SOETE LABORATORY – EMSME (EA08)

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NUMERICAL STUDY OF FRETTING WEAR CONSIDERING SHOT PEENING SURFACE MODIFICATION TECHNIQUE

Background

- The shot peening (SP) is one of the newly developed surface modification technique which can improve the mechanical and tribological properties by grain size refinement, and surface severe plastic deformation (SSPD).
- Change of mechanical properties:
  - Residual stress (CRS),
  - Higher overall elastic modulus (*E*) and ultimate tensile stress (UTS).
- Tribological properties:
  - Surface roughness,
  - Lower coefficient of friction (COF) and wear coefficient,
  - Higher wear resistance and fatigue lifetime.
- However, the experimental cost is high, and the numerical analysis of the effect of SP on fretting wear is seldom performed.

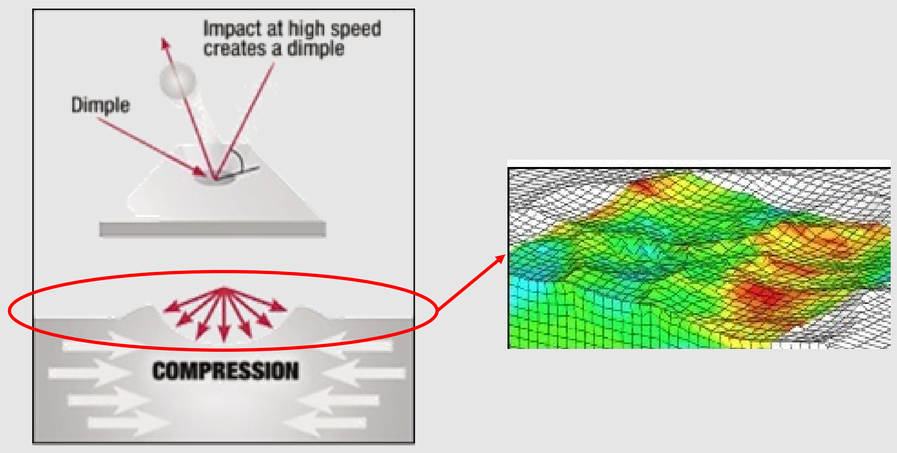


Fig. 1. The diagram of SP process.

Methods and Models: FEM, Finite Element Model

- The material for pad and specimen is Ti-6Al-4V. Fretting cycles: 1000.
- Model partition: divided into contact zone and non-contact area.
- Element type: Four-node plane strain (CPE4R) and the mesh size of contact area is 10 μm.
- Dissipated energy wear model: $k_E = V / \sum_i^N 4\mu_i P_i \delta_i$

Table 1 Mechanical properties of Ti-6Al-4V

Material	E [GPa]	V	σ_{yield} [MPa]
Ti-6Al-4V	119	0.29	970

Table 2 Fretting wear test conditions

Specimen	Normal load [N]	2δ [μm]	μ	K[Mpa^{-1}]
Untreated	400	50	0.8	9.2×10^{-9}
SP-treated			0.78	8×10^{-9}

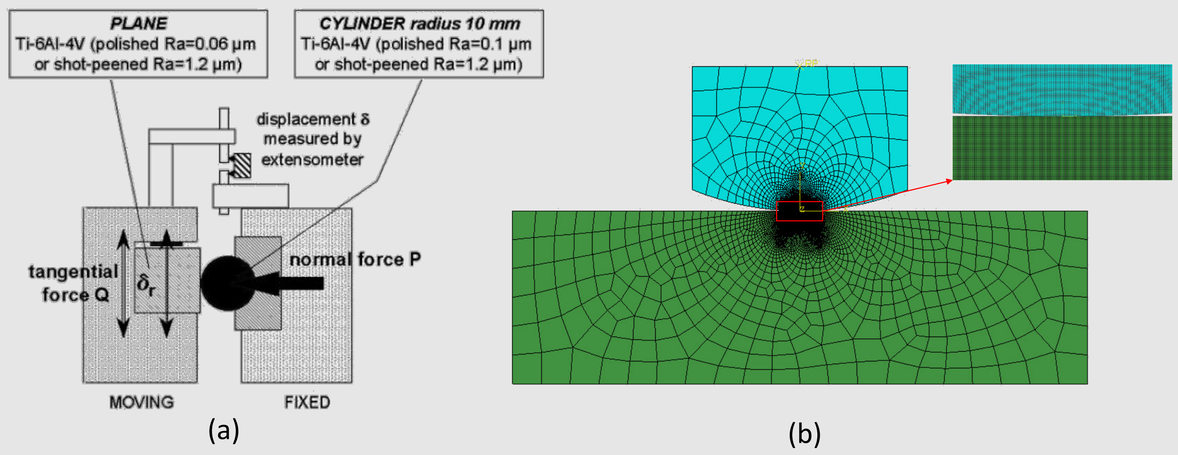
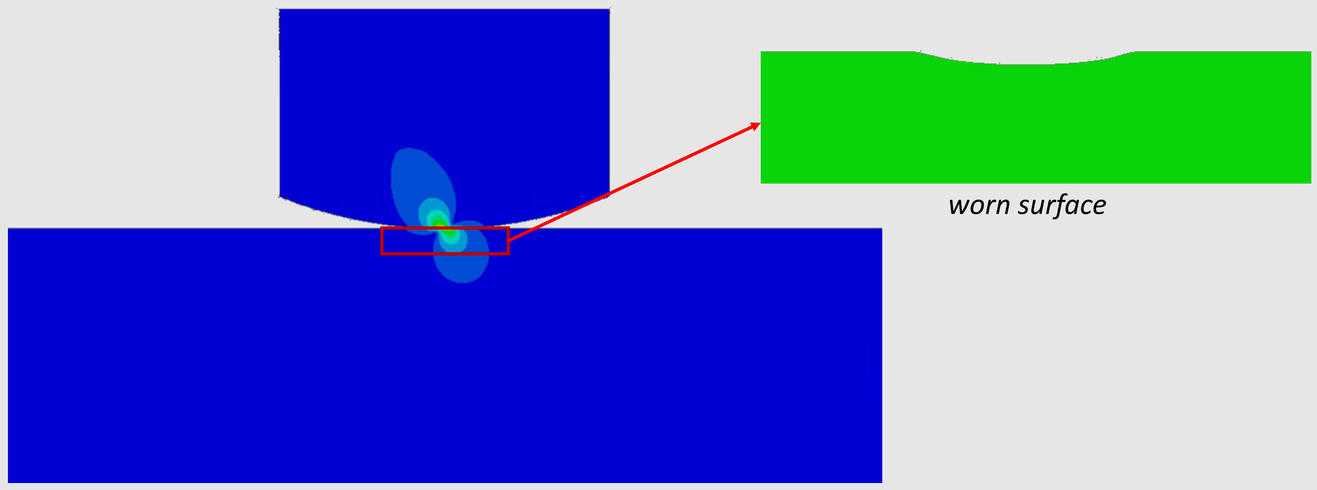


