Features of precession of a flexible rotor with a different number of elastic supports located with a clearance in the plane of rotation

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Abstract. A design model of a rotary system in the form of a cantilevered flexible shaft with a massive disk at the free end is considered. In the plane of rotation of the disk, point elastically damped supports are discretely located with a clearance, stabilizing the vibrations of the rotor in the supercritical zone. The influence of a different number of supports on the evolution of the rotor precession in the supercritical zone after the Poincare-Andronov-Hopf bifurcation is investigated. The effect of the clearance and friction at the contact of the disk with the supports on the precessional movement of the rotor is analyzed.

Introduction

The supercritical behavior of a rotor system in the form of a cantilevered fixed flexible shaft with an unbalanced disk at the free end is investigated (Figure 1). To stabilize the amplitudes of transverse vibrations of the rotor in the plane of rotation of the disk, point viscoelastic supports are discretely installed with a radial clearance [1]. Three options for the placement of supports are considered: one support, two supports – on opposite sides of the disk, three supports at an angle of $2\pi/3$ relative to each other. The distributed mass of the rotor shaft and the internal friction of the material are taken into account according to the Voigt elastic-viscous body model. With normal contact of the rotor with the support, normal (elastic) forces in the support and tangential forces (dry friction) arise.

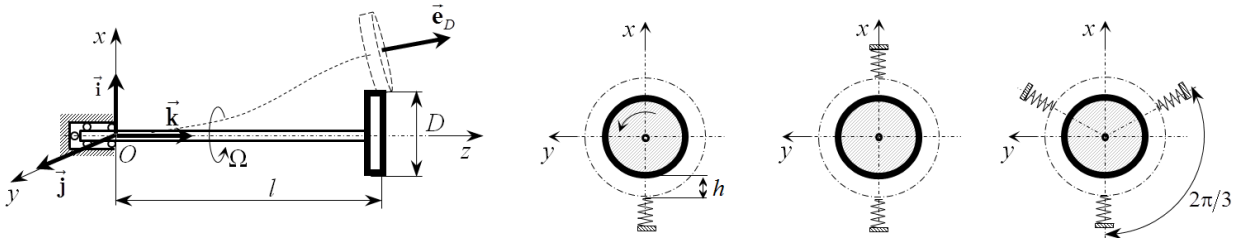

Figure 1: Design scheme.

Differential equations describing transverse radial and angular oscillations of the rotor during its rotation are obtained, taking into account gyroscopic moments from the disk and circulation forces caused by internal friction. For subsequent discretization and construction of a finite element model of the rotor, the solution is obtained using the Green function for the Bernoulli-Euler rod. A generalizing definition of the rotor precession index is introduced, which makes it possible to calculate the frequency and direction of precession from information about transverse vibrations of the rotor in two mutually perpendicular directions. For all the cases under consideration, the evolution of precession and the spectral composition of precession motion oscillations after the Poincare-Andronov-Hopf bifurcation are analyzed [2, 3].

Results and discussion

The main attention in the work is paid to determining the type of precession of the rotor without calculating its full spectrum, which makes it possible to directly determine precession in the case of nonlinear interaction with additional supports. For the case of a single support, it is established that, depending on the eccentricity of the disk and the supercritical velocity, both periodic modes and non-periodic rotor oscillations can occur. In the case of two supports, a backward whirling of the rotor occurs. In the case of three supports, a stable backward whirling (close to synchronous) is maintained at a certain level of rotor imbalance. The greatest amplitude of oscillations of the angular velocity of the precession of the rotor occurs at the whirling frequency multiplied by the number of viscoelastic supports installed with an initial clearance.

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References

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