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بالرسالة صفحات لم ترد بالأصل

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ROTOR DYNAMIC ANALYSIS USING TRANSFER MATRICES

BY

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THESIS

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ABSTRACT:

Rotor dynamic analysis is considered the most important part of the design of rotating machinery. A proper estimation of rotor-bearing system parameters leads to a safe and durable operation.

Transfer Matrix models of rotor-bearing systems are widely used to perform the critical speeds, unbalance response, and stability analysis of rotating machinery. It is also capable of handling many complicated rotors with a relatively simple models and satisfacting results.

This thesis demonstrates the transfer matrix method with its types of models namely the Lumped and Continuous models. Critical speed analysis is performed using these models showing the difference in modeling procedure and results obtained. The difference in results is then explained using an order of magnitude analysis of the distinctive quantities impeded in transfer matrices of the continuous and lumped models.

Also a new technique is introduced in the stability analysis to evaluate the complex frequencies of the rotor-bearing system using the continuous approach. A first step solution is performed using continuous rotor model with the application of Transfer Matrix Polynomial method to obtain preliminary values for complex frequencies. Which in turn are entered to the continuous scheme program as initial guesses to extract the continuous approach results.

The unbalance response of rotors due to disk eccentricity is obtained without increasing the dimension of the transfer matrices. The presented method allows to investigate the case of more than one eccentric disk with phase shift in direction of eccentricity using a single rotor analysis.

CONTENTS

Nomenclature

ω	Rotor whirling speed (rad/s)
Ω	Rotor spin rate (rad/s)
$\underline{S}$	State vector
m_f	Field mass (Kg)
m	Disk mass (Kg)
I_d	Disk diameteral moment of inertia (Kg m^2)
I_p	Disk polar moment of inertia (Kg m^2)
ρ	Field density (Kg/m^3)
ρ_d	Disk density (Kg/m^3)
E	Young's modulus (N/m^2)
q	Complex frequency (rad/s)
K_{ij}	Stiffness in i direction due to displacement in j direction (N/m)
C_{ij}	Viscous damping in i direction due to velocity in j direction (N s/m)
A_c	Cross sectional area of the field (m^2)
M	Bending moment (N m)
V	Shear force (N)
θ	Slope angle in x-y plane (rad)
ϕ	Slope angle in x-z plane (rad)
I	Field area moment of inertia (m^4)
L	Field length (m)
J	Field diameteral inertia per unit length (kg m)
t	Time (s)

G	Field modulus of rigidity	(N/m^2)
K	Shear factor	
Δ	Unbalance eccentricity of disk (m)	
d	Field diameter	(m)

Superscripts;

$\cdot$	Derivative with respect to time
$*$	Dimensionless form
L	Variable at left end
R	Variable at right end

Subscripts;

i	Variable in i^{th} station
y	Variable in y direction
z	Variable in z direction

CHAPTER I

INTRODUCTION

The calculation of critical speeds of rotary systems and prediction of system stability are important parts in rotor design. In the power generation field, the ratio of power generated per (Kg) of rotating elements has been increased steadily. As a consequence, engines are designed to operate in the super critical speed regime. An important part of engine design and development is the calculation of critical speeds and the forced response within the operating speed range. In addition, the investigation of the dynamic stability of rotor-bearing systems is also necessary. Engines which incorporate journal bearings, intershaft viscous dampers, internal shaft damping, drum rotor rubbing or aerodynamic excitation experience dynamic instability and self-excited vibration.

Generally there are three types of procedures for analysis,

* Continuum theory
* Finite element theory
* Transfer matrix theory

The transfer matrix method is widely used to find critical speeds and to predict stability of rotor-bearing systems as well. This is due to the simplicity of its application on general types of rotor-bearing systems, as it reveals a significant saving in computational time .