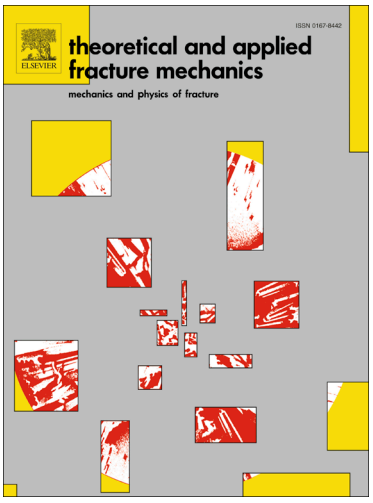

Experimental study of fatigue crack growth in raw and annealed pure copper with considering cyclic plastic effects

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Experimental study of fatigue crack growth in raw and annealed pure copper with considering cyclic plastic effects

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Abstract

Some material, such as copper indicates hardening behavior under cyclic loading. Linear elastic fracture mechanics can be applied for low loads that the plastic zone size is small in compare with specimen dimensions. However, the cyclic J integral depends on the cyclic plastic response, therefore in ductile materials, the elastic plastic fracture mechanics based on the cyclic J integral justify fracture parameters better than the linear elastic fracture mechanics in various loadings. In this paper, for the cyclic loading in various loading conditions, crack growth behavior of copper with 99.9% purity was studied. For evaluation and comparison of the cyclic plastic behavior effects on the fatigue crack growth, some specimens were annealed in thermal furnace under $420℃$ for 35 minutes. With symmetric strain-controlled loadings, hysteresis loops were obtained for annealed and raw specimens. For studying of the fatigue crack growth rates, two important parameters as ΔK(stress intensity range) and ΔJ(J-integral range) are evaluated. Crack growth parameters such as the fatigue life, crack growth rate and constants of Paris law and Dowling equation were investigated. Results revealed that in the same loading ranges, if growth rate is expressed versus ΔK, Paris law parameters are dependent to the load ratio, R while in representation versus ΔJ, these parameters are almost constant. Also, the fatigue crack growth rate calculations based on the ΔJ in materials such as annealed copper that has important hardening behavior, are more accurate.

Keywords: cyclic plastic deformation, hardening, fatigue crack growth, J-integral range

1. Introduction

The phenomenon of formation and propagation of a crack under fatigue loading occurs in many engineering materials. After recognizing the created cracks, studying their growth and estimating the reminder fatigue life are vital. Behavior of the crack growth follows different models that depend on the amplitude value and its variations. In materials which the size of plastic zone is small in compared with the specimen dimensions, assumption of Linear Elastic Fracture Mechanics ($LEFM$) is used. Therefore, the concept of $LEFM$ is used which was considered as the driving force of the fatigue crack growth. In cases such as the crack growth in weld region, variable amplitude loading or loading with large amplitude which created plastic region near the crack-tip is large, the assumption of elastic-plastic fracture mechanics($EPFM$) governs study of the Fatigue Crack Growth(FCG). In these cases, in loading phase, a large region around the crack-tip yields plastically and in unloading phase, it can't return to its initial state as elastic regions. While the crack-tip reaches these regions, the plastic zone is moved along crack front and reduces the crack driving force. J-Integral value can be considered as the most important