Fatigue Crack Growth in Plastically Bent Beams

The fatigue life of a crack growing through a residual stress field is commonly predicted using the original residual stress from the uncracked body, the principle of superposition, and linear elastic fracture mechanics. These fatigue predictions may contain errors due to inaccurate knowledge of the original residual stress, relaxation of residual stress due to cyclic loading, inelastic material behavior, contacting of the crack faces, ignoring the contribution of compressive loading to crack tip damage, or changes in material properties due to plastic straining during the introduction of residual stress. This paper presents modeling and experiments on plastically bent aluminum 2024-T351 beams under constant ΔK controlled four point bending fatigue. The errors mentioned above were either minimized in this experiment or accounted for in the prediction. Baseline material fatigue crack growth data was generated using middle tension specimens at R ratios ranging from -1 to 0.6. Beam residual stress was characterized theoretically, through measurement of the stress strain curve during bending, as well as experimentally by the slitting method and sectioning methods. Fatigue crack growth rates are presented along with their correlation with predictions.