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Elliptical ultrasonic side milling for improved surface integrity and fatigue resistance of thin-walled Ti6Al4V components

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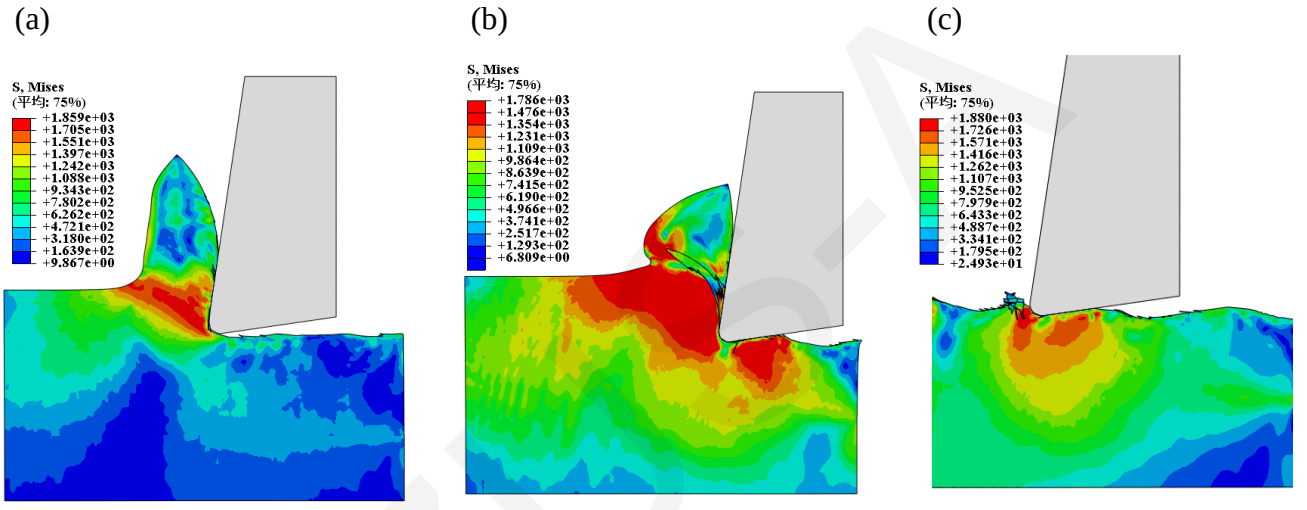
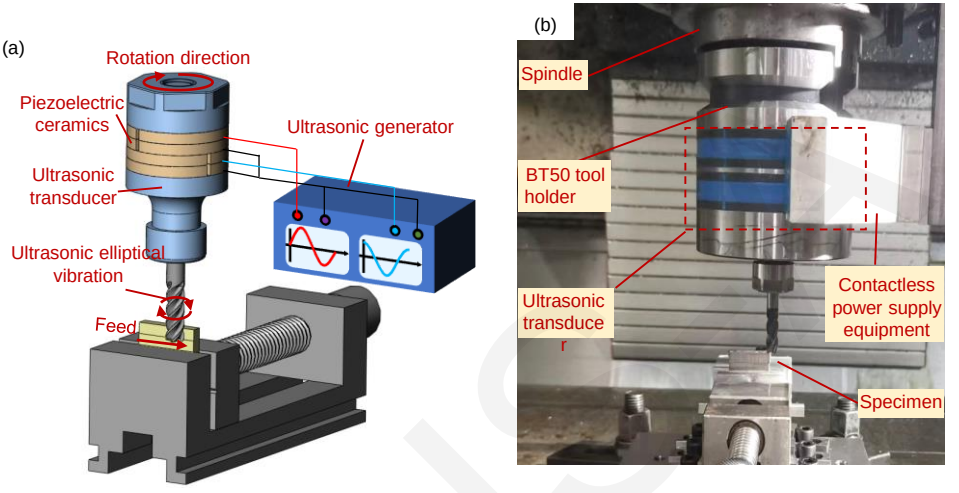
The strengthening mechanism of UPSM and TUPSM



Stress distribution nephograms under different cutting parameters for: (a) conventional cutting; (b) A = 8 μm in ultra-sonic peening cutting; (c) A = 8 μm in two-pass ultrasonic peening cutting

The stress evolution during different cutting processes was revealed through the finite element method. It was found that an edge's extrusion effect and the flank face's ironing effect exist in UPSM, and that TUPSM leads to further strengthening of the surface.

