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Rotary Machine Sealing Oscillation Frequencies and Phase Shift Analysis

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Abstract : To ensure the gas transmittal GCU's efficient operation, leakages through the labyrinth packings (LP) should be minimized. Leakages can be minimized by decreasing the LP gap, which in turn depends on thermal processes and possible rotor vibrations and is designed to ensure absence of mechanical contact. Vibration mitigation allows to minimize the LP gap. It is advantageous to research influence of processes in the dynamic gas-structure system on LP vibrations. This paper considers influence of rotor vibrations on LP gas dynamics and influence of the latter on the rotor structure within the FSI unidirectional dynamical coupled problem. Dependences of nonstationary parameters of gas-dynamic process in LP on rotor vibrations under various gas speeds and pressures, shaft rotation speeds and vibration amplitudes, and working medium features were studied. The programmed multi-processor ANSYS CFX was chosen as a numerical computation tool. The problem was solved using PNRPU high-capacity computer complex. Deformed shaft vibrations are replaced with an unyielding profile that moves in the fixed annulus "up-and-down" according to set harmonic rule. This solves a nonstationary gas-dynamic problem and determines time dependence of total gas-dynamic force value influencing the shaft. Pressure increase from 0.1 to 10 MPa causes growth of gas-dynamic force oscillation amplitude and frequency. The phase shift angle between gas-dynamic force oscillations and those of shaft displacement decreases from 3π/4 to π/2. Damping constant has maximum value under 1 MPa pressure in the gap. Increase of shaft oscillation frequency from 50 to 150 Hz under P=10 MPa causes growth of gas-dynamic force oscillation amplitude. Damping constant has maximum value at 50 Hz equaling 1.012. Increase of shaft vibration amplitude from 20 to 80 µm under P=10 MPa causes the rise of gas-dynamic force amplitude up to 20 times. Damping constant increases from 0.092 to 0.251. Calculations for various working substances (methane, perfect gas, air at 25 ˚C) prove the minimum gas-dynamic force persistent oscillating amplitude under P=0.1 MPa being observed in methane, and maximum in the air. Frequency remains almost unchanged and the phase shift in the air changes from 3π/4 to π/2. Calculations for various working substances (methane, perfect gas, air at 25 ˚C) prove the maximum gas-dynamic force oscillating amplitude under P=10 MPa being observed in methane, and minimum in the air. Air demonstrates surging. Increase of leakage speed from 0 to 20 m/s through LP under P=0.1 MPa causes the gas-dynamic force oscillating amplitude to decrease by 3 orders and oscillation frequency and the phase shift to increase 2 times and stabilize. Increase of leakage speed from 0 to 20 m/s in LP under P=1 MPa causes gas-dynamic force oscillating amplitude to decrease by almost 4 orders. The phase shift angle increases from π/72 to π/2. Oscillations become persistent. Flow rate proved to influence greatly on pressure oscillations amplitude and a phase shift angle. Work medium influence depends on operation conditions. At pressure growth, vibrations are mostly affected in methane (of working substances list considered), and at pressure decrease, in the air at 25 ˚C.

Keywords : aeroelasticity, labyrinth packings, oscillation phase shift, vibration
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