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Determination of global damping and stiffness coefficients of journal foil bearing

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Abstract: For the few last years, in modern low-power generation systems, a demand for oil-free compressors has appeared. The development of reliable bearing technology for this relatively high-speed small turbomachinery could be crucial. In order to implement this technology more widely, a selection of the optimal design from the viewpoint of machine reliability must be conducted. A high speed turbomachinery with nominal speed of tens of thousands rpm strongly depends on the proper rotordynamic design. This is especially important when the foil bearings are taken to consideration. These compliant surface gas bearings are a class of hydrodynamic bearings that use the ambient gas as their working fluid and, thus, require no dedicated lubrication system. On the other hand, due to their relatively low damping, a designer should analyze thoroughly the dynamics of the rotor-bearing-casing system in the whole operating rpm range. A correctly operating rotor supported in foil bearings is a design solution that have wide possibilities of applications, unavailable for conventionally supported one. In the turbomachinery, a dynamic behaviour of the machine is related mostly to the stiffness and damping coefficients of system components like rotor, bearings and casing. The foil bearings, although simple in design, indicate complex behaviour resulting from Coulomb friction between their elements. This Coulomb friction affects the damping and stiffness of a given bearing support. Gas film, as a bearing part with relatively high stiffness, plays less role in the rotordynamics than the elastic structure of corrugated foils. So far, many more or less reliable numerical models of this phenomenon have been built and their experimental verification results have been described in literature. The research approach presented in this paper is different. The authors suggested obtaining the data experimentally from the bearing isolated on a test bench, where, the shaft is stationary (fixed), and the gas film is not present. The shaker excites the bearing sleeve while the damping and stiffness are provided to the system by the foil structure. The test bench can be described mathematically as system with single degree of freedom with damping and external forcing. The information collected about the bearing's global coefficients can be implemented afterwards to the rotordynamic software as a tabular data. This will allow to prepare reliable models that will shorten the design process of newly developed compressors with these oilfree supports.

Keywords: foil bearings, bearing damping, bearing stiffness