THE INVESTIGATION OF ANGULAR OSCILLATIONS OF THE CENTRIFUGAL PUMP ROTOR IN ANNULAR SEALS

Sahalaeva I.A., student, SumSU, Sumy

Analysis of differential equations that describe the radial-angular oscillations of the centrifugal pump rotor in annual seals with the account of radial hydrodynamic forces, moments and inertia of the disk rotation represents mathematical difficulties. Therefore, it is convenient to consider simpler partial systems, committing only radial and angular oscillations.

The consideration of independent angular oscillations represents a methodical and a cognitive interest. As compared with radial oscillations, the angular oscillations have characteristic which appears due to the influence of the gyroscopic moment of the disk. This is most clearly manifested in the influence of rotor oscillations in the air. Therefore to assess the quality of the influence of the gyroscopic moment of the disk is considered an idealized model of the rotor which shown in Fig. 1. This model performs independent angular oscillations in the air (without hydrodynamic moments that arise in the annular seals).

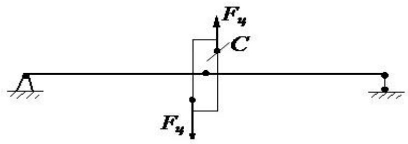

Figure 1 – The models of rotors with only angular oscillations

Angular oscillations of the centrifugal pump rotor in the annual seals are written as an equation in compressed form:

$$\ddot{\theta} + b_{20}\dot{\theta} + \Omega_{\vartheta 0}^{2}\theta \mp i b_{40}\dot{\theta} = (1 - j_0)\omega^2 \left|\gamma^*\right| e^{i\omega t},$$

or in projections:

$$\ddot{\theta}_x + b_{20}\dot{\theta}_x + \Omega_{\vartheta 0}^{2}\theta_x + b_{40}\dot{\theta}_y = (1 - j_0)\omega^2 \gamma_x^*,$$

$$\ddot{\theta}_y + b_{20}\dot{\theta}_y + \Omega_{\vartheta 0}^{2}\theta_y - b_{40}\dot{\theta}_x = (1 - j_0)\omega^2 \gamma_y^*;$$

$$\lambda = -n \pm is, \quad \bar{s} = s_{\vartheta 0}/\Omega_{\vartheta 0}, \quad \bar{\omega}_{\vartheta} = \omega/\Omega_{\vartheta 0}.$$

It is interesting to analyze the influence of dimensionless parameter j_0, which is equal to the ratio of the polar moment of inertia to the equatorial $j_0 = I_0/I$ on natural frequencies of angular oscillations. Fig. 2 shows the frequency diagrams which are constructed for different values of parameter j_0.

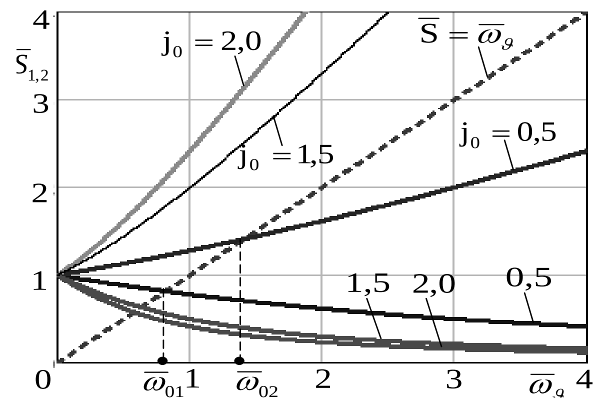

Figure 2– The influence of parameter $j_0 = I_0/I$ on natural frequencies of angular oscillations

With increasing parameter j_0 the first frequency decreases, and the second frequency increases in comparison with the natural frequency $\Omega_{\vartheta 0}$ of angular oscillations of nonrotating rotor. The intersection of the natural frequencies with a straight line $\bar{s} = \bar{\omega}_{\vartheta}$ gives the values of the critical frequencies. The values of the critical frequencies can be determined by the following formulas (dimensionless form):

$$\overline{\omega}_{01} = -\overline{\omega}_{03} = \frac{1}{\sqrt{1 + j_0}}, \quad \overline{\omega}_{02} = -\overline{\omega}_{04} = \frac{1}{\sqrt{1 - j_0}}$$

The real values of the frequencies $\overline{\omega}_{02}$, $\overline{\omega}_{04}$ are provided on condition that $j_0 < 1$. Positive critical frequencies correspond to the direct precession, negative – to the retrograde precession. The larger parameter j_0 is, the higher are the natural frequencies. So, for independent angular oscillations of the rotor in the air two critical frequencies for both direct and retrograde precessions are possible only for drum-type rotor with polar inertia moment smaller than the equatorial: $I_0 < I$.

The paper was performed under supervision of prof. Martsinkovsky V.A.