Materials and Design 92 (2016) 23–35

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Optimization of wear parameters and their relative effects on TiN coated surface against Ti6Al4V alloy

I. Saravanan [a,*], A. Elaya Perumal [b], R. Franklin Issac [c], S.C. Vettivel [d], A. Devaraju [e]

[a] Department of Mechanical Engineering, College of Engineering Guindy Campus, Anna University, Chennai 600025, India
[b] Department of Mechanical Engineering, College of Engineering Guindy Campus, Anna University, Chennai 600025, India
[c] Department of Mechanical Engineering, Adhi College of Engineering and Technology, Kanchipuram 631605, Tamilnadu, India
[d] Department of Mechanical Engineering, V V College of Engineering, Tisaiyanvilai 627657, Tamilnadu, India
[e] Department of Mechanical Engineering, Adhi College of Engineering Technology, Kanchipuram 631605, Tamilnadu, India

ARTICLE INFO

Article history:
Received 6 May 2015
Received in revised form 29 November 2015
Accepted 30 November 2015
Available online 2 December 2015

Keywords:
Wear
Surface profile
Optimization
Surface roughness
TiN
Ti6Al4V alloy

ABSTRACT

This study focuses the relation between the surface roughness, hardness and wear depth on the dry sliding environment. The wear performance of the hard TiN coated surface slides against the Ti6Al4V alloy was studied by considering the different parametric conditions. The wear maps clearly revealed the relative effects of the wear parameters and their influences on the wear mass loss and the coefficient of friction (COF). The initial surface roughness plays a major role in deciding the wear mechanism when sliding takes place. The SEM morphology and profile study on the worn surfaces clearly evident the wear mechanism. The Response Surface Methodology (RSM) confirms the feasible zone for the responses and it identified the optimal parameters of applied load 2.8 N and sliding velocity 0.25 m/s which leads to minimal responses for the composite desirability of 91.2%.

1. Introduction

Biocompatible grade stainless steel (SS) 316L is widely used for surgical equipments in medical applications [1,2], since it possesses superior corrosion resistance due to the chromium oxide film formation on the surface. It has a unique role to play as an orthopaedic implant material, but the surface hardness remains poor. Hence, it is important to overcome the deficiency by the necessary surface modifications [3,4]. The coating is an effective technique with good adhesion strength, which can be used to enrich the surface and wear properties, without affecting the base material properties [5].

Titanium nitride (TiN) is a bio-ceramic material which is used for hard coatings due to the presence of nitrogen [6]. The TiN coated SS 316L resists the wear in the sliding environment due to its improved hardness [7,8]. Especially, this combination of material is widely used in the contact interface of an artificial human hip prosthesis, and it is subjected to a constant applied load with uniform sliding motion at a temperature of about 37 °C [9]. The Cathodic Arc Deposition (CAD) is considered as an effective coating technique, due to its high ionization rate for achieving higher bonding strength and dense coating [10]. The coating material has a significant effect on the tribolayer formation, which controls the friction and wear behaviour during sliding [11]. The CAD TiN coating on SS 316L surface showed a strong peak at (111) plane which improves the bonding strength [12].

The surface roughness of the TiN deposition by CAD was influenced by the occurrence of the macro-droplets and pits, developing due to the titanium micro-particles dropping out during the process [13–15]. The surface roughness depends mainly on the nature of the substrate, deposition time, coating thickness, substrate temperature, and bias voltage [16]. Song et al. [17] analysed the influences of surface roughness in multilayer nitrate coatings and inferred that the decrease of the surface roughness results in better mechanical and adhesion properties of the material. The initial surface roughness has a major influence on the friction and wear behaviour of the coated surface [18]. The friction and wear behaviour of the coated surface are controlled by the incidence of normal load, thermal effect and oxidation, which are interconnected and related to the sliding contact mechanism. These factors are

* Corresponding author.
E-mail addresses: is.annauniv@gmail.com (I. Saravanan), ep_mal@yahoo.com (A. Elaya Perumal), franklin.0508@gmail.com (R. Franklin Issac), vettivel@vvcoe.org (S.C. Vettivel), adevaa2008@rediffmail.com (A. Devaraju).

http://dx.doi.org/10.1016/j.matdes.2015.11.119
0264-1275/