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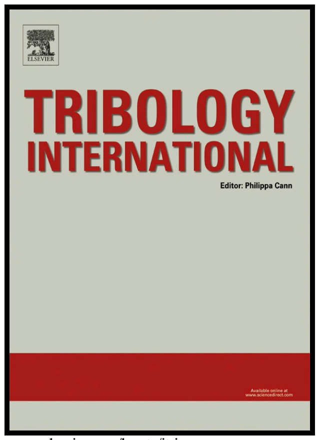

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A non-collinear fretting-fatigue experiment to compare multiaxial fatigue criteria: critical shear plane strategy is better than invariant formulations

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Abstract

Fretting-fatigue crack nucleation is usually predicted from multiaxial fatigue criteria combined with non-local approaches to take account of fretting stress gradient. Conventional collinear fretting-fatigue loadings, being effectively uniaxial near the hotspot surface contact border, lead to similar predictions whatever the non-local approach and fatigue criterion. To differentiate between approaches, a new non-collinear fretting-fatigue set-up was developed applying fatigue stress at a β-angle to the fretting direction. Using this device, the crack nucleation condition of 35NiCrMo16 steel was investigated as a function of the β-angle. 3D elastic simulations enabled, for the first time, performance to be compared between critical plane versus invariant formulations. Experiments and modeling suggested that the McDiarmid criterion provides the best crack nucleation predictions.

Keywords: Fretting-Fatigue; non-collinearity; crack nucleation; multiaxial fatigue criteria

Highlights
- A new non-collinear β-angle fretting-fatigue experiment is introduced
- A real multiaxial fretting-fatigue crack nucleation analysis was performed
- Reliable comparison was achieved between multiaxial fatigue criteria
- The best predictions were provided by McDiarmid's maximum shear critical plane approach
- The relative influence of fatigue stress ratio and β-angle were quantified

Nomenclature

%E	Mean absolute error (%)
%SD	Standard deviation (%)
a_H	Hertzian contact radius (mm)
b	Crack length (µm)
b_{CN}	Crack nucleation length b_{CN}=10µm
$b_{\emptyset}$	Short-to-long crack propagation regime transition (µm)
E	Young’s modulus (MPa)
e	Eccentricity (µm)
FF	Fretting-fatigue (collinear)
ℓ	Non-local length scale (µm)
ℓ_D	Critical distance (µm)
ℓ_L	Line averaging length (µm)
ℓ_V	Process volume cubic length (µm)