lubricants

MDPI

Editorial

Rolling Contact Fatigue and White Etching Cracks of Bearings

Walter Martin Holweger [1,*] and Jürgen Gegner [2,*]

[1] Faculty of Operational Mathematics, School of Engineering, Faculty of Engineering and Physical Sciences, University of Southampton, Southampton SO17 1BJ, UK
[2] SKF GmbH, Department of Material Physics, D-97424 Schweinfurt, Germany
* Correspondence: walter.holweger@t-online.de (W.M.H.); juergen.gegner@skf.com (J.G.)

Lubricants have taken a leading role as drive- train system components in recent years, mainly attributed to their viscosity as a quality criterion. The increase in complexity and power density in automotive and industrial driven trains has continuously shifted the interest of tribology engineering toward the research field of thin film and boundary lubrication and how to describe it numerically [1,2]. The reduction in lubrication film thickness, leading to uncovering these asperities, raised the question of how lubricants act when in intense contact with metals with respect to tribocatalysis (TC) [3], and how to describe this via predictor sets [4]. The matter of White Etching Cracks (WECs) and their relation to lubricant chemistry has finally enlightened this aspect, namely that lubricants are not only serving a liquid film by means of their viscosity, but they are instead involved by their chemistry and molecular physics [5,6]. These facts enlarged the parameter field of mechanical engineering, inevitably leading to the question of understanding how a molecular and material scale of a few nanometers in size is related to a submicron's and macro scale [4]. White Etching Cracks and their relation to the presence of transient and persistent electricity have stimulated research on how lubricant chemicals are involved, and whether a numerical description is accessible [7,8]. The forecast of the continuous electrification of automotive drives intensifies the search for new predictors for lubricant chemicals. Thus, more than a half century after Dowson and Higginson published their theory on Elastohydrodynamic lubrication (EHL) [9], physics and chemistry are moving into new and fascinating fields.

1. A Study on Early Stages of White Etching Crack Formation under Full Lubrication Conditions: The authors show that WECs are initiated under very full lubrication, but in the presence of a low reference oil combined with electricity. It came out that WECs initiate very early on by forming cracks and pores locally in the subsurface in contrast to Rolling Contact Fatigue [5].
2. A Study on Decisive Early Stages in White Etching Crack Formation Induced by Lubrication: this paper investigates how White Etching Cracks start by the use of a critical lubricant under boundary lubrication conditions in a very early stage, and by quenching the test run. Prone to WEC failure, plenty of pores were found locally in the subsurface. Hydrogen was found to be present at the surface in the tribolayer [6].
3. Simulation of the Fatigue Crack Initiation in SAE 52100 Martensitic Hardened Bearing Steel during Rolling Contact: this paper shows, through a detailed simulation, that pores allocated at grain boundaries drastically reduce the load cycles to initiate the formation of long cracks (Stage 3), thus confirming the former experimental results [10].
4. Polyphenyl Ethers as High-Performance Synthetic Lubricants: Lubricants exhibiting both thermal and chemical stability that consequently generate less hydrogen during friction are required to avoid the hydrogen embrittlement of moving mechanical components. The present work studied the effects of the length and number of alkyl chains on the tribological properties of polyphenyl ethers (PPEs), which feature good

Citation: Holweger, W.M.; Gegner, J. Rolling Contact Fatigue and White Etching Cracks of Bearings. *Lubricants* **2023**, *11*, 247. https://doi.org/10.3390/lubricants11060247

Received: 23 May 2023
Accepted: 2 June 2023
Published: 4 June 2023

thermal and radiation resistance. PPEs were found to have much lower friction coefficients compared with a poly-alpha-olefin and alkyldiphenyl ether, and the effect of the running-in process on friction appeared to be negligible [11].

5. Nano- and Micro-Tribological Investigations of Boundary Layers on Axial Bearing Washers Tested under WEC Critical Conditions: The author presents a detailed study on the formation of boundary layers of Zinc-dialkyldithiophosphate under WEC critical conditions using high lateral surface spectrometry and nano-hardness measurements [12].
6. An Analysis of Reaction Forces in Crankshaft Support Systems: This article proposes a measuring system developed to support the crankshaft with a set of flexible supports. The research also shows that the values of the reaction forces ensuring the elimination of shaft deflections under the assumption of nodal support can be treated as corresponding to the resultant reaction forces realized by the prismatic heads [13].
7. A Study on the Influence of Electrical Discharges on the Formation of White Etching Cracks in Oil-Lubricated Rolling Contacts and Their Detection Using Electrostatic Sensing Technique: this article presents in detail the parameters leading to WECs in contrast to pitting by the use of an electrified two-disc test rig. WECs are found within a small window at boundary lubrication. Interestingly, it came out that WEC formation is accompanied in junction with the built-up of specie and their continuous self-charging [7].
8. A Validated Computational Study of Lubricants under White Etching Crack Conditions Exposed to Electrical Fields: the authors are presenting within this paper a theory based on ab-initio calculations, that certain chemicals are capable of creating molecular clusters. The ability to upload electrical charges has been directly linked within the paper to the formation of White Etching Cracks [8].

