Fatigue crack growth in two TWIP steels with different stacking fault energies

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PII: S0142-1123(17)30043-9
DOI: http://dx.doi.org/10.1016/j.ijfatigue.2017.01.034
Reference: JIJF 4224

To appear in: *International Journal of Fatigue*

Received Date: 13 November 2016
Revised Date: 22 January 2017
Accepted Date: 23 January 2017

Please cite this article as: Yang, H.K., Doquet, V., Zhang, Z.F., Fatigue crack growth in two TWIP steels with different stacking fault energies, *International Journal of Fatigue* (2017), doi: http://dx.doi.org/10.1016/j.ijfatigue.2017.01.034

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Abstract

Fatigue crack growth tests with R=0 and 0.4 were carried out on Fe-22Mn-0.6C and Fe-22Mn-0.6C-3Al (wt. %) Twinning-Induced Plasticity (TWIP) steels with stacking fault energies around 21.5 and 37 mJ/m^2, respectively. The former exhibits more crack closure effects, partly due to stronger asperity-induced closure. Strain-controlled push-pull tests followed by scanning electron microscope observations show that both steels are prone to mechanical twinning under low-cycle fatigue, associated with an increasing kinematic hardening. Twinning is however more profuse in Fe-22Mn-0.6C steel. Elastic-plastic finite elements simulations of crack growth, using specific constitutive equations able to capture the increasing kinematic hardening suggest that plasticity-induced crack closure is lower in Fe-22Mn-0.6C steel. Even after closure corrections, the Al-free steel, exhibits a lower resistance to fatigue crack growth, which is attributed to a pronounced strain localisation at the crack tip, and maybe also to environment effects.

Key words: TWIP steel; Fatigue crack growth; Crack closure; Mechanical twinning; kinematic hardening.