Characterisation of Plasticity Response for Reciprocating Sliding Wear Test Of Ti-6Al-4V under Variables Normal Load

D. Harun1,a, A.L. Mohd Tohir1,b, A. Singh Chaal1,c, R. Md. Nasir2d
1Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Malaysia.
2USM School of Mechanical Engineering, Universiti Sains Malaysia (Engineering Campus)
Seri Ampangan 14300 Nibong Tebal Seberang Perai Selatan, Pulau Pinang, Malaysia

a dalila@uthm.edu.my, b abdlatif@uthm.edu.my, c amree88@hotmail.com, d meramdziejah@eng.usm.my

Abstract
Reciprocating sliding wear test of uncoated titanium alloy, Ti-6Al-4V is investigated using pin-on-flat arrangement under variable applied normal load. The wear scar produced by the reciprocating sliding wear test is analysed by surface profile examination using 2D and 3D optical microscope (OM) and Scanning Electron Microscope (SEM). The hardness value of the wear scar is investigated at three regions which are; worn, unworn and the end of the wear track using Micro Vickers Hardness Test. The presence of moderate oxygen composition and the increasing in hardness value at the end of wear track suggesting evidence of plastic deformation.

Keywords: Plasticity, reciprocating wear test, pin-on-flat tester, variable normal load.

Introduction
Tribology is the science and technology of interacting surfaces in relative motion where friction and wear field are covered in the tribology area [1]. Wear can occur in most engineering applications involving multi-body contact by the undesired cumulative change in dimensions brought about by the gradual removal of discrete particles [2]. Delamination wear can be predicted by sliding wear with the concept of ratchetting wear for the metallic material [3]. Wear in reciprocating sliding wear can reduce the fatigue life of the components [4]. Reciprocating sliding wear occurs at larger amplitude compared to fretting wear and the wear mechanism is much simpler. The reciprocating sliding is categorized in the fourth regime of wear and mainly dependent on the amplitude of sliding [5]. The other three regimes are partial slip, gross slip and fretting wear slip [5-6]. Until now the dynamics of the loading cycle have not been taken into account.

Experimental method
Titanium alloy, Ti-6Al-4V was machined into two different shapes (i) rectangular flat bar with dimensions of 100 mm x 25 mm x 8 mm and (ii) cylindrical pin of 6.5 mm in diameter. The experiment is done using the tribometer pin-on-flat machine (model, TR-20, by Ducom Triboinnovaters, Bangalore) in dry condition at ambient air. Set up parameter with variable normal loads 5 kg, 15 kg and 20 kg, constant sliding speed 100 RPM with 20 numbers of cycles. Each wear scar is examined by observing it with 2D and 3D (Ali-Cona Infinite Solution) optical microscope (OM). The morphologies of the wear scar were observed with Scanning electron
microscopy (SEM, Zeiss Evo MA, UK) system coupled with the energy-dispersive spectroscopy (EDS) mapping (EDAX Apollo X, USA). The hardness of the wear region is determined by Micro Vicker's hardness-tester, set at load of 980.7 mN (HV0.1) according to ASTM E384 standard.

Results & discussions
Fig. 1 shows the result for coefficient of friction, COF for those three variables load. Average result is 0.32 achieved.

![Fig. 1: Evolution of coefficient of friction for different normal loads](image1)

Wear scar result show as in Fig. 2 and profilometry result analyzed to determine the wear area. Wear scar shape observed shows W-shaped. Fig. 3 supporting the SEM result on surface focus on accumulates region at the end of wear track suspecting plasticity. The plastic deformation has performed the presence of oxygen with 4.42% by exceeding EDX analysis with determining the composition of the located surfaces.

![Fig. 2: (a) Optical microscope image on plan view (b) The profilometry of the wear scar width and depth](image2)

Hardness test approved the plastic deformation by showing the hardness on the accumulated experience high value compared to unworn and worn region. Also, the hardness increase to the increasing of variables normal load.

![Fig. 3: SEM image on accumulated of extruded during the wear test](image3)

Conclusion
Reciprocating sliding wear test between uncoated Ti-6Al-4V/Ti-6Al-4V in dry condition distinguished the evidence of plasticity. The plasticity response shows the presence of oxygen composition with different percent and giving increasing hardness for increase applied load.

References