Residual stress in expanded austenite on stainless steel; origin, measurement, and prediction

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Expanded austenite is a supersaturated solid solution of nitrogen/carbon in austenite that forms as a case by the diffusion of nitrogen/carbon into austenitic stainless steel. Expanded austenite has a high level of hardness that provides resistance against galling and wear, superior resistance against localized corrosion, and contributes to improvement of the fatigue performance. This latter characteristic is a consequence of the huge compressive residual stresses in the expanded austenite case. Such stresses are induced by the high interstitial content in the austenite lattice and are accommodated elasto-plastically. The experimental assessment of the elastic lattice strains is complicated by the presence of steep composition-depth and stress-depth profiles, which necessitate special measurement or correction procedures to unravel the influence of composition and stress on the lattice spacing and avoid artifacts arising from (steep) lattice-spacing gradients. In the present work the $\sin^2\Psi$ method was combined with grazing incidence X-ray diffraction to keep the information depth during measurement shallow, independent of the (effective) tilt angle $\Psi$. The plastic strains in the expanded austenite 27 zone were estimated from the lattice rotations, as determined with electron backscatter diffraction. It is demonstrated that the level of elastic lattice strains in expanded austenite can be adjusted by retracting part of the dissolved nitrogen. The experimental results for elastic and plastic strains are compared to those predicted by a comprehensive numerical model that simulates the time-dependent development of composition-depth and stress-depth profiles in expanded austenite. The work described in this manuscript is a combination of a review of previously achieved and published results as well as the newest results of ongoing research activities.

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