Fig. 2. The experimental setup (a) and the finite element model (b) for fretting wear.

Results



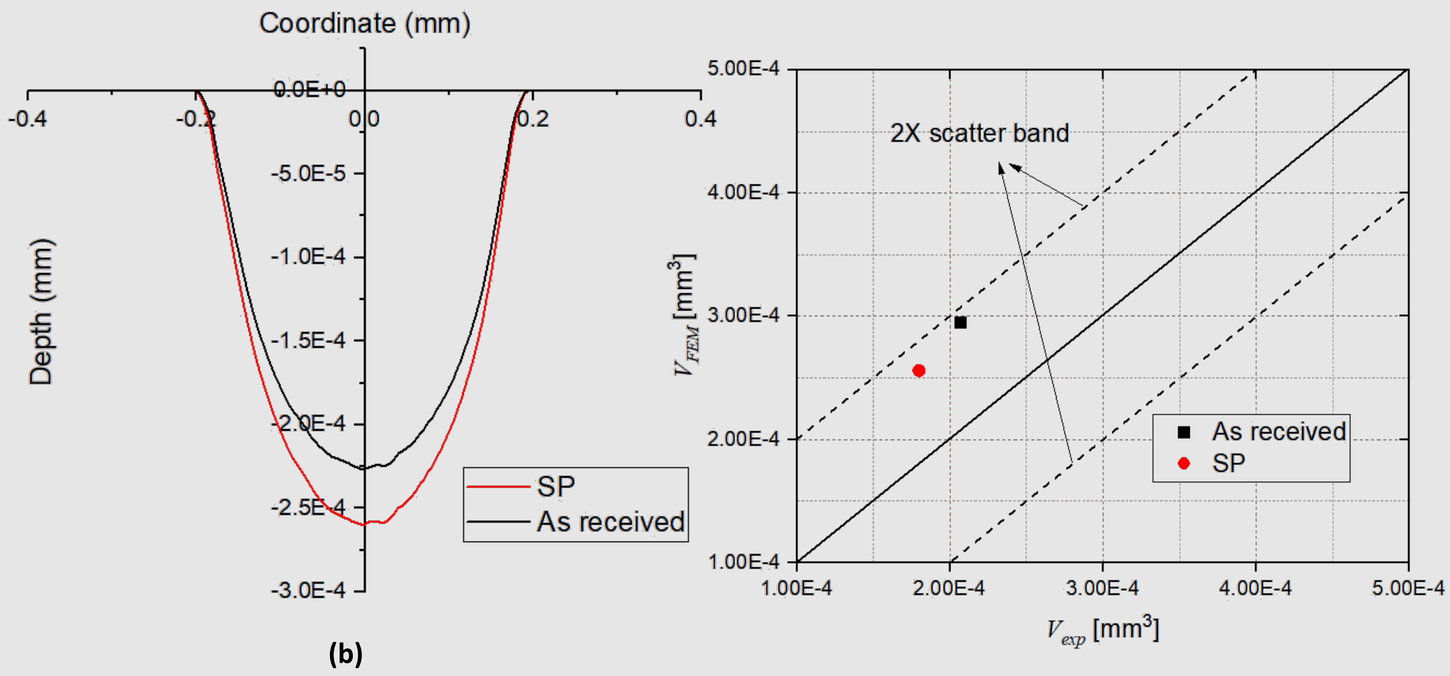


Fig. 3. The process of fretting wear and worn surface in FEM (a), wear profile after 1000 cycles (b), and wear volume comparison between FEM results and experimental measurements (c).

Key Findings

A numerical study of the fretting wear behavior of polished and shot-peened specimens show that:

- A finite element model was established to simulate the fretting wear process. Due to the plane strain condition, a 2D model is used to save computational cost.
- Numerical results show that SP can significantly improve the fretting wear performance of materials. The wear depth was significantly reduced by 13.5% and the wear volume was reduced by 13.3%.
- Comparison of numerical results with experimental measurements shows that the FEM can provide relatively high accuracy. The simulation results will provide guidance on surface treatment parameters to improve fretting wear performance in specific application area.

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