Abstract

Turbine rotors are generally equipped with hydrodynamic journal bearings for which the main requirement is high operational reliability. Either multi-lobe or tilting-pad bearings are deployed. The latter offer, among other things, advantages during assembly (easier alignment) and rotordynamic stability (no self-excited vibrations). However, in practice and experiments the maximum load-bearing capacity of tilting-pad bearings is considerably lower. Hence, these bearings can not be used in applications with high radial forces. However, the tendency in turbomachinery applications is towards higher performance and power density, resulting in higher forces for the bearings.

The reason for the loss of load capacity lies in the high thermomechanical loads. Contrary to multi-lobe bearings, where due to their design radial deformations are restricted, highly loaded tilting-pads show considerable convex, axial bending. This bending represents a deviation from the axial parallel gap, which greatly reduces the hydrodynamic pressure build-up at the axial pad edges and ultimately results in a loss of load capacity.

In this paper, the influence variables on axial pad bending are systematically investigated. For this purpose, a co-simulation of fluid film bearing calculation and FE software is developed and the calculation results are verified by means of experiments on a reference tilting-pad bearing (ϕ500 mm). The resulting thermal and mechanical deformations are analyzed and those design parameters are identified which have a significant influence on the pad bending. A sensitivity analysis is then used to show the influence of those parameters that can be influenced during the design process with justifiable effort. This enables the designer to avoid unfavourable constellations with regard to pad bending. The transferability of the observations is discussed by similarity considerations. It is shown analytically that the thermally induced segment deformations increase disproportionately with increasing diameter. This explains the increased relevance of deformations in particularly large bearings.

In a synthesis part, a procedure for axially concave pad profiling is developed: On the basis of the simulations, a pad profile is derived which is based on the inversion of anticipated deformations. The axial bending of the tilting-pads is significantly compensated for without changing the operating characteristics of the bearing. The reference bearing is simulatively and experimentally investigated with cylindrical bore and in the axially concave profiled state. With the same operational safety, the load-bearing capacity can be increased by 45.5% through profiling. By keeping parts of the running surface cylindrically shaped, inadmissibly high stresses are avoided when the rotor is resting on it. For the transition from standstill to pure hydrodynamic operation and vice versa, the function of the hydrostatic jacking is confirmed experimentally. The practical suitability of the presented profiling has thus been proven.