Modeling and evolutionary optimization for rotor dynamics

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Abstract

This research aims to develop a new evolutionary structural optimization approach for rotor dynamics problems using a bidirectional strategy named BESO - Bidirectional Evolutionary Structural Optimization. The BESO method is based in a sensitivity analysis which is done using a numerical model of the rotor dynamic systems. In this work, a study about the modeling of rotating structure is presented considering the basic formulation of rotor dynamics where shafts, disks and bearings are modeled using finite element method. In order to check the validity of the implemented models, problems involving basic configurations of beams and simple rotors are solved. A Matlab solver was created including a pre-post processing routines and a Campbell diagram solver.

Key words: Rotor dynamics, Evolutionary Method, Structural Optimization.

Introduction

Rotating machines are composed of a shaft, disks and bearings. Their applications are multiples: gas turbines, hydroelectric plants, compressors, etc. Their efficiency and reliability are crucial but various problems such as resonance, large deformation or large unbalance response can affect them. Therefore it is important to develop tools to predict their dynamic behavior and tools to design machines with innovative topologies. Besides, the structural optimization of a rotor can minimize noise and vibrations.

The overall aim of this project is to develop a methodology to simulate and optimize rotor dynamics problem. Initially we will model, validate and analyze the dynamic behavior of rotors involving simple bearings, shafts and discs.

Results and Discussion

The first part of the project was to implement a Matlab interface, shown in Figure 1, in order to build models of rotors. Materials, geometry and boundary conditions data are informed by the user. The user can visualize the model and a input data file is generated to the solver.

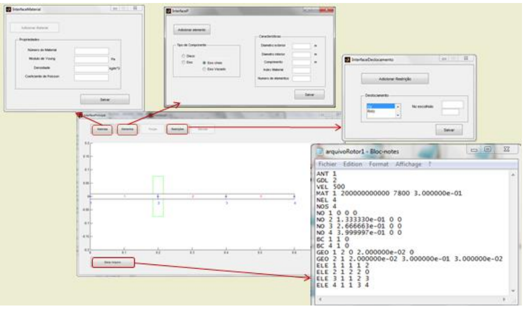

Figure 1. Overview of the pre-processor interface

The finite element method was used to model the shaft as Timoshenko beam elements, the discs as punctual masses[1] and the bearings as rigid. The calculation of the natural frequencies and bending modes was implemented considering a 4 degrees of freedom per node model (2 displacements and 2 rotations) including gyroscopic effects. A Campbell diagram was plotted in order to identify the critical rotor speed, as shown in Figure 2.

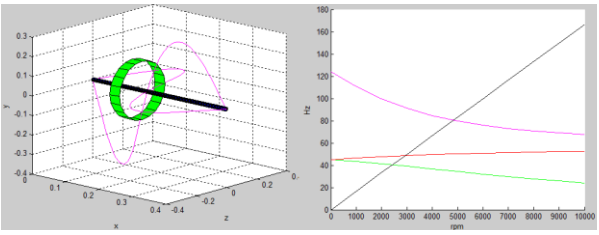

Figure 2. Bending mode of a static rotor (left) and Campbell Diagram (right).

Conclusions

The analysis of the dynamic behavior of rotors has been realized successfully and we are now able to calculate their critical speeds and corresponding mode shapes. The next steps will be to do a sensitivity analysis of the dynamic response and to apply an Evolutionary optimization method, first for beams in bending and then for rotor dynamics.

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[1]Lalanne, M., Ferraris, G.; "Rotordynamics Prediction in Engineering", John Wiley & Sons, **1990**.