A note on the short crack behavior at elongated notch roots

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The notch sensitivity factor q can be associated with the presence of non-propagating fatigue cracks at the notch root. Such cracks are present when the nominal stress range $\Delta\sigma_n$ is between $\Delta\sigma_0/K_t$ and $\Delta\sigma_0/K_f$, where $\Delta\sigma_0$ is the fatigue limit, K_t is the geometric and K_f is the fatigue stress concentration factors of the notch. Therefore, in principle it is possible to obtain expressions for q if the propagation behavior of small cracks emanating from notches is known. Several expressions have been proposed to model the dependency between the threshold value ΔK_{th} of the stress intensity range and the crack size a for very small cracks. Most of these expressions are based on length parameters, estimated from ΔK_{th} and $\Delta\sigma_0$, resulting in a modified stress intensity range able to reproduce most of the behavior shown in the Kitagawa-Takahashi plot. Peterson or Topper-like expressions are then calibrated to q based on these crack propagation estimates. However, such q calibration is found to be extremely sensitive to the choice of $\Delta K_{th}(a)$ estimate. In this work, a generalization version of El Haddad-Topper-Smith's equation is used to evaluate the behavior of cracks emanating from circular holes and semi-elliptical notches. For several combinations of notch dimensions, the smallest stress range necessary to both initiate and propagate a crack is calculated, resulting in expressions for K_f and therefore for q. It is found that the q estimates obtained from this generalization, besides providing a sound physical basis for the notch sensitivity concept, better correlate with experimental data from the literature.

Moreover, an experimental study was carried out on specimens SE(T) in order to evaluate the life extension of a fatigue crack after drilling a hole centred at the bottom of the crack, in an aluminium alloy 6082. The mechanical characteristics of studied alloy were determined by tensile and fatigue crack propagation tests, which were carried out on a 100KN servo-hydraulic machine at a load-ratio $R = 0.57$, to avoid crack closure effects. The stop-holes drilled at the crack tips had radius $\rho = 1$, 2.5 or 3 *mm*, always leaving a notch of length $a_0 + \rho = 27.5$ *mm*. When a hole is drilled at a crack tip, the crack growth will be arrested and a new crack will eventually initiate from the hole edge, and then propagate again. The influence the hole may have on the cycles of initiating a new crack depends on the size of the hole. The re-initiation life of the crack after the hole-drilling is the number of cycles.

Three εN methods were used to predict the measured re-initiation lives, Morrow elastic, Morrow elastic-plastic and Smith-Watson-Topper, using the **ViDa** software. The experimental results for the 5 and 6mm holes were well reproduced by the classical εN techniques. But for the 2mm holes, it was necessary to introduce the notch sensitivity factor, calculated following a recently proposed methodology considering the notch geometry and the Al 6082 fatigue limit and the fatigue crack propagation threshold, to use the so-called fatigue stress concentration factor in Neuber's rule. This is a quite interesting evidence that such an approach can be recommended for fatigue design, and that the short crack analysis used in this paper is indeed appropriate to simulate the behavior of elongated notches.