The study of the effect of overload-induced residual stresses on fatigue crack growth considering residual stress relaxation

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Abstract

A numerical and experimental study was conducted on fatigue crack growth (FCG) of metallic components to investigate the effect of redistribution of mechanical residual stresses induced by single overloading during FCG on the fatigue life of notched specimens. For this purpose, the compact tension specimens of an aluminium alloy were used. In addition, mechanical residual stresses were introduced near the crack tip by applying tensile overload (OL), followed by fatigue loading of the specimens. In the numerical simulation, the modified cyclic J-integral was used as the crack growth fracture parameter and a good agreement was observed between the numerical and experimental results. The results of the finite element method demonstrated a clear redistribution of mechanical residual stresses and so the variation of the overload plastic zone size during FCG. After a few cycles, the residual stress field around the crack tip reached a lower magnitude value confined in a smaller zone, although this zone was stable during the remaining fatigue process. Finally, the present study evaluated the effects of stress ratio, load amplitude, and overload ratio on the redistribution of residual stresses and the size of the plastic zone around the crack tip. It was observed that the residual stresses are mainly released during the first steps of fatigue loading.

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