The XIV Finnish Mechanics Days 2022
May 18–20, 2022, Lappeenranta, Finland

Re-analysis of annular flat-on-flat fretting experiments using the contact oxygenation concept

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ABSTRACT

Fretting stands for the action of reciprocating sliding where sliding amplitudes are smaller than the characteristic length of the contact so that most of the contact remains closed. It causes fretting wear and fretting fatigue, the latter being notoriously harmful type of damage [6]. Regarding to the contact oxygenation concetp, adhesive to abrasive fretting wear regime transition in fretting with 34NiCrMo16 was studied recently by Baydoun et al [2, 1]. The contact type used was a flat-on-flat with rectangular shape. Various contact sizes were used ranging up to 5.0 mm x 5.0 mm. It was suggested that di-oxygen partial pressure inside the fretting contact defines the regions of abrasive wear and adhesive wear [3]. Locations where di-oxygen partial pressure is above certain threshold value are characterized by formation of oxides and abrasive wear, and regions where oxygen partial pressure is below the threshold, remain mostly metallic showing adhesive fretting damage. Baydoun et al. modeled the transport of oxygen in the fretting contact using an Advection-Dispersion-Reaction (ADR) approach, where flow of oxygen occurs through porous media (layer of fretting wear debris) and is being consumed by oxidation of fresh metallic surfaces [1]. Baydoun et al. also derived a parametric equation for predicting the predominantly oxygenated distance from contact edge (d_o) for their test setup, which is shown in Eq.1, where f and p stand for frequency and pressure respectively [2]. The constants of the equation are $d_{o,ref}$ = 1.51 mm, f_{ref} = 1 Hz, p_{ref} = 100 MPa, n_f = -0.22 and n_p = -0.32.

$$d_o = d_{o,ref} * (f/f_{ref})^{n_f} + (p/p_{ref})^{n_p} \tag{1}$$

Quenched and tempered steel (34CrNiMo6+QT) has been studied extensively under fretting conditions. Experiments done using the annular flat-on-flat test rig have shown that the first 10^5 load cycles are characterized by adhesive damage in a form of localized adhesion spots [4]. The measured friction exhibits a non-Coulomb characteristics, which has been linked to adhesive material transfer. Furthermore, the adhesion spots showed evidence of cracking [5]. These experiments were done using normal pressure in range of 10 to 50 MPa, average sliding amplitude in range of 5.0 to 65.0 μm, loading frequency of 40 Hz and in ambient laboratory atmosphere. The contact shape is annular with inner and outer radii of 7.5 and 12.5 mm, a section of which matches closely to the specimen dimensions used by Baydoun et al. The Eq.1 predicts that 44 %, 60 % and 67 % of the contact area should remain adhesive with the annular flat-on-flat experiments, when contact pressure is 10 MPa, 30 MPa and 50 MPa, respectively. This indicates that the experimental conditions should be quite adhesive agreeing with the experimental observations. Initial findings of the contact oxygenation concept shows promise, justifying a deeper re-analysis of the annular flat-on-flat results.

Keywords: abrasion, adhesion, wear, steel

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