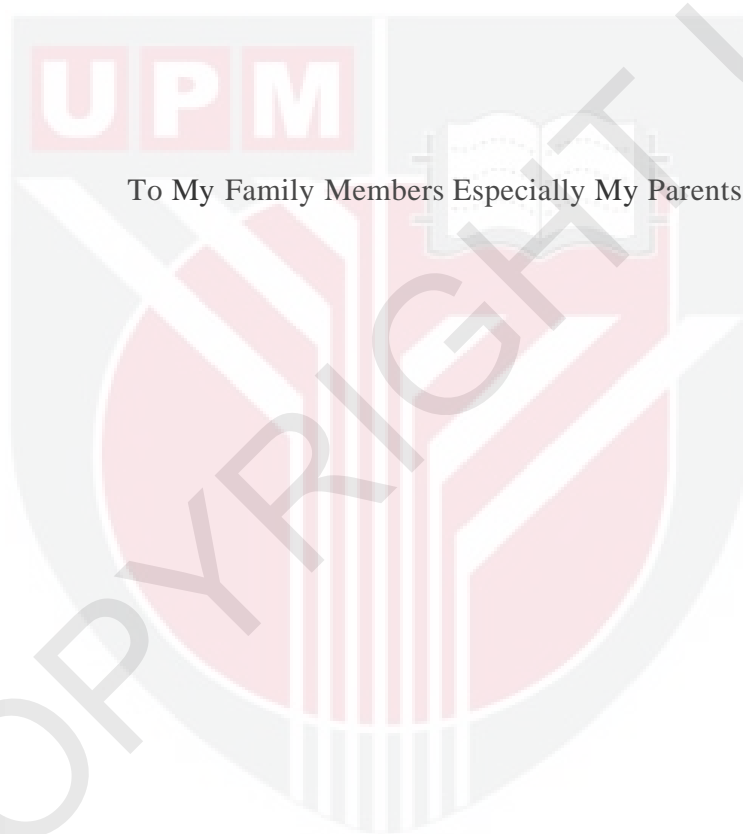
By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
fulfilment of the Requirement for the Degree of Doctor of Philosophy

August 2011



To My Family Members Especially My Parents

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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The Second-order Shear Deformation Theory (SSDT) is applied to evaluate the displacement and stress fields included in a functionally graded plate (FGP) by thermo-mechanical loadings. Uniformity, linearity, nonlinearity, heat-flux, and sinusoidal thermal conditions are imposed at the upper and lower surfaces of the FGPs. The SSDT is also employed to analyze the free vibration of temperature dependent and independent FGP's. Equilibrium equations and equations of motion of FG square and rectangular plates are derived by employing second order shear deformation theory (SSDT). Navier's method is applied to find the analytical results

for the derived equations using an energy method for the case of simply supported boundary conditions. The power law material properties and linear steady-state thermal loads are assumed to be graded between full ceramic at the upper and full metal at the lower surface. In the numerical study, different types of FGPs such as ZrO₂/Ti-6Al-4V and Si₃N₄/SUS304 are considered. A comparison is made of the non-dimensional results for the temperature-dependent and temperature-independent FGPs and validated using the results published in the literature. By comparing the results with some numerical results, a quantitative agreement is exhibited. This research study used numerical results to quantify the effects of material composition, plate geometry, and temperature fields on vibration characteristics and mode shapes. The effects of the material grading index of a plate on stresses and displacements were investigated to reveal that, the longitudinal stresses in the FGP lie between full-metal and full-ceramic plates. It was found that, the neutral axes for FGP move to the upper surface not to the mid-surface as predicted in homogeneous plates. The SSDT has computed results for in-plane stresses, free vibration and displacement fields, which are acceptable and exhibit very close qualitative behavior and quantitative agreement to other shear deformation theories in existing literature, thus demonstrating its robustness.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

