Tribocorrosion Testing: Design and Typical measures

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Tribocorrosion is the interaction of mechanical and chemical phenomena during friction. The aim of this paper is to present one possible approach to extend a traditional tribological test to tribocorrosion measurements. A great number of devices operate in medium to highly corrosive environment and are therefore relevant of tribocorrosion.

A better understanding of tribocorrosion can be achieved through tribological testing in the corrosive environment. Combined electrochemical techniques can be used to access the corrosive part of the wear.

The electrochemical wear test rig is based on a traditional reciprocating tribometer shown in figure 1. Pin (1) is rubbed against a flat sample (2) hold into an electrochemical cell (3). The pin displacement is generated by an actuator (4), either an electrodynamic vibration exciter (Brüel Kjaer 4809) or a linear motor (ETEL EPMA-DE01B). The first for better dynamic properties, the linear motor to achieve a better displacement control. Both tangential (5) and normal (6) forces are measured. A piezo electric sensor (Brüel Kjaer 8200) measures the tangential forces thanks to the blades (7) supporting the main holder. The normal force transducer (Interface Minibeam MB-25) is a single point beam load cell designed for weighing applications. Those cells are insensible to other forces except the normal one. The pin displacement is measured vertically and horizontally by using a laser diode (8 : ILEE LDA1001, <1mW, 670nm) mounted on the pin holder. The displacements of the laser beam are recorded by a two dimensional position sensitive detector (Hamamatsu S1880 photodiode). The vertical displacement relates to the contact

topography and total wear, the horizontal one relates to the actual pin displacement.

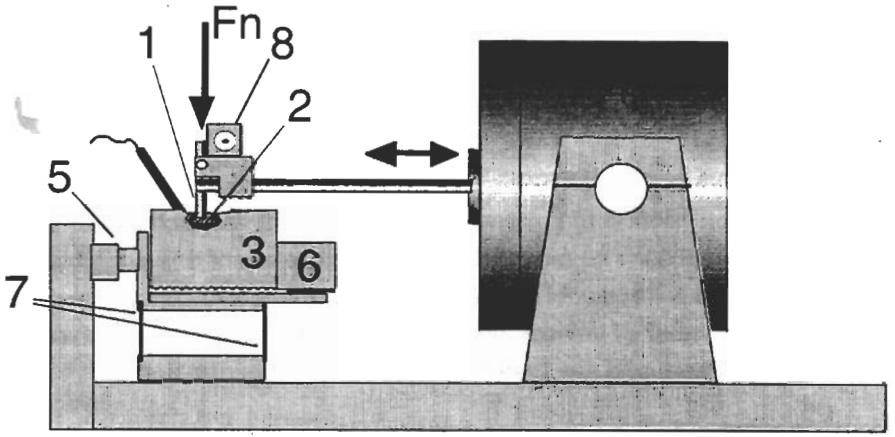

Fig. 1 Electrochemical wear test rig side view

The electrochemical cell, 72 x 60 x h43 mm, shown in figure 2 hold a flat sample (1) with four nylon screws. The squared sample is imbedded into a polymeric resin (Kulzer, Technovit 4071) and polished in order to have a well defined surface exposed to the electrolyte (60ml) and the rubbing antagonist. The counter electrode (2) is a platinum wire placed in a channel on three sides of the cell. The working electrode can either be the pin (3), the flat sample, or both of them. Nevertheless an electrochemically inert pin in Al_2O_3 has usually been used allowing to relate the electrochemical response to only one of the antagonists. A reference electrode (4) is placed in front of the pin path. The oscillating pin is a 4mm alumina rod with the end in the shape of truncated cone (120° included angle). A HEKA PG285 potentiostat is used to apply the electrochemical potential.

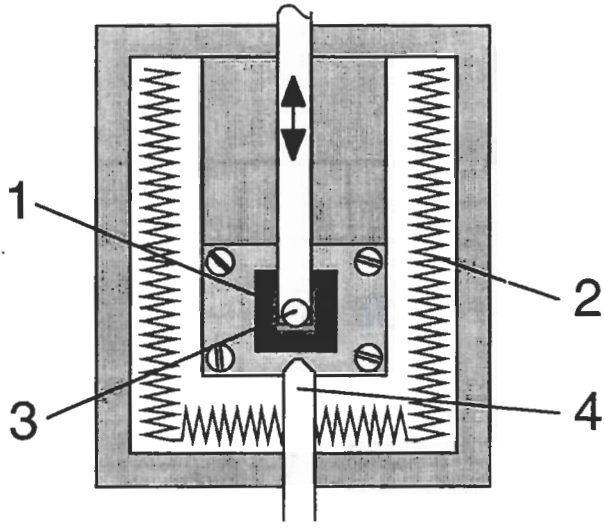

Fig 2. Electrochemical cell, top view

The experimental setup is controlled and monitored via a Labview Software developed at the EPFL-LMCH. The PC (MacIntosh IIfx) controls the pin displacement (amplitude and frequency) and simultaneously records up to eight transients at 16 bits resolution. Measures include tangential (friction) and normal forces, vertical (total wear & topography) and horizontal pin positions, applied potential and electrochemical current. Transients are recorded every few seconds with typically 1000 points at 4 Khz/channel, transient as well as mean values can then be filed.

This setup allowing one to perform tribological tests under electrochemical conditions, figures 3 illustrates typical transients recorded for an alumina pin (Metoxit AG, Thayngen, Switzerland) rubbing against stainless steel (Fe17Cr, Böhler AG, Wallisellen, Switzerland) in 1N H_2SO_4. The applied potential is in the passive region for the Fe17Cr at

900 mV SHE. The pin was oscillating at a frequency of 5 Hz. The stroke length was 1.9 mm, The normal force was 45 N.

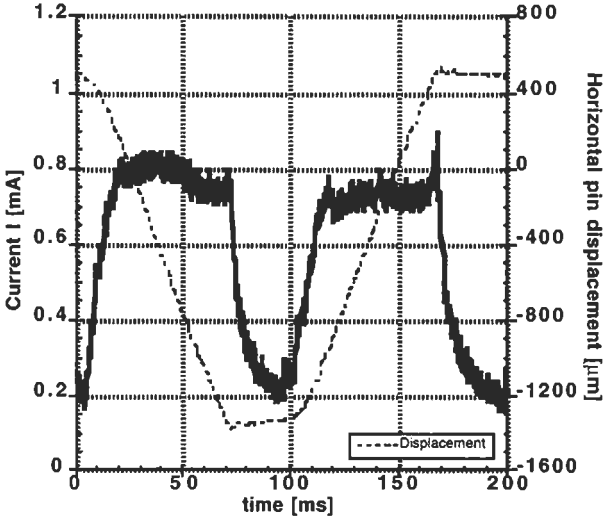

Fig. 3 Current & pin position transients recorded for Fe17Cr in 1N H_2SO_4

When rubbing the current density raises from 0.01 mA/cm_2 to 58 mA/cm^2 due to the partial removal of the passive layer. When the pin holds on both stroke ends the current drops according to the repassivating properties of the Fe17Cr.

The electrochemical wear test rig allows one to perform tribological test and electrochemical measurements simultaneously, but the intermittent nature of the reciprocating tribometer seems to be a key factor to enlighten the role of the kinetics, as illustrated by the repassivation of $Fe_{17}Cr$ in 1N H_2SO_4.