Fractographic studies of fatigue cracks under pure Mode II loading

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Introduction

In general structural components such as rails and bearings are subjected to complex combinations of Mode I, II and III loadings during service. Studies have shown that under monotonic loading a crack subjected to pure Mode II loading propagates into a certain direction and bifurcates under a distinctive angle, which can be described with certain criteria, for instance the maximum stress criterion. From the physical point of view that can be explained by a void initiation and coalescence process, which shows a maximum under a certain bifurcation angle. However in the case of cyclic loading the situation is more difficult to understand. Cracks subjected to cyclic Mode II loading show often again a crack deflection under a certain angle, however after some coplanar crack growth. The latter case is not clearly to understand regarding the cyclic deformation behind the crack tip. The aim of the study is to get better insight for the mechanical reasons for the final bifurcation on the fatigue fracture surface.

Experimental and results

In this study pure Mode II fatigue crack propagation experiments were carried out with a ductile conventional austenitic steel (1.4301). The experiments were conducted on a Compact Tension Shear (CTS) specimen and exclusively under pure Mode II loading. The cyclic stress intensity factor was ranging from the near threshold regime up to the fracture toughness regime. Special interest was focused on the fatigue fracture surfaces.
In the near threshold regime an instant crack bifurcation starting from the fatigue crack was seen. Higher stress intensity factors resulted in some coplanar crack growth. Generally the length of coplanar crack growth increased with an increasing stress intensity factor. However a crack bifurcation in all specimens happened in the investigated stress intensity range. The fracture surfaces revealed during the shear dominated coplanar crack growth a very smooth surface because of the relative sliding of the crack flanks each to another. Therefore it is difficult to give an explanation for the crack growth mechanism in this state of crack growth. In contrast to this the bifurcated cracks showed on their fatigue fracture surfaces striations leading to the conclusion that in this state the crack growth is mainly tensile stress dominated. Possible explanations for the final bifurcations based on fractographic studies will be presented.