Numerical analysis of the influence of the last cycle scheme on plasticity induced crack closure

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Abstract Plasticity Induced Crack Closure (PICC) is considered the main mechanism related to the premature contact of the crack flanks when a crack grows under cyclic loadings. This phenomenon has been studied numerically since the early 70's, when some researchers approached to metal fatigue problems by means of the finite element analysis. Most of these analyses have been performed considering bi-dimensional models. Lately, the use of three-dimensional models has been extended.

A great number of numerical parameters have to be taken into account when this kind of problems are analysed. The mesh size, the material model, the number of loading cycles, how the contact between crack flanks is modelled, when the nodes are released and other parameters have a great influence on the results. The methodology considered in the three-dimensional models is usually inherited from previous bi-dimensional studies of the influence of these parameters. The current computational capabilities allow a comprehensive study of the influence of these numerical parameters in three-dimensional models.

When running a finite element analysis, it is not possible to consider all the loading cycles involved in an experimental analysis. The computational cost is not acceptable. The crack growth usually is simulated releasing nodes. The numerical rates are unrealistic when comparing with real ones. Therefore, in this work, the crack growth scheme is analysed. In particular, the influence of the number of loading cycles after releasing the last set of nodes on the PICC results is studied.

For this purpose, a CT aluminium specimen has been modelled three-dimensionally. Several calculations have been made in order to evaluate the influence of the number of loading cycles after realising the last set of nodes. The results are analysed in terms of crack opening and closure values. Eight different cases have been analysed for a 3mm specimen thickness. The load applied is which corresponds to a stress intensity factor K=25MPa·m$^{1/2}$. The plastic wake length previously developed is 0.4 times the plastic size. Two different stress ratios are considered R=0.1 and 0.3. For each one, four different number of load cycles between node releases are considered ranging from 1 to 8 cycles.