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Kishan Habib, Motomichi Koyama, Toshihiro Tsuchiyama, Hiroshi Noguchi

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Fatigue crack non-propagation assisted by nitrogen-enhanced dislocation planarity in austenitic stainless steels

Kishan Habib, Motomichi Koyama*, Toshihiro Tsuchiyama, Hiroshi Noguchi

Affiliation

Kyushu University, 744 Motoooka, Nishi-ku, Fukuoka, 819-0395, Japan

Corresponding author: Motomichi Koyama

e-mail:koyama@mech.kyushu-u.ac.jp

- The Fe-25Cr-1N steel exhibited a non-propagating fatigue crack at the fatigue limit.
- Roughness-induced crack closure contributes to the non-propagating crack.
- Enhanced planar dislocation and high dislocation pile-up stress play a key role.
- The crack propagation occurred along the $\{111\}_\gamma$, even in the long crack

Abstract

Rotating bending fatigue tests were conducted to assess the fatigue crack propagation behavior of the Fe-25Cr-1N and Fe-18Cr-14Ni austenitic steels in terms of the microstructure, crack propagation paths, and non-propagating fatigue crack characteristics. The Fe-25Cr-1N steel exhibited a non-propagating fatigue crack at the fatigue limit (310 MPa), but this did not occur in the Fe-18Cr-14Ni steel at the fatigue limit (110 MPa). The non-propagating fatigue crack observed in the Fe-25Cr-1N steel was produced by roughness-induced crack closure. This phenomenon was caused by the enhanced planar dislocation and high dislocation pile-up stress resulting from the suppression of cross-slip, which inhibited the dislocation emission from the crack tip. The Fe-25Cr-1N steel exhibited a lower fatigue crack growth rate than the Fe-18Cr-14Ni steel because of the enhanced dislocation planarity produced by the Cr-N interaction. The Cr-N interaction affected the fatigue crack growth behavior as follows. The short crack region exhibited a planar glide dislocation pattern, but multiple slip systems were activated as the crack lengthened. As the dislocation pattern remained planar on each slip plane, the crack propagation occurred along the $\{111\}_\gamma$ slip planes, even in the long crack. Moreover, the dislocation pile-up

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