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Local phenomena in tilting-pad journal bearing's pivot

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Tilting-pad journal bearings (TPJBs) are often used to support rotating machines where high load-carrying capacity is needed. The tilting motion of the pads is secured by various joint types: rocker-back pivots, cylindrical coupling or ball-and-socket. The latter, which we focus on, brings several design advantages. However, it also generates additional friction moments that negatively affect the bearing's behaviour with respect to the static equilibrium path and stability [4, 5].

As shown in the previous research [2], one of the key factors in modelling TPJBs behaviour is a normal force in ball-and-socket coupling. Usually, the Hertz theory is used for the contact force description. However, considering the conforming contact of the ball-and-socket bodies, the assumptions of the Hertz theory are not satisfied, and a theory for conformal contact should be used. Here, we use a Fang theory [1] for the inner contact of two spheres which describes a pressure distribution in such contact.

As noted before, the friction in ball-and-socket coupling plays an essential role in the bearing's performance. For the friction description, we use representatives of both statical and dynamical friction models: the Bengisu-Akay and the LuGre model. The latter allows a description of such phenomena as stick-slip transitions, presliding or frictional lag. However, the dynamic models are tricky from the viewpoint of parameter estimation.

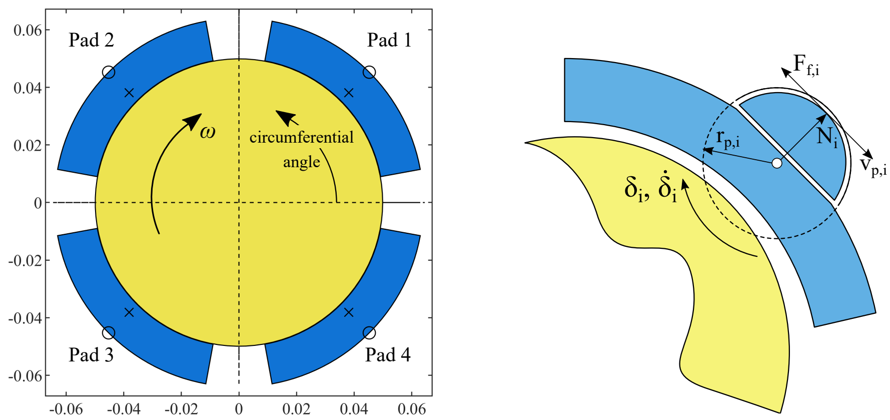

Fig. 1. A scheme of the considered TPJB and a detailed view of the ball-and-socket pivot with emphasised friction force

As a benchmark model, we use four-pad TPJB with the load-between-pads configuration, see Fig. 1. For simplicity, the rotating part is represented by a simple Jeffcott-like rotor: a journal with vertical and horizontal displacements as degrees of freedom. Moreover, since we focus on the local behaviour of pads' pivots, we omit upper pads – the previous analyses [3] showed that they are not carrying a load and are rather subjected to pad fluttering.

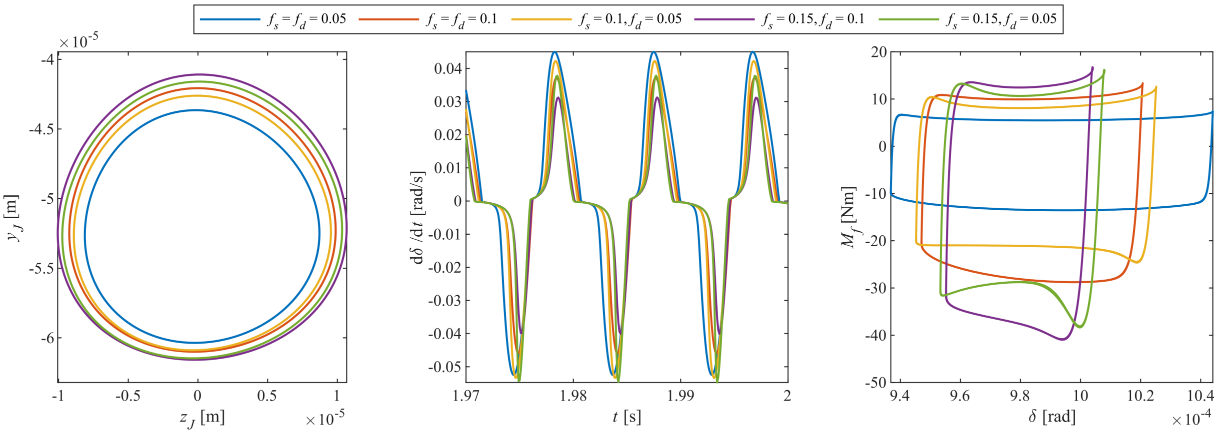

Fig. 2. Journal orbit for various friction coefficients, tilting velocity of one of the lower pads and the hysteresis loops of the considered cases

As shown in Fig. 2, the friction strongly affects the pads' tilting motion concerning velocity amplitudes, stick phases near zero velocity, and dissipation properties, as demonstrated via hysteresis loops. As a consequence, the orbit gets larger with an increasing friction coefficient. We also show a crucial influence of friction parameter settings, e.g., critical velocity, bristle stiffness and damping of the LuGre model, etc.

The proposed model provides a comprehensive basis for further research focusing on the interferences between friction phenomena in ball-and-socket couplings and the unloaded upper pads behaviour.

Acknowledgement

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