Influence of the mesh size on plastic CTOD

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Abstract The fatigue crack growth rate is experimentally correlated to the applied range of stress intensity factor, ΔK. However, the crack growth is taking place in an area where there are significant plastic deformations. At the same time, ΔK is an elastic parameter that cannot predict the influence of the load stress ratios and load history.

Elastic-Plastic Fracture Mechanics parameters such as the energy release rate, *G*, *J*-integral, or Crack Tip Opening Displacement (CTOD) have been used to represent the crack propagation when considering ductile materials. The CTOD is a parameter usually employed as a measurement of fracture toughness. Besides, it can be used as a crack driving force in fatigue predictions. This parameter can be decomposed into two different components: the elastic and the plastic one. The plastic component is responsible for the degradation of the material, while the elastic component is only affecting the atomic spacing.

In some recently published studies, the plastic CTOD range has been considered to study fatigue crack propagation instead of the range of stress intensity factor, which is an elastic parameter. The idea is to obtain a da/dN-ΔCTODp model, being ΔCTODp the range of plastic CTOD. For this purpose, it is necessary to obtain CTOD values with enough accuracy.

In this study, the influence of the mesh size on plastic CTOD results is analysed. For this purpose, a titanium CT specimen is modelled bi-dimensionally using the finite element method. Only one kind of element was employed to mesh the specimen. An element defined by four nodes with two degrees of freedom at each one. The mesh was divided into two different areas. The first one was defined around the crack growth region with a mesh size reduction, ranging from 4 to 64μm. The second one, where coarser elements were considered, is used in the rest of the model to not penalise the computational cost. Plane stress conditions were considered.

CTOD values were obtained in the first and the second node behind the crack front. It is concluded that the crack closure and the gradient of the linear behaviour increase with the increase of the element size. Although the CTOD at maximum load does not suffer significant variations for all the element sizes, the elastic CTOD decreases with the increasing of the element size while the plastic component increases.