Thesis

Title

A Thesis for the ...

POLITÉCNICA

Technical University of Madrid
Departamento de Matemática Aplicada a la Ingeniería Aeroespacial

Author:

Advisor:

September 18, 2022

Abstract

The objective of this thesis...

Key words: LPT, bladed-disk, flutter, vibration, bifurcation, dynamical systems, traveling wave.

Contents

Abstract iii

List of Figures vi

List of Tables ix

Nomenclature xi

1 Introduction 1

1.1 Goals of the Study 1

1.2 Outline of the Thesis 1

2 Chapter 2 3

2.1 Elastic problem 3

2.2 Aerodynamic Forces 3

2.3 Mistuning 3

2.4 Friction Forces 3

3 Chapter 3 5

3.1 Mass-Spring Model 5

3.2 Asymptotic Model 5

3.2.1 First Modal Family 5

3.2.2 Friction Model: Microslip Regime 5

3.2.3 Multiple Scales Asymptotic Technique 5

3.3 Numerical Implementation 5

3.3.1 Numerical Scheme . . . 5
3.3.2 Initial Parameters . . . 5
3.3.3 Mistuning . . . 5
3.3.4 Friction . . . 5
3.3.5 Simulations . . . 5

4 Chapter 4 **7**

4.1 Stability of the Periodic Solutions . . . 7
4.1.1 Stability in TW Basis . . . 7
4.1.2 Stability Results of the Periodic Solutions . . . 7
4.2 Continuation of Quasi-periodic Solutions . . . 7
4.2.1 Setting the Equations for the Continuation Software . . . 7

5 Chapter 5 **9**

5.1 Summary of the Main Contributions . . . 9
5.2 Suggestions for Further Work . . . 9

A Appendix **11**

A.1 Installation and Setup . . . 11
A.2 Configuration of the AUTO files . . . 11
A.2.1 Modification to the Compiler Files . . . 11
A.2.2 Configuration File and .f90 Function . . . 11
A.2.3 AUTO Run . . . 11

List of Figures

List of Tables

Nomenclature

Chapter 2

$[M]$ Mass matrix of the bladed-disk

Chapter 3

$[\circ]^H$ Complex conjugate transpose

Chapter 4

k Wave number

Acronyms

CFD Computational Fluid Dynamics

TW Travelling Wave

Chapter 1

Introduction

1.1 Goals of the Study

1.2 Outline of the Thesis

Chapter 2

Chapter 2

2.1 Elastic problem

2.2 Aerodynamic Forces

2.3 Mistuning

2.4 Friction Forces

Chapter 3

Chapter 3

3.1 Mass-Spring Model

3.2 Asymptotic Model

3.2.1 First Modal Family

3.2.2 Friction Model: Microslip Regime

3.2.3 Multiple Scales Asymptotic Technique

3.3 Numerical Implementation

3.3.1 Numerical Scheme

3.3.2 Initial Parameters

3.3.3 Mistuning

3.3.4 Friction

3.3.5 Simulations

Chapter 4

Chapter 4

4.1 Stability of the Periodic Solutions

4.1.1 Stability in TW Basis

4.1.2 Stability Results of the Periodic Solutions

4.2 Continuation of Quasi-periodic Solutions

4.2.1 Setting the Equations for the Continuation Software

Chapter 5

Chapter 5

5.1 Summary of the Main Contributions

5.2 Suggestions for Further Work

Appendix A

Appendix

A.1 Installation and Setup

A.2 Configuration of the AUTO files

A.2.1 Modification to the Compiler Files

A.2.2 Configuration File and .f90 Function

A.2.3 AUTO Run

Bibliography

Jack K Hale and Hüseyin Koçak. *Dynamics and bifurcations*, volume 3. Springer Science & Business Media, 2012.

Oualid Khemiri, Carlos Martel, and Roque Corral. Forced response of mistuned bladed disks: quantitative validation of the asymptotic description. *Journal of Propulsion and Power*, 30(2):397–406, 2014.

Carlos Martel and JJ Sánchez-Álvarez. Maximum mistuning amplification of the forced response vibration of turbomachinery rotors in the presence of aerodynamic damping. *Journal of Sound and Vibration*, 397:108–122, 2017.

Carlos Martel, Roque Corral, and Rahul Ivaturi. Flutter amplitude saturation by nonlinear friction forces: Reduced model verification. *Journal of Turbomachinery*, 137(4), 2015.

Ulf Olofsson. Cyclic micro-slip under unlubricated conditions. *Tribology International*, 28(4):207–217, 1995.

George F Simmons. *Differential equations with applications and historical notes*. CRC Press, 2016.

Steven H Strogatz. *Nonlinear dynamics and chaos: with applications to physics, biology, chemistry, and engineering*. CRC Press, 2018.