Transport of solid lubricants in tribological systems - measurement of transfer rates to improve service life models

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A common task for the surface analysis of solids is the quantitative and spatially resolved measurement of the elemental composition. But also the determination of the absolute amount of substance on surfaces is a goal-oriented approach for many questions in technology, which can be pursued reasonably with suitable analytical methods. One example is the quantitative characterization of mass transport in various tribological systems. In combination with gravimetric measurements to determine wear rates, it is possible, for example, to measure the material flows in rolling bearings with liquid-free lubrication. The transport of solid lubricants from specially developed sacrificial components into the respective tribocontacts plays a decisive role here and is intended to significantly increase the service life of the bearings [1]. On the surfaces of the components in the respective tribological system, a certain mass thickness dynamically adjusts itself in the equilibrium of new building and degradation processes, which is measured at selected points along the service life in order to determine the associated transport rates. The aim is to develop a model for calculating the service life of rolling bearings or to measure the solid lubricant rate that can be provided by suitable tribological subsystems [2]. Depending on the geometric shape and the existing total mass density of the component surfaces, suitable analytical methods must be selected. For example, for spherical rolling elements, the measurement of representative mass coverages with the plasma-assisted Secondary Neutral Mass Spectrometry SNMS is advantageous, which, when using absolute sensitivity factors, allows the measurement of element-specific mass thicknesses directly from the total flux of the sputtered particles. In addition to the local geometric measurement of layer coverages with the Focused Ion Beam method FIB or electron microscopy, energy-dispersive X-ray analysis EDX can also be used to find the associated mass thicknesses from the attenuation of the substrate signal. In rolling bearings, we were able to show through the use of surface analysis methods that the element-specific lubricant transfer factors reach values of up to 10%. For molybdenum disulfide as a solid lubricant, the associated mass flows are then, for example, in the range of several 10-5 µg per revolution. In the article, the respective procedure for different tribological systems is described and comparative measurements for validation of the methods are presented together with the results obtained.

[1] M.Werner, S. Emrich, B. Sauer, M. Kopnarski, S. Thielen: Experimentelle Untersuchungen an feststoffgeschmiertenWälzlagern im Hochvakuum, Forsch Ingenieurwes (2021) 85:1077–1090, https://doi.org/10.1007/s10010-021-00558-8

[2] Leyu Lin, Stefan Emrich, Michael Kopnarski, Alois K. Schlarb: Lubrication performance of a polyetheretherketone (PEEK) and polytetrafluoroethylene (PTFE) blend within a steel/steel tribosystem, Wear 484-485 (2021) 203997