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Kinematic Excitation of the Rotor

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Abstract: Dynamic response of rotor with kinematically excited support is investigated. The finite element method model was set up and results were validated using MSC.Adams software.

Introduction

The work deals with rotor dynamics problem. Dynamic response of rotor with kinematically excited support is investigated. The studied case can represent for example a turbocharger that is component of an engine. Vibration of the engine is transported to the rotor of turbocharger through bearings. The finite element method model was prepared and results were validated using the MSC.Adams software. The finite element method describes the shaft [1], the disc is assumed to be rigid. The complete model of rotor with discs and bearings is studied, including modal analysis and simulation of motion [2]. All computation is performed using the math software Scilab [3].

The current work concentrates on problems which arise when body rotates. Therefore, the physical model considers internal material damping and gyroscopic effect. The most important phenomenon in rotor dynamics is the non-constant critical speed and area of instability.

Model of rotor

The rotor is described using the finite element method in Scilab. Only beam elements are used. The obtained results were compared with those of solid FEM model in NASTRAN software. During this tuning stage, only static analysis was performed. Simulation in Scilab was preceded by such tuning procedure.

Our contribution divides into three parts:

- The first part of work describes finite element model of rotor.
- Next, the natural frequencies and stability of rotor are studied.
- The last part is devoted to the simulation of motion and comparing all results.

The basic equation of motion which describes the rotor system can be schematically written as:

$$\mathbf{M}\ddot{\mathbf{q}} + (\mathbf{B}_\mathbf{E} + \mathbf{B}_\mathbf{I} + \omega_0\mathbf{G})\dot{\mathbf{q}} + (\mathbf{K} + \omega_0\mathbf{K}_\mathbf{I})\mathbf{q} = \mathbf{F}(t) \tag{1}$$

In Eq. 1 is denoted: matrix of mass $\mathbf{M}$, matrix of external damping $\mathbf{B}_\mathbf{E}$, matrix of gyroscopic effect $\mathbf{G}$ and matrix of stiffness $\mathbf{K}$, vector of displacements $\mathbf{q}$ and vector of kinematical excitation $\mathbf{F}(t)$. Physical model considers internal damping. This effect is described by matrix of internal damping $\mathbf{B}_\mathbf{I}$ and circular matrix $\mathbf{K}_\mathbf{I}$. In rotor dynamics, the physical model depends on the rotor speed ω_0. Maximal speed of experimental rotor is 318 rps, but in the numerical experiments the speed range from 0 to 500 rps was considered. The frequency of kinematic excitation can be arbitrary, but only the range from 0 to 500 Hz was studied.

Results

The transfer function of disc 1 in radial displacement for varying rotor speed and different frequency vibration of support is displayed in Fig. 1. The area of resonance is white and the area of antiresonance is black. Resonance and antiresonance are next to each other somewhere and it is very interesting result. Resonance can be like forward precession (FP) or backward precession (BP). The value of displacement is in logarithmic value, "A" is amplitude of motion of disc, "A_{ref}" is amplitude of kinematic excitation. MSC.Adams confirmed the results in simulation experiment. This research shows us safe areas and danger areas of using rotor.

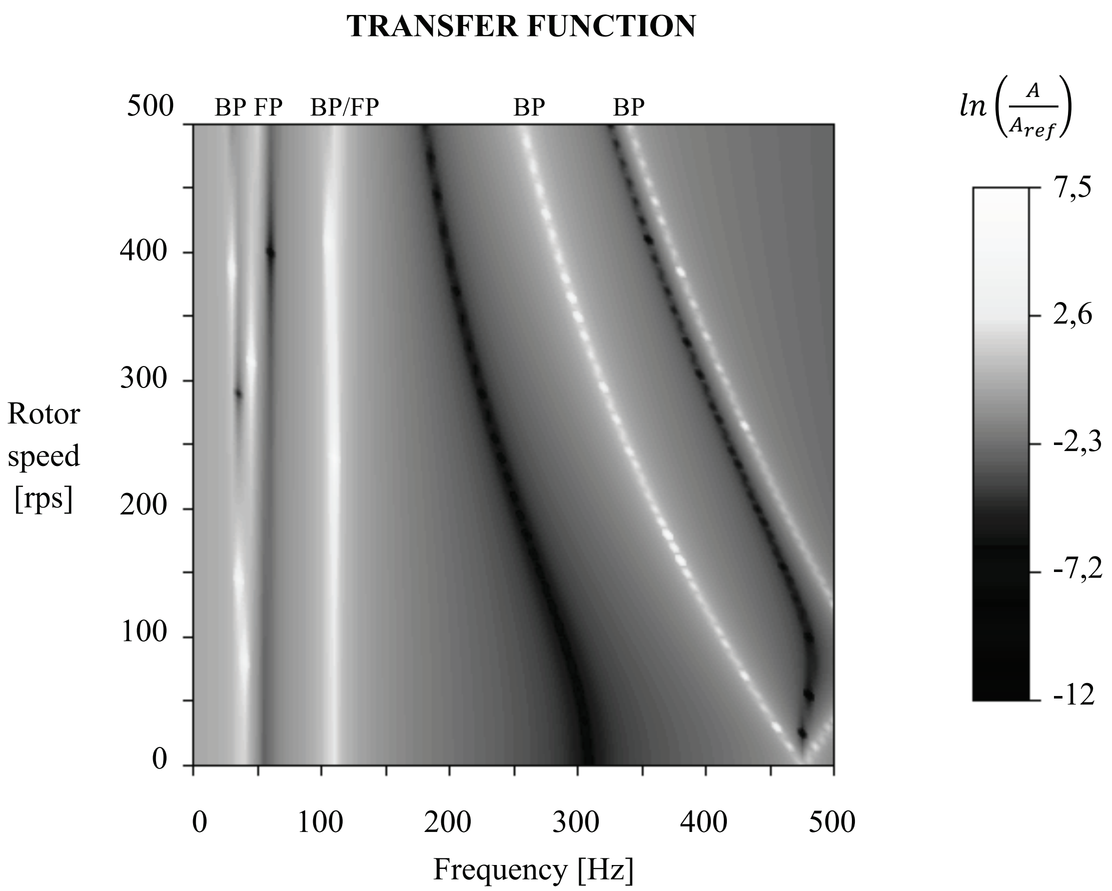

Fig.1: Response of system

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References

[1] J. Slavík, V. Stejskal, V. Zeman, Základy dynamiky strojů. ČVUT, Praha 1997.

[2] M. Byrtus, M. Hajžman, V. Zeman, Dynamika rotujících soustav. ZČU, Plzeň 2010.

[3] Information on http://www.scilab.org/ (cited in March 2015)