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论文

CTS试件中复合型疲劳裂纹扩展

马世骧, 胡泓

哈尔滨工业大学深圳研究生院, 518055

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摘要 针对复合型循环载荷作用下的金属构件中的裂纹扩展问题进行了实验分析和理论建模. 首先采用紧凑拉剪试件(CTS)和 Richard研制的复合型载荷加载装置, 对承受复合型循环载荷的裂纹进行了实验研究. 实验选择了两种金属材料试件, 分别承受3种形式的复合型循环载荷的作用, 在裂纹尖端具有相同的初始应力场强度的条件下考察复合型循环载荷对裂纹扩展规律的影响. 实验结果表明, 疲劳裂纹的扩展速率与加载角度有关. 对于同样金属材料的试件, 当裂尖处初始应力场强度相等时, 载荷越接近于II型, 裂纹增长速率越快. 采用等效应力强度因子(I型和II型应力强度因子的组合)、裂纹扩展速率及复合强度等参数, 以实验数据为基础, 建立了一个疲劳裂纹扩展模型, 用来预测裂纹在不同模式疲劳载荷作用下的扩展速率. 为验证其有效性, 该模型被应用于钢制试件的数值模拟计算中. 实验结果与模拟计算曲线保持一致, 表明该模型可以用来估算带裂纹金属构件的寿命.

关键词 疲劳裂纹, 复合型载荷, 裂纹扩展速率,裂纹扩展路径, 应力强度因子

分类号

The mixed-mode propagation of fatigue crack in CTS specimen

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哈尔滨工业大学深圳研究生院, 518055

Abstract

In this paper, the mixed-mode fatigue tests are carried out with the CTS specimen (Compact-Tension-Shear) and the mixed-mode loading device developed by Richard [1]. Three loading angles and two materials are selected in the experiments. The effect of loading angle on the crack propagation is analyzed numerically and experimentally. According to the experimental results, the fatigue crack growth rate is related to the loading angle. For the same initial equivalent stress intensity factor (combination of the stress intensity factor in mode I and in mode II), the crack grows slowest under pure mode I loading. The photos of crack bifurcation and the results of the crack growth rate in different specimens under different mixed-mode loadings are presented. Furthermore, a numerical model of fatigue crack propagation is proposed on the basis of the experimental results to evaluate the influences of loading mode on the crack growth rate. The validation of the model is performed on the steel specimens under mixed mode loading. The numerical evaluations are in good agreement with the experimental results.

Key words 疲劳裂纹 复合型载荷 裂纹扩展速率 裂纹扩展路径 应力强度因子

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通讯作者 mashixiang@hitsz.edu.cn