The Effect of a Novel Surface Topography on the Wear Behaviour of a High-Nitrogen Stainless Steel

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Abstract:

Since austenitic stainless steels provide a high mechanical strength and a good formability, they are in common use for orthopaedic implant devices. In particular, high-nitrogen steels exhibit excellent tribological properties due to high work hardening rates and a high corrosion resistance [1]. Metallic implants in a self-mating or tribological contact with human tissue are usually electro- or mechanically polished prior to implantation. The aim of this paper is to investigate the effect of a novel, non-polished surface topography on the tribological behavior of high-nitrogen steels. Therefore, an austenitic nickel-free stainless steel with the trade name P2000 was wet-chemically etched using chromosulfuric acid at elevated temperatures [2,3]. This treatment creates a macroscopically smooth (R_a = 0.8 ?m) and a micro- and nanoscopically rough surface with features in the nm-range. As-modified samples were compared with mechanically and electropolished specimens on a disc-on-pin apparatus in distilled water and Ringer´s solution.

In all experiments, the shortest run-in and the lowest wear rates were observed for the (roughest) wet-chemically etched samples. Since this behaviour is most surprisingly, scanning electron microscopy was employed to detect the acting wear mechanisms. Microwelding and microploughing occurred on the wear tracks of *all* samples indicating that the topography is removed and the dominating wear mechanisms are adhesion and abrasion, respectively. Merely on the shoulders of the wear track, where the topography is not totally flattened, a different behaviour was observed. Submicron wear particles which are carried in the sliding contact between pin and disc are trapped and compacted in the microdimples of the etched surface. Hence less debris leaves the tribological system and extremely low wear rates ($w < 10^{-10}$) are obtained. With further penetration a hybrid contact surface with improved physical and chemical properties is generated which is composed of metallic (high-nitrogen steel) and ceramic-like (compacted debris) microparts. Through the combined effect of material properties, particle characteristics and surface topography the system is self-adjusting to the applied loading. Therefore, wet-chemically modified P2000 may be an appropriate alternative to commonly used highly polished implant metals in self-mating contacts.

References:

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