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Prediction of Surface Roughness During Dry Sliding Wear:
Characteristics of Ti-6Al-4V Alloys

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ABSTRACT

Due to the relatively low strength and poor wear resistance of unalloyed titanium and its good mechanical properties, corrosion resistance, and biocompatibility, Ti6Al4V has been extensively used in various type of application including aerospace, biomedical, and offshore industries. The goal of this research is to enhance the surface properties of the high strength alloys examined such as Ti6Al4V pin sliding against Al2O3disc, due to the various surfaces roughness parameters. The COF and the wear rate were found to be lower at higher applied load due to higher frictional heating leading to thermal oxidation and thereby formation of several mm thick tribo-layers on the worn surfaces. Characterization of the tribological sample was performed using a scanning electron microscope (SEM) equipped with energy dispersive x-ray analysis (EDAX) to ensure that the wear pattern and debris morphologies of the Ti6Al4V and alumina disks were distinct, suggesting a surface roughness value determined by 3D profilometer at various load and sliding speed of 0.01ms-1.

KEYWORDS

Friction, Surface Roughness, Ti6Al4V Alloy, Wear

INTRODUCTION

Titanium and its alloys are attracting significance as spinal implant materials because of their high specific strength, strong biocompatibility, and efficient corrosion resistance (Merola et al., 2019). Due to its superior strength, Ti6Al4V with extra-low interstitial was commonly used as a substitute material for spinal fixing instruments. The vanadium in Ti6Al4V, however is venomous to the physical structure and thus the modulus of Elasticity of Ti6Al4V (about 110 GPa) has higher than plant tissue (about 30 GPa), which causes stress shielding (Zivic et al., 2011). Moreover, due to non-toxicity, it exhibits good biocompatibility and as it shows the elastic modulus of alumina (about 90 GPa) is less than that of Ti6Al4V (Amalraju et al., 2012; Lee et al., 2014).

Pure titanium and titanium alloys, on the other hand, have a poor wear resistance (Budinski et al., 1991) which can be due to two main reasons (Molinari et al., 1997): (a) They have low plastic shear

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resistance and low work hardening. As a result, the material weakly counteracts wear phenomena related to tribological properties such as abrasion and adhesion. (b) The oxide layer, which is formed due to high flash temperatures caused by friction during dry sliding, provides protection and is quickly eliminated by scaling or micro-fragmentation, so that subsurface layers are not protected against the wear phenomenon. As a result, several surface treatment processes for pure titanium and its alloys have been produced (Deligianni et al., 2001; Chern et al., 2020; Matos et al., 2019). However, to maximise the surface treatment, the untreated alloys harm mechanisms must be carefully studied. The inferences from the previous reports do not appear to be analyzed in details in any scientific studies along with the interpretation of mechanisms of damages. Various experiments have shown that morphological choices at the micron level regulate the rate and consistency of new tissue development at the interface. (Suh et al., 1973) experimentally investigated the damage mechanisms of metals under low speed slippy conditions to explore the validity of the harm theory of delamination. Mistreatment was documented using nine completely different metals with varied chemical composition and microstructure under an argon atmosphere, the underground harm beneath and tearing the damaged tracks were observed. The outcome of the experiments reported that the prevailing wear mechanism was the wear it induces by the delamination sheets. The damage sheet caused by an underground crack that extends over a distance that was typically one to two magnitude orders longer than the asperity contact diameter. Throughout plastic deformation, the voids are nucleated around the inclusion. The void nucleation rate in metals while not inclusions were found to be low than that of the wear rate which was low even after they have a lower hardness. (Findik et al., 2020) reported that the major medical devices were developed using a variety of typical conventional metal, ceramic, polymeric and composite biomaterials that were significantly restricted. The latest metallic implant advances were summarized for biomedical applications. In addition to the distributed studies, additional studies were also planned on the opposite metallic materials, the alternation for the implementation of conventional Ti6Al4V alloys, the developments of some additional Ti based implant alloys and emphasis has also been devoted to further investigation of the degradation process in metallic implants. Implant materials are subjected to relative movements (Hammood et al., 2019) that can cause wear injury alongside the corrosive body fluid side attacks. (Chausovet et al., 2016) carried out experimental studies, the impact oscillation load (dynamic method without equilibrium) can be used as a preliminary method of refining microstructure for materials. All tests were completed at ambient temperature. Therefore, fine grains are not formed just within the basis of the alloy itself but also the process of refining the undergrain takes place inside this database (Dey et al., 2018; Rahman et al. 2017). The authors assume that the forming of fine grain alloy microstructure under impact oscillatory loading leads to a substantial increase in the alloy initial plastic deformation under more static tension because of its high volume material. (Khan & Dey, 2021; Yuan et al., 2008) performed a sliding wear test using a ball on disc appratus at room temperature to study the change in surface roughness as wear progresses under appropriate lubrication and lubrication conditions inadequately. Analysis of particle size distribution and surfaces of wear debris and test samples based on wear conditionand wear rates for wear components were performed in the present study. Changes in surface topography of wear debris and wear components have been studied as wear progresses. (Dey & Khan 2021; Wang et al., 2020) surface roughness parameters are a significant factor influencing surface wear resistance. In dry frictional conditions, the wear resistance was not directly related to the topographic offset distance and the shape of the surface topography,but this was closely linked to the roughness parameters of the superficial texture. (Yu et al., 2016) sliding wear tests were carried out at different speeds and loads using a pin on disc apparatus in dry conditions. The results suggest that the coefficient of friction is significantly lower in Al-Ti-C master alloy composites than in TiC reinforced composites Meanwhile, wear rates are lower in composites with Cu additions. Based on microstructural and 3-D pfofile analysis, coefficient of friction,measurements of wear rate and roughness settings of aluminum matrix composites, the best wear behavior shows Al samples strengthened with 15% Al-Ti-C master

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