Author Contributions: Conceptualization, W.M.H., Writing original—draft-preparation, W.M.H. and J.G., writing—review and editing, W.M.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ma, L.; Luo, J. Thin film lubrication in the past 20 years. *Friction* **2016**, *4*, 280–302. [CrossRef]
2. Mathas, D.; Holweger, W.; Wolf, M.; Bohnert, C.; Bakolas, V.; Procelewska, J.; Wang, L.; Bair, S.; Skylaris, C.-K. Evaluation of Methods for Viscosity Simulations of Lubricants at Different Temperatures and Pressures: A Case Study on PAO-2. *Tribol. Trans.* **2021**, *64*, 1138–1148. [CrossRef]
3. Fan, F.-R.; Xie, S.; Wang, G.-W.; Tian, Z.-Q. Tribocatalysis: Challenges and perspectives. *Sci. China Chem.* **2021**, *64*, 1609–1613. [CrossRef]
4. Holweger, W.; Bobbio, L.; Mo, Z.; Fliege, J.; Goerlach, B.; Simon, B. A Computational Study on the Role of Lubricants under Boundary Lubrication. *Lubricants* **2023**, *11*, 80. [CrossRef]
5. Holweger, W.; Schwedt, A.; Rumpf, V.; Mayer, J.; Bohnert, C.; Wranik, J.; Spille, J.; Wang, L. A Study on Early Stages of White Etching Crack Formation under Full Lubrication Conditions. *Lubricants* **2022**, *10*, 24. [CrossRef]
6. Wranik, J.; Holweger, W.; Lutz, T.; Albrecht, P.; Reichel, B.; Wang, L. A Study on Decisive Early Stages in White Etching Crack Formation Induced by Lubrication. *Lubricants* **2022**, *10*, 96. [CrossRef]
7. Esmaeili, K.; Wang, L.; Harvey, T.J.; White, N.M.; Holweger, W. A Study on the Influence of Electrical Discharges on the Formation of White Etching Cracks in Oil-Lubricated Rolling Contacts and Their Detection Using Electrostatic Sensing Technique. *Lubricants* **2023**, *11*, 164. [CrossRef]
8. Holweger, W.; Bobbio, L.; Mo, Z.; Fliege, J.; Goerlach, B.; Simon, B. A Validated Computational Study of Lubricants under White Etching Crack Conditions Exposed to Electrical Fields. *Lubricants* **2023**, *11*, 45. [CrossRef]
9. Dowson, D.; Higginson, G.R. A Numerical Solution to the Elasto-Hydrodynamic Problem. *J. Mech. Eng. Sci.* **1959**, *1*, 6–16. [CrossRef]
10. Dogahe, K.J.; Guski, V.; Mlikota, M.; Schmauder, S.; Holweger, W.; Spille, J.; Mayer, J.; Schwedt, A.; Görlach, B.; Wranik, J. Simulation of the Fatigue Crack Initiation in SAE 52100 Martensitic Hardened Bearing Steel during Rolling Contact. *Lubricants* **2022**, *10*, 62. [CrossRef]

11. Lu, R.; Tani, H.; Koganezawa, S.; Hata, M. Alkylated Polyphenyl Ethers as High-Performance Synthetic Lubricants. *Lubricants* **2022**, *10*, 275. [CrossRef]
12. Pape, F. Nano- and Micro-Tribological Investigations of Boundary Layers on Axial Bearing Washers Tested under WEC Critical Conditions. *Lubricants* **2022**, *10*, 198. [CrossRef]
13. Nozdrzykowski, K.; Grządziel, Z.; Grzejda, R.; Warzecha, M.; Stępień, M. An Analysis of Reaction Forces in Crankshaft Support Systems. *Lubricants* **2022**, *10*, 151. [CrossRef]