



OPEN ACCESS

EDITED AND REVIEWED BY
Andrea Ghiotti,
University of Padua, Italy

*CORRESPONDENCE
Florian Pape,
✉ pape@imkt.uni-hannover.de

RECEIVED 07 December 2023
ACCEPTED 14 December 2023
PUBLISHED 03 January 2024

CITATION
Pape F, Terwey JT, Maiss O and Li X
(2024), Editorial: Rolling bearing
optimization through innovative
manufacturing processes.
Front. Manuf. Technol. 3:1352187.
doi: 10.3389/fmtec.2023.1352187

COPYRIGHT
© 2024 Pape, Terwey, Maiss and Li. This is
an open-access article distributed under
the terms of the [Creative Commons
Attribution License \(CC BY\)](#). The use,
distribution or reproduction in other
forums is permitted, provided the original
author(s) and the copyright owner(s) are
credited and that the original publication
in this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Editorial: Rolling bearing optimization through innovative manufacturing processes

Florian Pape^{1*}, Jan Torben Terwey², Oliver Maiss³ and Xinming Li⁴

¹Institut für Maschinenkonstruktion und Tribologie (IMKT), Leibniz Universität Hannover, Garbsen, Germany, ²Thyssenkrupp Rothe Erde Germany GmbH, Lippstadt, Germany, ³Ecoroll AG Werkzeugtechnik, Celle, Germany, ⁴School of Mechanical and Automotive Engineering, Qingdao University of Technology, Qingdao, China

KEYWORDS

rolling bearings, fatigue, manufacturing, tapered roller bearing, micro textured surface

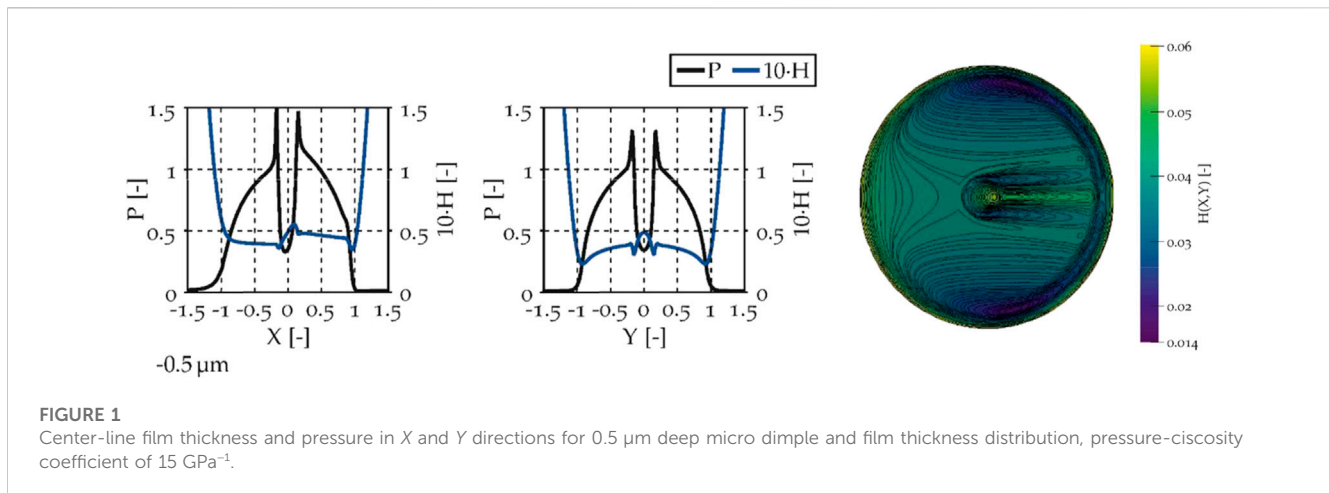
Editorial on the Research Topic

Rolling bearing optimization through innovative manufacturing processes

Addressing the imperative issues of resource conservation and the reduction of CO₂ emissions is crucial in the global effort to mitigate climate change. The demand for solutions in this domain is steadily increasing, particularly in the field of conventional machinery executing rotational movements. As the transition to larger wind turbines and electric drives unfolds, new challenges emerge concerning the fatigue and durability of bearing materials. Effectively addressing these challenges necessitates the translation of innovative research findings into industrial applications. Currently, there is a heightened focus on pioneering procedures, both existing and in development, aimed at significantly enhancing the performance of bearings and lubrication systems. This emphasis on innovation is essential for fostering a sustainable and efficient future.

In recent years, a considerable body of research has been dedicated to enhancing bearings through the utilization of novel manufacturing processes. One notable example is the use of deep rolling processes to significantly extend the service life of bearings (Pape et al., 2020). This approach has been coupled with hard turning, taking into account the impact of induced residual stresses and improved surface roughness. Moreover, emerging manufacturing techniques, such as tailored forming, have demonstrated the ability to conserve valuable raw materials and reduce the weight of bearings (Coors et al., 2018). Surface modifications applied to bearing surfaces have been explored as a means to decrease frictional losses. The application of coatings on bearings is particularly noteworthy, as it serves to prevent damage to bearing surfaces in the event of conventional lubricant failure during operation. Furthermore, the integration of sensors has been investigated to enable more effective monitoring of bearing conditions (Pape et al., 2023). Notably, self-regenerative coatings like molybdenum oxide with a molybdenum reservoir exhibit intriguing properties in this context (Konopka et al., 2022). Ongoing research is also placing emphasis on developing additional optimized surfaces and surface textures for further advancements in bearing performance. Three exciting contributions have been submitted in the field of bearings.

