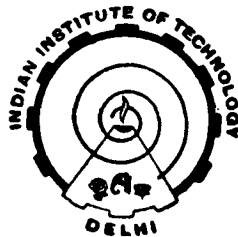


VIBRATORY STRESS ANALYSIS AND FATIGUE LIFE ESTIMATION OF TURBINE BLADE

By
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A Thesis Submitted
in fulfilment of the requirements of the degree
of
DOCTOR OF PHILOSOPHY



Department of Mechanical Engineering
INDIAN INSTITUTE OF TECHNOLOGY DELHI
1986

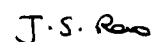
to my parents

CERTIFICATE

This is to certify that the thesis entitled 'VIBRATORY STRESS ANALYSIS AND FATIGUE LIFE ESTIMATION OF TURBINE BLADE' by Nalinaksh S. Vyas has been prepared under our supervision in conformity with the rules and regulations of the Indian Institute of Technology, Delhi. We further certify that the thesis has attained a standard required for a Ph.D. degree of the Institute. The results contained in this thesis have not been submitted, in part or full, to any other university for any degree or diploma.



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ACKNOWLEDGEMENTS

I express my gratitude to Dr. J.S. Rao, Professor, Deptt. of Mech. Engg. and currently Science Counsellor, Embassy of India, Washington for the motivation and direction, I received from him during the entire course of my post-graduate studies.

I am thankful to Dr.K.Gupta, Asstt. Professor, Deptt. of Mech. Engg. for his rigorous guidance and constant encouragement during the course of study.

I also wish to thank Dr. E. Raghavacharyulu, Asstt. Professor, Deptt. of Mech. Engg. and Dr. P.C. Dumir, Asstt. Professor, Deptt. of Applied Mechanics for their suggestions and help.

I have received whole-hearted co-operation from Messrs. H.L. Sharma, Joginder Kumar, Gamdur Singh, K.N. Madhu and Diwan Singh of the Vibration and Instrumentation Lab., in carrying out the experimental work. Mr. K.N. Madhu has been a teacher to me in the laboratory. I wish to record my gratitude towards him.

Thanks are due to the Aeronautical Research and Development Board, Ministry of Defence, for their financial assistance and Bharat Heavy Electricals Ltd., Hyderabad for the help in fabrication of the test rig.

Finally, I take this opportunity to thank Smt. J. Indira Rao for her affection, I received during this period.

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ABSTRACT

Analysis of vibratory stress behaviour of a turbine blade has been attempted through theoretical and experimental models. Reissner's dynamic functional in conjunction with Ritz process has been employed to set up the eigenvalue problem for a practical case of a tapered, twisted, asymmetric aerofoil cross-section blade mounted on a rotating disc at a stagger angle. Taking experimentally generated nozzle excitation data in Fourier form and viscous damping, the problem of forced vibration is formulated. Modal analysis technique is used to obtain the decoupled equations of motion. Experimentally generated modal damping data is employed in obtaining the blade response in terms of displacements and moments. Blade stresses, obtained using Strength of Materials formulae, are analysed as functions of rotor speed, blade geometry, vibrational modes and nozzle excitation.

An experimental rig has been set-up to conduct investigations on rotating turbine blades. Nozzle excitation is simulated by use of electromagnets. The excitation is distributed over the blade length. Strain-gauge technique is employed for measurement of blade strains. Investigations are also carried out on blade damping. Damping data is generated for different blade vibratory modes as function of

rotor speed and strain amplitude. Blade strains are obtained for different harmonics of nozzle excitation at various rotor speeds. Comparisons are made between the theoretical and experimental stress harmonics.

A theoretical analysis of the transient response of blade during step-up and step-down operations of a turbomachine is made. Initially the response of a stationary plane cantilever beam to a force with variable excitation frequency is obtained using Duhamel's integral. The analysis is extended to the case of an actual turbine blade rotating with constant angular acceleration, to obtain resonant stress levels.

On the basis of the stress analysis done and using known fatigue theories, a fatigue life estimation procedure is outlined. Numerical examples worked out for the test blade under laboratory conditions of operation are presented.

CONTENTS

CHAPTER	Page
Certificate	(i)
Acknowledgements	(ii)
Abstract	(iii)
Contents	(v)
List of Figures	(ix)
List of Photographs	(xi)
List of Tables	(xii)
Nomenclature	(xiii)
1. INTRODUCTION	1
2. LITERATURE REVIEW	5
2.1 Free Vibration Characteristics	5
2.1.1 Continuum Model Approach	6
2.1.2 Discrete System Models	10
2.1.3 Small-Aspect Ratio Blades	13
2.2 Damping	15
2.3 Forced Vibrations	18
3. USAGE OF VARIATIONAL METHODS FOR FORCED VIBRATION ANALYSIS	22
3.1 Bending Vibrations	24
3.1.1 'Exact' Method	25
3.1.2 Lagrange Method	27

3.1.3	Reissner Method	30
3.2	Torsional Vibrations	33
3.2.1	'Exact' Method	34
3.2.2	Lagrange Method	35
3.2.3	Reissner Method	36
3.3	Illustration	37
4.	APPLICATION OF REISSNER METHOD TO A TURBINE BLADE SUBJECTED TO DISTRIBUTED NOZZLE EXCITATION	44
4.1	Reissner's Dynamic Functional-Formulation	45
4.1.1	Displacements	45
4.1.2	Non-Zero Strains and Stresses	45
4.1.3	Bending Moments and Shear Forces	47
4.1.4	Strain Energy	48
4.1.5	Complementary Energy	49
4.1.6	Body and Traction Forces	51
4.1.7	Kinetic Energy	53
4.2	Derivation of State Equations	55
4.3	Damping	63
4.4	Modal Analysis	64
4.5	Computer Program	67
4.6	Theoretical Results	68
5.	EXPERIMENTAL INVESTIGATIONS	86
5.1	The Rig	88
5.1.1	Overhung Disc and Rotor Shaft	88
5.1.2	Blades	88
5.1.3	Bearings	88

5.1.4	Motor	92
5.1.5	Vacuum Chamber	92
5.2	Instrumentation	92
5.3	Nozzle Passing Excitation	93
5.3.1	Electromagnets	99
5.3.2	Calibration of Magnetic Forces	99
5.4	Balancing of Rotor	106
5.5	Strain Measurements	106
5.6	Damping Measurements	114
5.7	Results and Discussion	120
6.	TURBINE BLADE RESPONSE DURING STEP-UP AND STEP-DOWN OPERATIONS	133
6.1	Response of A Uniform Cantilever Beam to A Force with Constantly Varying Excitation Frequency	133
6.2	Response of Accelerating Turbine Blade under NPF Excitation	141
7.	FATIGUE LIFE ESTIMATION	154
7.1	Fatigue Considerations	155
7.1.1	Bagci's Fatigue Failure Surface Line	155
7.1.2	Miner's Cumulative Rule	159
7.1.3	Endurance Limit Modifying Factors	159
7.2	Mean Stress due to Blade Rotation	162
7.3	Illustrations	162
7.3.1	Fatigue Life Estimation for Constant Speed Rotation	166

7.3.2 Fatigue Damage during Start-up, Shut-Down Operations	169
7.3.3 High-speed rotation	175
7.4 Remarks	176
8. CONCLUSIONS AND SCOPE FOR FUTURE WORK	177
REFERENCES	179
PUBLICATIONS	197