Rotor Vibrations when touching the Fixed and Floating System Elements

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Abstract

At the constant contact of the rotor with elements of the rotor system the two different situations can arise: 1) the rotor touching with a fixed or resiliently fixed rigid stator; and 2) the rotor touching with the light moving elements (floating seals, hydrostatic bearings with a floating sleeve). In the first case, a rolling of the rotor along the stator occurs with the backward whirling and a large angular velocity. In the second case, there is a "running' regime of the ring around the rotor with the direct whirling ("hula-hoop" type oscillations). For these regimes the analytical solutions, as well as experimental results are presented.

Rolling the rotor along the fixed stator occurs when the oil layer is insufficient. The motion equation for an unbalanced rotor describes the rolling angular velocity of the rotor with account for the slip at the contact moment. It is an essentially nonlinear equation [1]. An analytical solution is found for the rolling velocity. It is shown that this velocity is the imposition of small oscillations on the average velocity, which depends on the rotation speed and the system parameters. The trajectory of the rotor eccentric point is a hypotrochoid and its loops number decreases with increasing of rotation speed. With a small imbalance, the average speed is close to the rotor natural frequency. In this case, the normal reaction between the rotor and the stator is zero, so occur the permanent micro-impacts of the rotor and stator. As the rotation speed increases, the rolling mode is replaced by a vibro-impact mode. In the case of an anisotropic support, a two-shock regime arises in the plane of least rigidity.

Permanent contact of the rotor at its rotating inside the light floating elements. In this case, there is a "running" regime of the ring around the rotor. An unbalanced rotor performs a "lunar" motion, so that the contact of the floating ring with the rotor occurs all the time at the identical rotor point, farthest from the rotation center; it determines the specificity of the rotor systems [2]. The trajectory of the ring points is an epitrochoid, since the ring center performs a direct whirling (in contrast to the rolling regime).

The dynamic analysis of the running regime was performed taking into account the dry friction arising at the contact moment, as well as the hydrodynamic forces in the gap between the rotor and the ring. The oscillation equation of the "rotor-ring" system describes the angle between the line connecting the ring - rotor geometric centers, and the vertical. Assuming the hydrostatic forces proportional to the square of the rotation speed, we find that the trajectory of the ring points in its absolute motion relative to the system rotation center is an epitrochoid with one loop only. The average velocity of ring running in case of an ideal fluid is close to the ring natural frequency at a given rotational speed for a wide range of the system parameters. In this case, as well at rolling mode, arise the permanent micro-impacts between the rotor and the ring.

The obtained analytical results were confirmed experimentally.

References

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