Hwang and Poll presents a method to more accurately predict bearing life under complex operating conditions, such as oscillation, while considering surface residual stresses. In the standardized calculation method, material properties, such as fatigue limit stress, were taken



into account by introducing the fatigue limit stress proposed by Ioannides and Harris. This standard calculation method provides a reasonable range for fatigue life, aligning well with experimental results under ideal test conditions, such as constant external load. However, complex operating conditions of bearings, such as fluctuating loads and oscillating movements, are not considered. Nevertheless, this is essential for the application of bearings in machinery, such as wind turbines. Hence, there is a need for a new analytical calculation model that can predict the fatigue life of bearings under these complex conditions. In the proposed approach, fatigue life is determined based on the Palmgren-Miner linear damage rule by evaluating subsurface stresses below the rolling contact using the S-N curve according to the fatigue criterion of Lundberg and Palmgren. Hwang and Poll work confirmed that the analytically determined fatigue life according to ISO 281 still remains close to the results of bearing life tests.

In another article, tapered roller bearings are optimized concerning lubrication. Liu et al. investigate the contact between the roller end and the rib of tapered roller bearings. This contact significantly influences the lubrication state and performance loss. To enhance the lubrication performance of the inner ring rib and the large roller end in tapered roller bearings used in railway wagons, a thermal elastohydrodynamic lubrication model was created based on the structural analysis of the inner rib and the large roller end. This considers spin-slide effects between the rib and the large roller end, using a Carreau rheological model in a tapered roller bearing. Under various conditions, variations in the friction coefficient were compared to the ratio of the curvature radii of the large roller end to the rib, and the film thickness and film temperature varied with the speed, while the effect of the load between the two rib structures was compared. The results showed that rotational movement has little influence on the lubrication at the contact point between the inner ring rib and the large roller end of the tapered roller bearing. There exists an optimal ratio of curvature radii between the large roller end and the spherical or conical rib; furthermore, the friction coefficient corresponding to this optimal ratio value is the lowest. With increasing inner ring speed, both the film thickness and temperature increase for the two rib structures. In contrast to the spherical rib, the difference between the minimum and central film thickness is nearly constant, and the conical rib shows a slight

temperature increase. With increasing load, the difference between the minimum and central film thickness becomes larger, and the temperature in the contact zone gradually rises for both ribs. In contrast to the conical rib, due to the higher film temperature, the spherical rib exhibits a lower friction coefficient and a smaller minimum film thickness

Kelley et al. pursue an alternative approach to enhance lubrication conditions by using micro textures on bearing surfaces. Microtextures are employed to mitigate friction in start-stop cycles, under mixed lubrication conditions, and during sliding in a rolling element bearing, as well as at the contact between a roller and a bearing rib. The selection of the microstructure geometry is crucial, ensuring that individual depressions in the contact area between the ball or roller and the bearing surface act as reservoirs for the lubricant. Initial applications involving microstructured angular contact ball bearings under oscillating motion conditions demonstrated friction-reducing effects during reciprocating motion, where the microstructures functioned as lubricant reservoirs. This concept is extended to the sliding contact for tapered roller bearings, exploring whether the observed reductions in friction can be attributed to the microstructures acting as lubricant reservoirs or if there is a positive hydrodynamic effect due to the microstructures. Through a calculation approach and some illustrative bench test measurements, the behavior of microstructured tapered roller bearings is investigated. An exemplary micro dimple is shown in Figure 1. It is obvious, that small dimples help to increase the central film thickness.

Author contributions

FP: Conceptualization, Writing—original draft, Writing—review and editing. JT: Writing—review and editing. OM: Writing—review and editing. XL: Writing—review and editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

Author JT was employed by the company Thyssenkrupp Rothe Erde Germany GmbH. Author OM was employed by the company Ecoroll AG Werkzeugtechnik.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Coors, T., Pape, F., and Poll, G. (2018). Bearing fatigue life of a multi-material shaft with an integrated raceway. *Bear. World J.* 3, 23–30.

Konopka, D., Pape, F., and Poll, G. (2022). “Untersuchungen zur Funktionsfähigkeit von trockengeschmierten molybdänbasierten Axialzylinderrollenlagern,” in *book: Reibung, Schmierung und Verschleiß Forschung und praktische Anwendungen, Proceedings, 63. Tribologie-Fachtagung* (Publisher: Gesellschaft für Tribologie e.V) P2/1–P2/4.

Publisher’s note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Pape, F., Coors, T., and Poll, G. (2020). Studies on the influence of residual stresses on the fatigue life of rolling bearings in dependence on the production processes. *Front. Mech. Eng.* 6, 56. doi:10.3389/fmtec.2020.00056

Pape, F., Konopka, D., Coors, T., Poll, G., Steppeler, T., Ottermann, R., et al. (2023). “Direct sensor integration on the raceway of roller bearings,” in *book: 64. Tribologie-Fachtagung 2023 Reibung, Schmierung und Verschleiß Forschung und praktische Anwendung, Chapter P3* (Publisher: Gesellschaft für Tribologie e.V) P3/1–P3/9.