Dynamics of multimass rotor with active hybrid bearings

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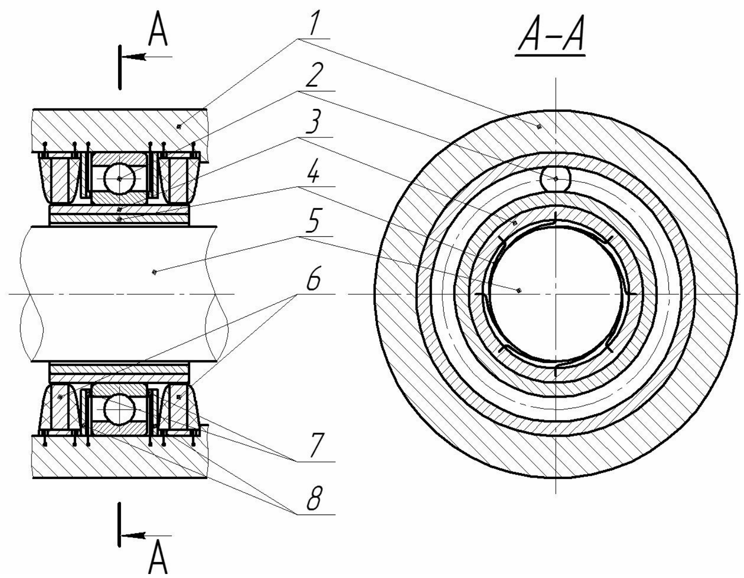
Abstract

The active management of the dynamic properties of the rotor system allows to achieve the improvement of rigidity, efficiency, life-time and reliability of a rotory machine (pumps, compressors, expansion engine, etc.). Figure 1 shows an example of a active hybrid bearing, which allows to change rigidity and damping of the bearing units, and thus, the dynamic properties of the rotor system during the operation. The active hybrid bearing operates in the following way: at reference time load transmission from a shaft (5) to a housing (1) is done through the multi-leaf foil bearings (3,4) and roller bearing (2) and through the electromagnetic field which is created by the electromagnets (6). With increase of the shaft's rotational speed (5) the voltage supplied to the magnets decreases, the multi-leaf foil bearings bend off the shaft surface, and between them (4) and a shaft (5) an air-gap is formed in which occurs a gas-dymanic force. The gas-dynamic force centers the shaft and has the external loading. Simultaneously piezoactuators (7) start operating and the inner race of the roller bearing (2) comes to a stop. When stopping the inverse processes take place.



1) housing; 2) roller bearing; 3) sleeve; 4) multi-leaf foil bearing; 5) shaft;
6) electromagnets; 7) piezoelements

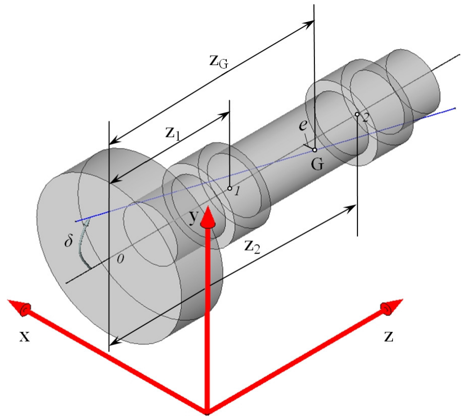
Figure 1: Active hybrid bearing

The fundamentals of simulation of the active hybrid bearings are described in [1,2,3]. To study the dynamic behavior of rotors at the active hybrid bearings a mathematical model of a multimass rigid asymmetrical rotor has been developed. Its scheme is given in Figure 2. The equations of motion for a rigid asymmetrical rotor have been got by means of Lagrange's Equations [4]

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i}\right) - \frac{\partial T}{\partial q_i} = \sum W_i \, , \tag{1}$$

where q_i - generalized coordinate, W_i - generalized force at the i -th movement.

The active management allows to change rigid and damping properties of the active hybrid bearing, that help to change eigenfrequency spectrum of all the rotor system. Figure 3 shows the Campbell Diagram for a rotor system with combined active hybrid bearings.



G – center of mass, ξ – main central rotor axis, δ – angle between rotor symmetry axis and main central axis, *e* – disbalance

Figure 2: Model of the rigid asymmetrical rotor

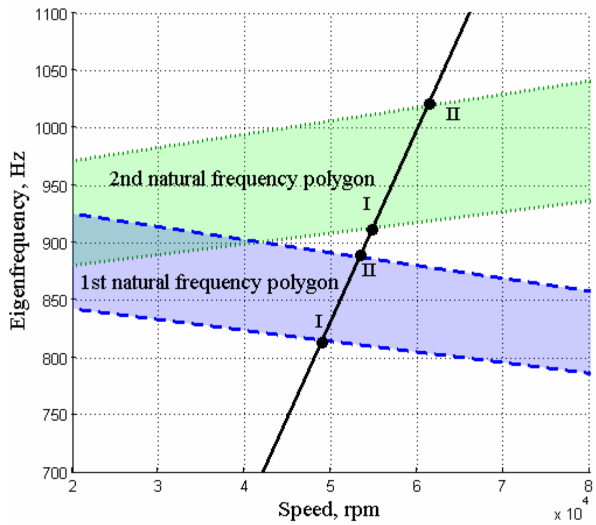


Figure 3: Campbell diagram for a rotor on the combined active hybrid bearing.

Point I for all the values of eigenfrequences corresponds to the first possible state of the rotor system (when the electromagnets are off, the rigidity of the active hybrid bearing is $2.2 \cdot 10^8$ N/m), Point II corresponds to the second possible (when the electromagnets are on, the rigidity of the active hybrid bearing is $3.7 \cdot 10^{10}$ N/m). When approaching the critical speed which corresponds to the first state of the rotor system, the value of the voltage of the electromagnets changes, the rigidity of the active hybrid bearing decreases, the rotor system moves to the second state. The second state is corresponded to the value of the critical speed which is less than the actual rotor speed**.** When reaching the operating speed the control parameters can be chosen for ensuring the minimum vibroactivity of the rotor system.

References

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