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Kejuruteraan

Kedua-Kumpulan Deformasi Luncurkan Teori (SSDT) dilaksanakan untuk menilai perpindahan sesaran dan tekanan diambil kira pada satu *Functional Graded Plate* (FGP) melalui beban termo-mekanikal. Keseragaman, keelurusan, ketakelurusan, fluks haba, dan keadaan terma sinusoidal yang dikenakan pada permukaan atas dan bawah FGPs. SSDT ini juga digunakan untuk menganalisis subu getaran bebas bagi FGP's yang bergantung dan bebas. Kaedah Navier adalah digunakan untuk mencari hasil analisis untuk persamaan yang telah diperolehi dengan menggunakan kaedah tenaga untuk kes keadaan batas sederhana disokong. Sifat elektrik bahan undang-undang dan linier mapan beban terma diandaikan mengikut gred antara logam

keramik penuh di atas dan penuh pada permukaan yang lebih rendah. Dalam kajian berangka, pelbagai jenis FGPs seperti $ZrO_2/Ti-6Al-4V$ dan $Si_3N_4/SUS304$ dipertimbangkan. Kajian perbandingan hasil dijalankan bagi ketidak-dimensi untuk FGPs pada suhu bergantung dan suhu bebas dan seterusnya validasi menggunakan hasil yang telah diterbitkan dalam kajian bacaan. Penyelidikan ini menggunakan hasil berangka untuk mengukur kesan daripada komposisi bahan, geometri plat, dan suhu terhadap ciri-ciri getaran dan mod bentuk. Kesan grad indeks bahan plat pada tegasan dan sesaran disiasat bertujuan mengetahui bahawa longitudinal stres dalam FGP diantara logam and plat ceramik. Didapati bahawa paksi neutral untuk pemindahan FGP ke permukaan alas dan tidak ke permukaan pertengahan seperti yang dijangkakan didalam plat homogen. SSDT telah mengira keputusan untuk tegasan di permukaan, getaran bebas dan kawasan sesaran yang boleh diterima pakai dan menghampiri teori deformasi luncur didalam kajian bacaan semasa dan ianya menunjukkan "*robustness*".

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I certify that a Thesis Examination Committee has met on 19 August 2011 to conduct the final examination of Ali Shahrjerdi on his thesis entitled "Second Order Shear Deformation Theory for Response Analysis on Temperature-Dependent Functionally Graded Plates Due to Vibration and Mechanical Loading" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Doctor of Philosophy.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any institution.

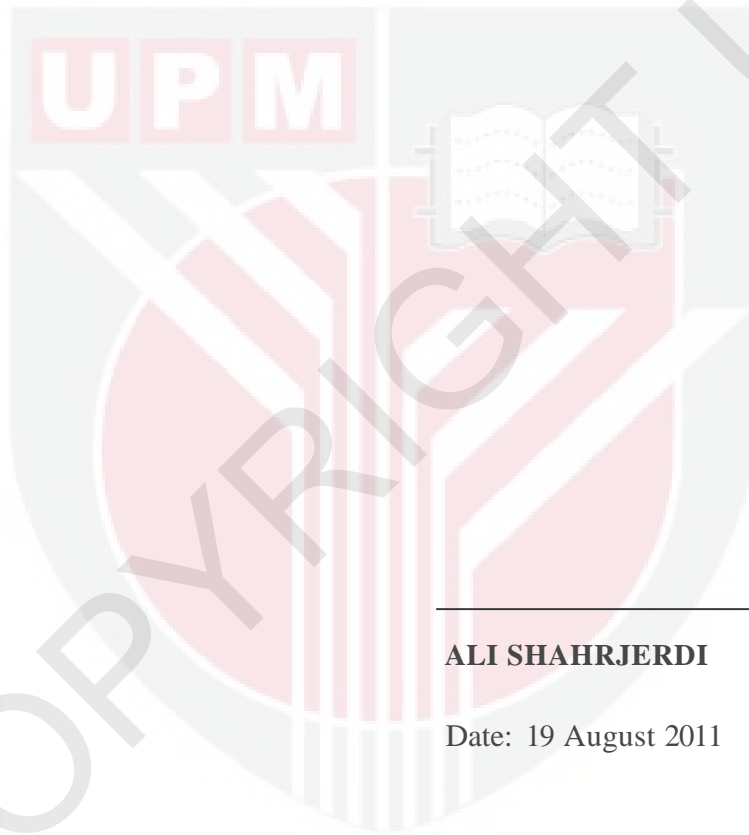


TABLE OF CONTENTS

ABSTRACT	Page
ABSTRAK	II
ACKNOWLEDGEMENTS	IV
APPROVAL	VI
DECLARATION	VII
LIST OF TABLES	IX
LIST OF FIGURES	XIII
LIST OF ABBREVIATIONS	XV
LIST OF NOTATIONS	XXI
	XXII

