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Editorial
Advances in Lubricated Bearings

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Advances in the design and development of lubricated bearings have been a goal of tribology engineers over decades, as the requirements on efficiency, power density, and robustness continuously increase in the history of rotating machinery. Today, numerous applications of bearings exist operating under different boundary conditions with high variety in bearing size, speed, and loads. Each of these aspects involves specific challenges ranging from the manufacturing process to the demands in operation. The latter ones typically include a sufficiently low wear level and acceptable vibrations ensuring safe and stable operation. Besides the general task of optimizing well-known bearing solutions, novel fields of application frequently occur. Solving the issues appearing during operation of all of these bearings in complex drive trains requires innovative approaches based on the experience and the physical understanding of the particular phenomena by tribology engineers. This Special Issue (SI) contributes to the latest steps in understanding bearing operating behavior [1–6], its interaction with lubricants [7,8], and its role as a component in the drive train [9–12].

Stottrop et al. [1] and Buchhorn et al. [2] investigate the operating behavior of original size large turbine tilting-pad bearings on a special test rig. The first study [1] compares the performance of the same test bearing with different lubrication designs provoking flooded conditions in the first case and non-flooded ones in the second case. The non-flooded design exhibits higher film thickness and lower power loss while the temperature level does not change significantly. In their second investigation [2], the authors show that the precise modification of convective heat transfer outside the lubricant gap by systematic modification of oil flow is an appropriate measure to optimize the operating behavior of tilting-pad bearings. In the investigated case, a trailing edge lube oil pocket designed to improve heat transfer at the pads' trailing edge free surface provides significant lower maximum pad metal temperatures with only slightly increasing power loss for the test bearing with evacuated housing. Schüler and Berner [3] propose a different approach to reduce temperatures in high-speed journal bearings. They apply so-called eddy grooves in the highly loaded pad region in order to generate radial flow components to reduce temperature gradients in the film. Experimental results for a five-pad tilting-pad bearing provide a reduction of maximum pad temperature of over 20 K for high surface speeds and simultaneously high mechanical loads. Tauviqirrahman et al. [4] investigate a different aspect of surface structure. In their theoretical study, the authors apply three types of heterogeneous/smooth sliding surface arrangements to a journal bearing in a CFD analysis and gain an improvement of load-carrying capacity and average acoustic power level compared to the conventional plain surface design. Colombo et al. [5] derive a design procedure for passively compensated bearings controlled by diaphragm valves applied in aerostatic bearings. Numerical investigations for a single pad show that significant improvements of stiffness can be achieved by the valve design. Moreover, sensitivity analysis of the design procedure proves its suitability for a wide range of parameters. Chernets et al. [6] present a calculation procedure for metal-polymer bearings operating at the lower end of Stribeck curve at boundary or dry friction. The authors put an emphasis on the impact of Young's modulus reduction with increasing temperature on the predicted results and establish an improvement of the operating behavior due to the decrease in the rigidity of the polymer composites of the bearing bushing.

The tribological interaction of bearing surface and the lubricant is a central question in bearing applications. Khaskhoussi et al. [7] study the hydrophobicity and oleophilic behavior of lead/lead-free bronze coatings for varying dimple diameters and density of laser textured surfaces. The experimental results highlight that the porous textured surface serves as an oil reservoir due to its good oleophilic behavior ensuring better lubrication and higher wear resistance. In addition, relevant hydrophobicity is observed, suggesting that surface texturing promotes the water-repellant barrier effect on the surface. Nassef et al. [8] investigate the dynamic behavior of ball bearings lubricated by lithium grease with different fractions of reduced graphene oxide (rGO) as a nano-additive. In their experiments, a significant reduction of the temperature level and improvement of damping is obtained by the application of rGO compared to base lithium grease showing the significance of this additive in enhancing bearing performance.

In high-speed turbomachinery applications, hydrodynamic journal bearings are the main damping element to ensure limited vibrational amplitudes in the resonance frequencies of the rotor-bearing system and rotordynamic stability within the entire operating range of the machine. In this domain, turbochargers used, for example, in automotive applications represent one of the most complex rotor-bearing system since they run at extremely high rotating frequencies and simultaneously low static loads. Generally, this combination encourages non-linear system behavior since self-excited sub-synchronous vibrations induced by the oil films arise. To enable safe operation, the bearing design commonly features two oil films connected by a full- or semi-floating bush to provide damping by the second film if the other one becomes unstable. Adiletta [9] theoretically studies the impact of non-circular bore profiles on the stability of a rigid rotor supported by full-floating bush bearings. The non-circular profile is applied on the stator side of the outer film. The investigations show an influence of the geometrical shape of the sliding surface as well as of its angular orientation in the bore. Results indicate that a suitable design is able to increase stability threshold speed. Ziese et al. [10] analyze the impact of bearing model complexity on predicted operating behavior of a turbocharger with semi-floating bush bearings. Validation with test data shows that increasing model complexity improves correspondence with experimentally determined vibrations. In particular, the cavitation in the journal bearing and the consideration of the commonly neglected thrust bearing contribute to the enhancements. Completely different issues are involved in the bearing arrangements of slow running planetary gear units for wind turbines. Hagemann et al. [11] investigate the impact of the special load situation in these type of bearings that exist due to the helical gears applied here. Consequently, the planet bearing has to restore high force as well as moment loads generated by the two mesh contacts between sun and planet gear and planet and ring gear, respectively. Different design measures and load situations are analyzed considering operation in the mixed friction regime and potentially occurring wear mechanisms. Moreover, the high flexibility of the structure due to the lightweight requirements and the simultaneously high mechanical loads accompany structure deformations that lead to modifications of the shape of the lubricant gap. Hagemann et al. [12] focus on this phenomenon in the second part of their study and show that its consideration is essential for the simulation results. Generally, the results indicate an improvement of predicted operating conditions by the consideration of structure deformation in the bearing analysis for this application. The peak load in the bearing decreases since the loaded proportion of the sliding surface increases.

Although lubricated bearings have been applied for centuries and studied with continuously improving methods for decades, continuous improvements of bearings and new challenges accompanying with their application are still part of current research. This SI contributes to the progress in this field. The guest editors would like to express their sincere

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