Tribological response of self-mated Zircaloy-4 under dry and water submerged conditions

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Abstract

Zirconium alloys are excellent materials having low neutron absorption cross-section and good mechanical properties, due to which these are widely used for core components in nuclear reactors. Reciprocating tribo-tests were conducted on Zircaloy-4 (Zr-4) under the self-mated conditions at varying amplitude, frequency, and test duration. To understand the active wear mechanism, worn surfaces were analyzed using Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS), Raman spectroscopy and 3D Profilometry. The change in amplitude severely affects the wear than other factors. The wear mechanism transits from stick-slip to gross slip with increasing amplitude. The dominant wear mechanisms were delamination at the amplitude of 100 µm whereas micro-cutting and micro-ploughing followed by delamination in some areas at the amplitude of 400 µm. However, the COF has indifferent behaviors under dry conditions, whereas it remains almost constant for the given parameters under water submerged conditions. Generally, COF and wear were less for water submerged conditions than for dry conditions. The oxide layer was also found on worn surfaces, which is prominent at 100 µm amplitude and decreases with increasing amplitude (present only at a few locations at 400 µm amplitude).

Keywords: Zircaloy, Fretting wear, adhesion, delamination, micro ploughing.