SOLID LUBRICATION OF NANOCOMPOSITE CERAMIC SI_3N_4- SI_3N_4 AND HYBRID SI_3N_4-STEEL CONTACTS

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ABSTRACT

Hybrid bearing uses ceramic rolling elements instead of the metal ones to reduce rolling or sliding friction resistance in high-speed hi-end applications. In many high-speed applications liquid lubrication is not possible due to elevated temperature, while under unlubricated conditions the rolling elements fabricated of silicon nitride ceramics suffer severe damage due to fatigue and wearing. Development of an adequate solid lubricant is of primary importance.

Dichalcogenides of transition metals are promising solid lubricants for hybrid and ceramic bearings. Among them, WSe_2 was chosen due to low chemical reactivity with steel and silicon nitride, low solubility of Se in steel at elevated temperatures, and higher resistance to oxidation. In our previous study, WSe_2 showed better performance than $MoSe_2$ and MoS_2 under liquid lubrication and heavy-duty loading conditions. Furthermore, it was found that by decreasing the size of solid lubricant particles down to 2-8 nm a significant decrease in wear rate and friction coefficient was achieved in comparison with the particles of 100 nm and bigger.

In this study tribological performance of nanometer WSe_2 solid lubricant was investigated for ceramic Si_3N_4 - Si_3N_4 and hybrid Si_3N_4-steel contacts. Ceramic components were sintered using spark plasma sintering (SPS) process and original nanostructured Si_3N_4 powders. Tribological tests were carried out using reciprocating sliding with pin-on-flat configuration and unidirectional sliding with pin-on-disk configuration. Both static and dynamic loading were used. Under dynamic loading the normal load was oscillating with frequency 25 Hz and amplitude 15% of the nominal load. Two methods of lubricand introduction into the contact zone were studied. The first one related to application of a small amount of nanometre WSe_2 powder on the flat sample before friction test. The second one used previous mechanochemical treatment of the ceramic balls in a high-energy planetary mill with addition of lubricating powder.

The balls sintered using nanocomposite Si_3N_4 showed around 50% increase in wear resistance in comparison with commercial ceramic balls (refer to Fig. 1). Without solid lubricant the wear rate for hybrid contact was several folds lower than for steel-steel contacts. With addition of solid lubricant, the wear performance further increased. Chemical analysis of worn surfaces using Raman spectrometry and FTIR showed that a tribolayer was formed.

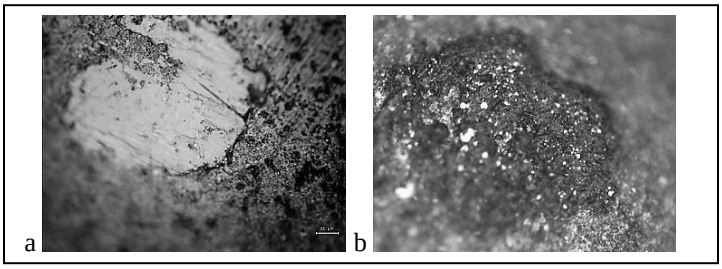

Fig.1 (a) Ball scar Si_3N_4– Si_3N_4 pair after wear with WSe_2, (b) A scar on the ceramic ball after wear test for Si_3N_4–AISI 52100 contact.

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