3D numerical study of the transient behavior on plasticity induced crack closure

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Introduction. The numerical analysis of the plasticity induced crack closure requires the development of a plastic wake. A transient behavior is observed when the crack starts to grow. The plastic wake length has an influence on the accuracy of the crack closure results and a huge impact on the computational cost, especially for three-dimensional models. Previous works have analyzed the influence of this parameter considering bi-dimensional models in either plane strain or plane stress conditions. Lately, some three-dimensional models have appeared to analyze the crack closure phenomenon. These three-dimensional models usually employ a methodology inherited from those developed for bi-dimensional analyses. The current computational capabilities allow a comprehensive study of the influence of different modelling parameters considering three-dimensional models.

The aim of this work is to analyze the influence of the transient behavior on plasticity induced crack closure results considering three-dimensional models. The numerical accuracy is analyzed in terms of crack opening values along the specimen thickness.

A compact tension specimen was modelled for this study. An aluminum alloy Al-2024-T351 was considered. The material was modelled considering the cyclic stress strain curve. For this purpose, a three-linear stress-strain curve with an isotropic hardening law was employed. Six different plastic wake lengths were considered ranging from 0.05 to 0.8 times the Dugdale's plastic size. The load applied is said in terms of stress intensity factor, being K=25MPa·m$^{1/2}$ and the stress ratio was R=0.1.

The results show that the opening values for all the different cases analyzed are quite similar at the interior of the specimen. Some differences can be observed near the surface, although for plastic wake lengths bigger than 0.2 times the Dugdale's plastic size, values collapse in a single curve. As expected, the opening values are bigger than the values at the interior, which implies that the crack opens later at the surface than in the mid-plane.

It is important to note the time consuming of each simulation which varies for the same computer configuration (i7 with 8Gb RAM) from 55 to 5 hours for the plastic wake lengths of 0.8 and 0.05 times the Dugdale's plastic size, respectively.

The main conclusion is that at least a plastic wake of 0.4 times the Dugdale's plastic size is necessary to develop in order to stabilize the numerical results.