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Interaction of Rolling-Element and Fluid-Film Bearings Dynamic Characteristics in Hybrid Bearings

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Abstract

The reliability of rotating machinery is to a considerable degree determined by the bearing units. For several applications the requirements in rotation speed, bearing load and maximal vibration level are so extreme that neither rolling-element bearings nor fluid-film bearings could provide the necessary performance characteristics in any operational regime. Hybrid bearings, which are a combination of rolling-element and fluid-film bearings, can improve performance characteristics and reliability of the rotor-bearing systems. The article presents the approach to the formation of the calculation and analysis methods of dynamic characteristics of the hybrid bearings, functioning by means of the speed division. This construction allows improving the reliability and supporting node resource of support by means of division and combined applications of ball and fluid-film bearings at different work stages. It also produces great vibration stability.

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1. Main text

The reliable rotor machine functioning of energy and transport machine building (pumps, compressors, expanders) is mainly determined by supporting unit work efficiency. For the objective reason ball bearings as rotor supports has become the most widespread in the technical systems. However, there are a lot of different rotor machines, where it is more preferable to use fluid-film bearings. First of all it applies to the power energy units and high speed sets with turbine and electric drives. Resource of Fluid-film bearing is not limited in the liquid friction regime. And the non-wear functioning performance leads to many difficulties at start-stop stages. According to the

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resource and reliability improvement, the use of the hybrid combinations ball bearings with fluid-film bearings [1-6].

The constructions of the hybrid bearing (fig.1) and their behavior guarantee the reliability and supporting unit resource improvement through the division and doubling of functions of bearings at different operating regimes. And it leads to the basic efficiency criteria realization even at toughening of the considerable requirements to the supporting nodes.

The mechanism of the given operating variants of hybrid combinations ball with fluid-film bearings consists in the following:

- PLEX – parallel load externally fed (fig.1a): at the basic operating regime ball bearing functions at the lower duty through the fluid-film bearing unloadness. And it leads to the ball bearing and the whole PLEX resource improvement, because of a guaranteed radial clearance fluid-film bearing;
- PSEX – parallel speed externally fed (fig.1b) and PSIN – parallel speed internally fed (fig.1c). PSEX operating principle lies in the following: rotor rotates in the ball bearing at start-stop moments. Thus excluding basic wearing factors for both kinds of bearings at the basic operating regime in the fluid-film bearings.

Operating mechanisms of the hybrid bearings prove the opportunities of supporting node efficiency improvement on the following directives:

– for PLEX:

- guarantee of the fluid-film bearing non-wear operating regime;
- improvement of the ball bearing life;
- increase of the supporting unit loaded capacity;
- improvement of the supporting node high-speed in comparison with the ball bearing single arrangement;
- increase of the supporting unit stiffness;
- improvement of the dynamic characteristics in comparison with the ball bearing single arrangement by means of the essential damping on the fluid-film bearing lubricating film;
- improvement of the lubricating and thermal regime of ball bearing through the fluid-film bearing flowing lubricant.

– for PSEX and PSIN:

- decrease of the damaged moments that influence on the fluid-film bearing plug at transitional regimes that leads to its resource improvement;
- decrease of the centrifugal loadings in fluid-film bearings by speed division;
- discharge of the autooscillating regimes that is a characteristic of rotor movement in the fluid-film bearing;
- improvement of the guarantee opportunities, necessary for dynamic characteristics of the supporting node for resonance regime efficiency guarantee with the possible oscillation amplitudes.

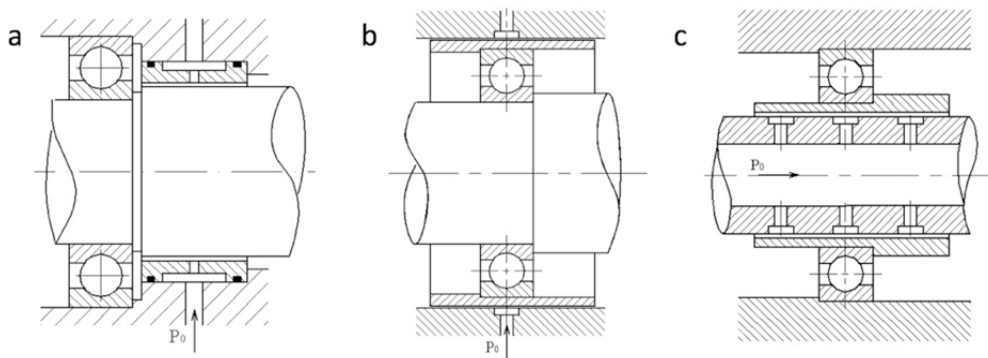


Fig. 1. Principle Schemes of the hybrid bearings: (a) PLEX; (b) PSEX; (c) PSIN.

The development of the aviation and rocket-space equipment units of turbo machines, attained by the rotor rotation frequency increase. That leads to the higher requirements to their supporting node occurrence. The use of the hybrid bearings with PSEX or PSIN speed division, as a possible solution of this problem, makes requirements

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