Tribochemical effects during running-in of metals and alloys

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1. Introduction

The formation of third bodies of metallic alloys depends on the mechanical mixing of the first bodies, debris and the lubricant or the atmosphere. While many previous results on pure metals have shown that the formation of 'mixed material' decreases friction and wear, inclusive correlations between the properties of this layer (e.g. thickness, structural, mechanical, and chemical) and the tribological properties have not yet been studied rigorously.

2. Experimental

As examples of two very different alloys, reciprocating sliding tests are performed using an 'on line' tribometer in order to monitor topographical changes on brass and tungsten [1]. This instrument consists of a force sensor, a holographic microscope, and an atomic force microscope. The experiments are performed in dry and lubricated conditions (i.e. hexadecane or PAO as lubricant). Wear and roughness measurements are performed after each cycle and correlated to the friction behavior, which is recorded at the position of the holographic microscope. *Ex situ* analysis is performed on the worn surfaces (i.e. plates and counterfaces) using X-ray photoelectron spectroscopy (XPS), AFM, and cross-sectional SEM imaging of the near-surface region.

3. Results

The tribometer experiments with brass (zinc content varied from 5-36 wt.-%) sliding against a 100Cr6 countersurface showed that the zinc concentration has a strong influence on the third body formation, while mechanical properties such as the hardness of the base material are less important. Correlating the tribometer results with the XPS analysis we find that a strong reduction of friction is taking place when a thin zone is forming that is enriched in zinc-oxide and mixed with carbon from the lubricant [2].

The dry and lubricated experiments of W sliding against WC lead to a different third body.*Ex situ* analysis for the dry tests reveal the formation of a grain refined layer in the near surface region of the tungsten specimen and an amorphous layer on the WC counterface[3]. These observations indicate that subsequently to the initial plowing events, the sliding occurs mainly within an amorphized WC layer.Classical molecular dynamics simulations of W sliding against WC (i.e. with and without Hexadecane) with rough surfaces are consistent with these observations. The lubricated sliding, on the other hand, results in a less pronounced third body formation; while a thin transfer layer is observed on the WC counterface, only slight grain refinement is evident in the near surface region of the W specimen. Similarly to the dry sliding, these *ex situ* analysis are consistent with atomistic simulations; subsequently to the initial adjustment of the two surfaces (i.e. plowing events of the WC surface), the sliding occurs on monolayers of the lubricant, which results in low friction values due to the low viscosity of hexadecane [4].

4. References

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