A Numerical Study on Fretting Wear of Inconel 718 Alloy Processed by Ultrasonic Nanocrystal Surface Modification

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Background

- **Laser-based additive manufacturing (AM) technology was invented in the 1980s and two of the most commonly-used commercial methods today are:**
  - powder-fed directed energy deposition (DED),
  - powder-based fusion (PBF) system.
- **An ultrasonic nanocrystalline surface modification (UNSM) technique is one of the newly developed surface modification technique which can improve the mechanical and tribological properties of various metallic materials by these ways:**
  - grain size refinement,
  - severe plastic deformation (SPD),
  - produces a corrugated structure and number of desired micro-dimples on surface.
- **However, the influence of UNSM process on wear resistance has not been quantitatively analyzed. Here we investigated the effects of UNSM technology on the improvement in numerical fretting wear model of Inconel 718 alloy at various conditions such as displacements and normal load.**

Experimental Results: Nanoindentation and SEM

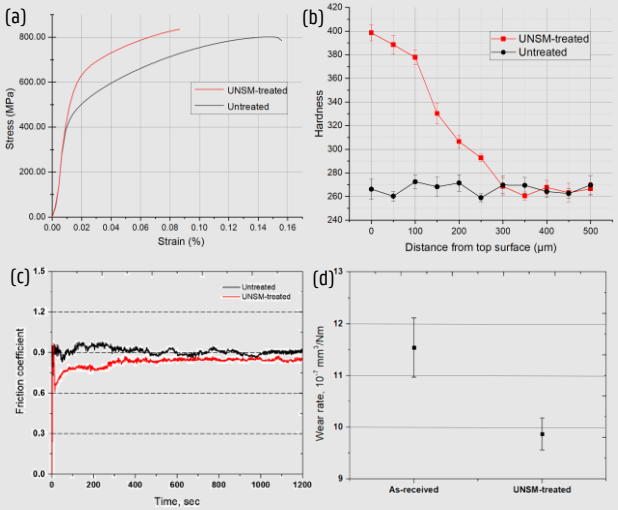

Fig. 3. Stress-strain curve (a), variations in hardness at near-surface (b), friction coefficient (c) and wear coefficient (d) of the as-received and UNSM-treated specimens.

Numerical Methods and Results: FEM, UMESHMOTION, USDFLD, Linear kinematic hardening rule

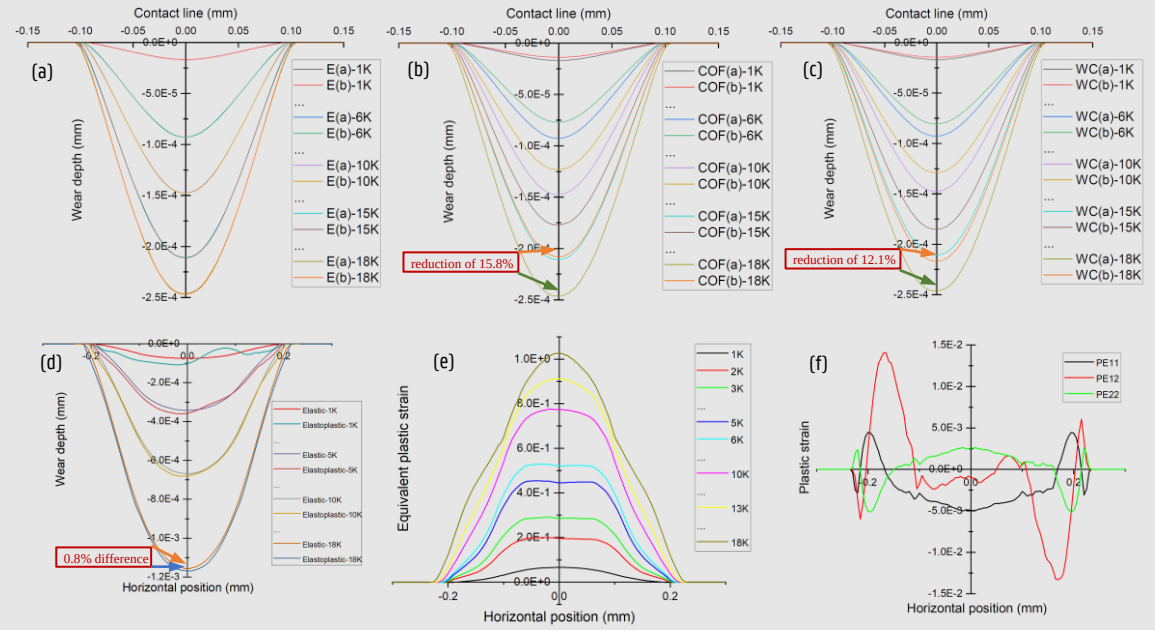

Fig. 4. The evolution of the wear scar for different elastic modulus (a), COF (b), wear coefficients (c), elastic/elastoplastic behaviors (d), equivalent plastic strain (e) and plastic strain components (f) during the wear process using FEM.

Experimental Model

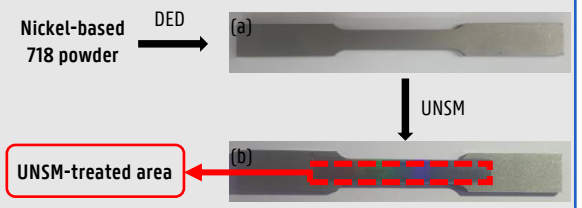

Fig. 1. The untreated (a) and UNSM-treated (b) dog-bone shape samples.

Finite Element Model

- Contact model is partitioned into two parts: contact zone and Non-contact area.
- 4-node bilinear plane strain elements (CPE4).

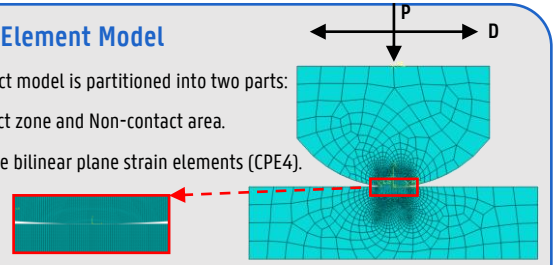

Fig. 2. The schematic of fretting wear model.

Key Findings

- **The UNSM-treated specimens exhibited better tribological and higher mechanical properties compared to that of the untreated specimens under fretting conditions.**
- **Through the establishment of a finite element model, the influence of UNSM technology on the near-surface is investigated and the wear performance of Inconel 718 alloy treated by UNSM is predicted.**
- **The considering of different elastic modulus and elastic/elastoplastic behaviors seems to have no significant effect on wear resistance.**
- **However, the COFs and wear coefficients modified by UNSM have a great influence on the wear profile. Therefore, it is highly foreseeable that the surface hardening technology will greatly improve the surface wear performance of the specimen.**

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