NOTCH SENSITIVITY EFFECTS UNDER STRESS CORROSION CRACKING CONDITIONS

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The vast majority of structural components have notches that locally concentrate stresses around their tips. The notch sensitivity factor q, widely used to quantify the effect of such notches on fatigue, can be associated with the generation of non-propagating cracks at the notch tips in fatigue tests when $S_L(R)/K_t < \sigma_n < S_L(R)/K_f$, where $S_L(R)$ is the fatigue limit of the material at a given $R = \sigma_{min}/\sigma_{max}$ ratio; $K_t = \sigma_{max}/\sigma_n$ is the stress concentration factor (SCF) of the notch; σ_n is the amplitude of the nominal stress that loads it; σ_{max} is the maximum stress at the notch tip; and $K_f = 1 + q(K_t - 1)$ is the (effective) fatigue SCF, which quantifies the actual notch effect on the fatigue strength of the notched component. Based on this behavior, a model was recently developed to calculate q considering the influence of the stress gradient of ahead of the notch tip on the fatigue behavior of mechanically short cracks, using only proper stress analysis techniques and the basic fatigue properties of the material, its fatigue limit and long crack propagation threshold. This model, whose predictions were validated by various appropriated experiments, considers all the notch geometry and loading characteristics on q, without the need of any data-fitting parameter.

This notch sensitivity criterion is extended here to treat Environmentally Assisted Cracking (EAC) problems explicitly considering stress analysis issues, properly accounting for notch effects on the resistance of structural components in a given aggressive medium. The chemical effects are quantified by the material resistance to EAC cracking, S_{EAC}, and by its crack propagation threshold under EAC conditions, K_{IEAC}, both measured in the aggressive environment in question by standard procedures. Like in the fatigue case, this model predicts the existence of a notch sensitivity q_{EAC} in EAC problems as well, when $S_{EAC}/K_t < \sigma_{max} < S_{EAC}/[1 + q_{EAC}(Kt - 1)]$, which can be quantified by stress analysis techniques analogous to those successfully used to quantify q in fatigue. This is no surprise, since EAC is a time-dependent mechanical-chemical damage process due to the joint effect of tensile stresses and aggressive environments, which include crack nucleation and eventually growth up to fracture under static loads well below those tolerable in benign media. Indeed, if we recognize that such cracks can grow only if driven by suitable tensile stresses, then environment contribution can be treated as e way to decrease the material resistance to the cracking process. Moreover, such contribution can be displayed in a Kitagawa

To experimentally verify the validity of this model predictions about the behavior of notched components under EAC conditions, S_{EAC} and K_{IEAC} properties were measured for different material/aggressive medium pairs. Using only the mechanics proposed in this new model and such basic material resistances to EAC, notched test specimens were designed to survive to maxima stresses at their notch tips at least ***twice*** as large as the stress that initiates and propagates cracks in smooth specimens, $\sigma_{max} > 2 \cdot S_{EAC}$. The model proposed here predicts that this behavior is possible due to the interaction of the stress gradient ahead of the notch tip with the small crack initiated there by EAC, which becomes non-propagating under conditions that can be quantified by the notch sensitivity q_{EAC}, properly calculated by stress analysis techniques. Therefore, the proposed methodology to calculate notch sensitivity under EAC conditions has potential to become a quite useful tool to quantify notch effects in structural problems that must endure EAC conditions.

[1] Castro,JTP; Landim,RV; Leite,JCC; Meggiolaro,MA "Prediction of Notch Sensitivity Effects in Fatigue and EAC", Fatigue and Fracture of Engineering Materials and Structures, in print, 2014.
[2] Castro,JTP; Leite,JCC "Does notch sensibility exist in environmentally assisted cracking (EAC)?", Journal of Materials Research and Technology v.2, p.288-295, doi:10.1016/j.jmrt. 2013.02.010, 2013.