ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

Enhancing wear relevant surface properties of Ti6Al4V and TiZrNbHfTa through thermal oxidation

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Thermal oxidation (TO) is a method to improve the wear characteristics of titanium alloys. We implemented four different TO processes to compare their influence on the surface properties of Ti6Al4V. A single-step TO process at elevated temperature in air leads to the formation of a hard TiO_2 layer with poor adherence. In a two-step process, this oxide layer is reduced during a heat treatment under vacuum, leading to a surface near oxygen diffusion zone with increased hardness. A protective oxide layer with an improved adhesion grows by adding a third oxidation step in air, with an oxygen diffusion hardened zone underneath [1]. Single-step TO at reduced oxygen partial pressure leads to a similar result.

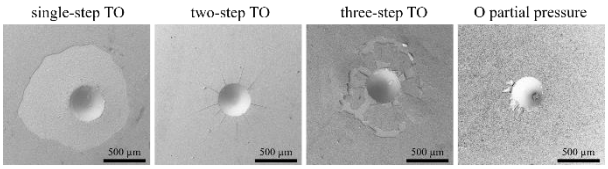

Fig.1 Process dependent oxide layer adhesion during Rockwell indentation tests

The process-dependent surface properties are investigated using scanning electron microscopy, roughness measurements, microhardness-depth profiling, glow discharge optical emission spectroscopy, Rockwell indentation tests, and wear experiments. Process knowledge gained during TO of Ti6Al4V is transferred to a new material system – the refractory high entropy alloy TiZrNbHfTa. We demonstrate under which conditions single-step thermal oxidation can enhance the surface hardness of this material despite its susceptibility to pesting by four times compared to the substrate.

Keywords: Ti6Al4V, TiZrNbHfTa, thermal oxidation, surface hardening, tribological properties

References:

[1] Dickes D., Öztürk B., Völkl R., Galetz M.C., Glatzel U.; Improving the Adhesion of a Hard Oxide Layer on Ti6Al4V by a Three-Step Thermal Oxidation Process; Advanced Engineering Materials (2021), p. 2100864