

Contents

1	Approximate Evaluation of Eigenfrequencies.	1
1.1	Introduction	1
1.2	Formulation of the Eigenvalue Problem	3
1.3	Dunkerley's Procedure	4
1.4	The Question of Accuracy	8
1.5	The Root-Squaring Process	11
1.6	Application with Dissipative Systems	14
1.7	Applications with Continuous Systems	16
1.8	Summary and Conclusions.	20
	References	21
2	Variable Elasticity Effects in Rotating Machinery	25
2.1	Introduction	25
2.1.1	Variable Length l	27
2.1.2	Variable Stiffness EJ	27
2.1.3	Variable Mass or Moment of Inertia	28
2.2	The Problem of Stability	28
2.3	The Mathieu-Hill Equation	31
2.4	The Classical Floquet Theory.	32
2.5	Matrix Solution of Hill's Equation	35
2.6	Solution by Transition into an Equivalent Integral Equation	36
2.7	The Bwk Procedure	37
2.8	Vibrations of Different-Modulus Media.	38
	References	40

3	Mathematical Models for Rotor Dynamic Analysis	43
3.1	Introduction	43
3.2	The Single Disc Model	47
3.2.1	Critical Speeds	51
3.2.2	Internal Damping	52
3.2.3	Bearing Forces	52
3.2.4	Environmental Forces	54
3.2.5	Stability of Motion, Second-Order Equations	54
3.3	The Discrete Model	59
3.4	Summary and Conclusions	72
	References	73
4	Flow-Induced Vibration of Rotating Shafts	77
4.1	The Steam Whirl Problem	77
4.2	Stability Criteria	86
4.3	Rotor Dynamics for Annular Flows	94
4.4	Dynamics of a Hollow Rotor Partially Filled with a Liquid	102
	References	111
5	Heat-Flow-Induced Vibration of Rotating Shafts:	
	The Newkirk Effect	115
5.1	Introduction	115
5.2	Analytical Model	117
5.3	Modes of the Newkirk Effect	137
	Appendix: Numerical Example	141
	References	142
6	Dynamics of Cracked Shafts	145
6.1	Introduction	145
6.2	Local Flexibility of a Cracked Shaft	147
6.3	The Open Crack	150
6.4	The Closing Crack	154
	References	160
7	Identification of Cracks in Rotors and Other Structures	
	by Vibration Analysis	163
7.1	Flexibility Matrix of Cracked Structural Members	163
7.1.1	Prismatic Cracked Beam Element	165
7.1.2	Circular Cracked Rod	168
7.2	Direct Methods	173
7.2.1	Rotors with a Circumferential Crack	173
7.2.2	Beam with a Lateral Crack	178
7.2.3	Clamped Circular Plate with a Peripheral Surface Crack	186

7.3	The Eigenvalue Sensitivity Problem	189
7.3.1	Introduction	189
7.3.2	Rayleigh's Quotient	191
7.3.3	Torsional Vibration of a Cracked Rotor	193
7.3.4	Cracked Structural Members	195
7.4	Summary and Conclusions.	197
	References	198
8	Thermal Effects Due to Vibration of Shafts	203
8.1	Heat Propagation Due to Torsional Vibration of Shafts.	203
8.2	Heat Propagation in Rotating Shafts Due to Bending	211
8.3	Summary and Conclusions.	218
	References	218
9	Variational Formulation of Consistent: Continuous Cracked Structural Members	221
9.1	Variational Formulation of Cracked Beams and Rods.	221
9.2	Lateral Vibration of a Continuous Cracked Beam.	222
9.2.1	The Variational Theorem for a Simply Supported Beam.	222
9.2.2	The Crack Disturbance Function	229
9.2.3	Natural Frequencies of Cracked Beams.	233
9.2.4	The Beam with Lumped Crack Flexibility.	234
9.2.5	The Finite Element Method	239
9.2.6	Experimental Procedure.	239
9.3	Torsional Vibration of a Continuous Cracked Rod	240
9.3.1	The Variational Theorem for a Cracked Rod in Torsion	240
9.4	Summary and Conclusions.	248
	References	249
10	The Variational Formulation of a Rod in Torsional Vibration for Crack Identification	251
10.1	Dynamic Behaviour of Cracked Shafts	251
10.2	Torsional Vibration of a Continuous Cracked Shaft: Variational Theorem	255
10.2.1	Cracked Rod-Variational Theorem	255
10.2.2	The Crack Disturbance Function	257
10.2.3	The Differential Equation of Motion.	258
10.2.4	Boundary Conditions	259
10.2.5	Torsional Natural Frequencies of the Cracked Rod-Rayleigh Quotient	260

10.3	Finite Element Analysis of a Vibrating Cracked Rod	263
10.4	Summary and Conclusions.	265
	References	266
Index	269

Analytical Methods in Rotor Dynamics

Second Edition

Dimarogonas, A.D.; Paipetis, S.A.; Chondros, Th.G.

2013, XIV, 274 p. 111 illus., 3 illus. in color., Hardcover

ISBN: 978-94-007-5904-6