CHAPTER

1	INTRODUCTION	1
	1.1 General Introduction	1
	1.2 Overview of Plate Theories	4
	1.3 Functionally Graded Materials (FGMs)	6
	1.4 Advantages of Functionally Graded Materials	9
	1.5 Application of Functionally Graded Materials (FGMs)	10
	1.6 Problem Statement and Motivation for Research Study	16
	1.7 Objectives of the Research	17
	1.8 Scope of studies	17
	1.9 Thesis Layout	18
2	LITERATURE REVIEW	19
	2.1 Introduction	19
	2.2 Definition of Functionally Graded Materials	19
	2.3 Functionally Grade Material Properties Models	21
	2.4 Plate Theories	31
	2.4.1 Mechanical Behavior of FG Plates Using Classical Theory of Plates	32
	2.4.2 Mechanical Behavior of FG Plates Using Shear Deformation Theories	33
	2.4.3 Vibration and Dynamic Responses of FG Plates	39
	2.4.4 Displacements, Deflection and Stresses Distribution of FG Plates	44
	2.4.5 Second Order Shear Deformation Theory (SSDT) History	50
	2.5 Thermal Vibration In FGMs with Temperature-Dependent and Independent Material Properties	51
	2.6 Fabrication of Functionally Graded Materials (FGMs)	57
	2.6.1 Powder Metallurgy Methods	61
	2.6.2 Infiltration Method	62
	2.6.3 Graded Casting Process	63
	2.6.4 Plasma Spraying Technique	63
	2.6.5 Laser Cladding Method	65

2.6.6	Vapor Deposition Method	66
2.7	Summary	68
3	SECOND ORDER SHEAR DEFORMATION THEORY (SSDT) FOR FREE VIBRATION ANALYSIS ON A FUNCTIONALLY GRADED SQUARE AND RECTANGULAR PLATES	69
3.1	Introduction	69
3.2	Methodology	70
3.2.1	Gradation Relations	71
3.2.2	Displacement Field and Strains	74
3.2.3	Stress-Strain Relations	75
3.2.4	Equations of Motion and Minimum Potential Energy	76
3.2.5	Boundary Conditions	82
3.2.6	Navier's Solution	83
3.3	Validation and Numerical Results	87
3.3.1	Verification's References	87
3.3.2	Numerical Example and Discussion for the First Tenth Modes in Square and Rectangular FG Plates	88
3.4	Summary	98
4	TEMPERATURE DEPENDENT VIBRATION ANALYSIS OF FG RECTANGULAR AND SQUARE PLATES USING SECOND ORDER SHEAR DEFORMATION THEORY	100
4.1	Introduction	100
4.2	Methodology	101
4.3	Gradation Relations	102
4.4	Elastic Equations	104
4.4.1	Displacement Field and Strains	105
4.4.2	Stress-Strain Relations	105
4.4.3	Thermal Conditions	105
4.4.4	Uniform Temperature	105
4.4.5	Linear Temperature	106
4.4.6	Nonlinear Temperature	106
4.4.7	Heat Transfer Rate by Heat Flux	108
4.4.8	Sinusoidal Temperature Rise	108
4.5	Equations of Motion	109
4.5.1	Boundary conditions	113
4.5.2	Method of Solution	114
4.6	Validation and Numerical Results	117
4.6.1	Verification of Work	117
4.6.2	Numerical Results	118
4.7	Summary	134
5	STRESS AND DISPLACEMENT ANALYSIS A FUNCTIONALLY GRADED SQUARE AND RECTANGULAR PLATE USING SECOND ORDER SHEAR DEFORMATION THEORY	136
5.1	Introduction	136

5.2	Methodology	137
5.2.1	Gradation Relations	138
5.2.2	Theoretical Formulations	139
5.2.3	Displacement Field and Strains	139
5.2.4	Stress-Strain relations	140
5.3	Governing Equations	140
5.4	Boundary Conditions	142
5.4.1	Geometrical Boundary Conditions	143
5.4.2	Loading Conditions	143
5.4.3	Sinusoidal Load	144
5.4.4	Uniform Load	144
5.4.5	Hydrostatic Load	144
5.4.6	Point Load	145
5.5	Method of Solution	145
5.6	Validation and Numerical Results	148
5.6.1	Validation	148
5.6.2	Numerical Examples	151
5.6.3	Investigate the Effect of Different Loads in FG Square and Rectangular Plates	152
5.7	Summary	166
6	CONCLUSION AND RECOMMENDATIONS	169
6.1	Concluding Remarks	169
6.2	Contributions of Work	173
6.3	Recommendations and Suggestion	174
	REFERENCES	176
	APPENDICES	194
	APPENDIX A	195
	BIODATA OF STUDENT	199
	LIST OF PUBLICATIONS	200