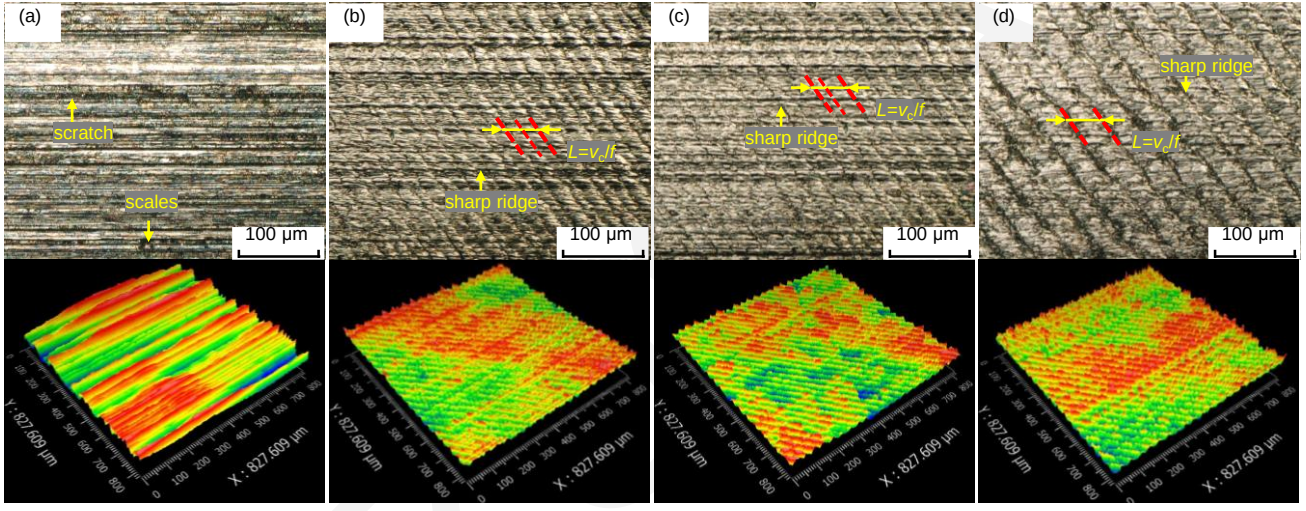


Experimental setup

Cutting parameters

Milling conditions	Values
Milling speed v_c (m/min)	40
Feed rate per tooth f_z (mm/z)	0.02
Radial depth of cut a_e (mm)	0.1 in UPSM, 0.003 in TUPSM
Axial depth of cut a_p (mm)	5
Vibration amplitude A (μm)	0, 4, 8
Vibration frequence f (Hz)	18500

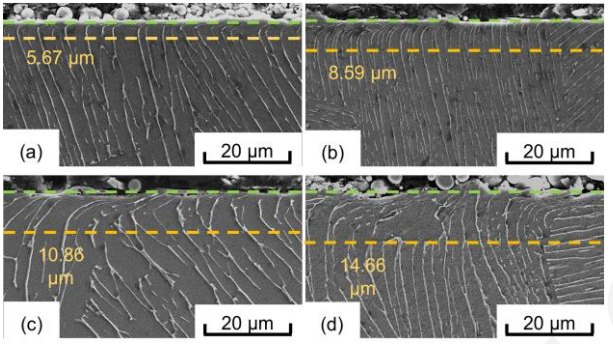
Optimization effect of surface morphology in UPSM and TUPSM



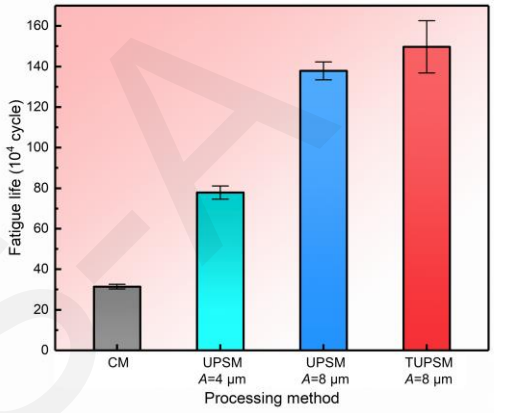
2D and 3D surface topography of the machined surface under different parameters for: (a) CM; (b) A = 4 µm in UPSM; (c) A = 8 µm in UPSM; (d) A = 8 µm in TUPSM

Compared to CM, UPSM minimizes surface defects such as scratching and scaling, despite inducing slightly higher surface roughness due to its associated texturing effects.

Strengthen effect in UPSM and TUPSM

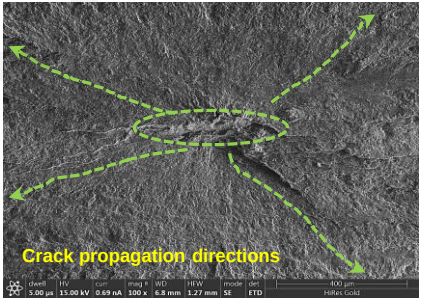


The sub-surface plastic deformation layer under different milling methods for: (a) CM; (b) A= 4 μm in UPSM; (c) A = 8 μm in UPSM; (d) A= 8 μm in TUPSM



Fatigue life under different milling methods

The fatigue source originates beneath the surface under UPSM at A = 8 μm and TUPSM



Both UPSM and TUPSM demonstrate excellent surface strengthening effects. At a vibration amplitude of 8 μm, UPSM and TUPSM increase the fatigue life by factors of 3.38 and 3.76, respectively.