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定向凝固镍基高温合金缺口低循环疲劳性能及寿命预测

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Properties and Life Prediction of Low Cycle Fatigue Behavior on Notched DS Ni-based Superalloy

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摘要

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摘要

针对定向凝固(DS)镍基高温合金DZ125开展了850℃条件下不同缺口形式和不同理论应力集中系数(K_t)下的低循环疲劳(LCF)试验研究。利用弹塑性有限元分析缺口根部的应力应变场,并将传统临界距离理论(TCD)及其 K_t 修正形式引入SWT参数,以此开展缺口试件LCF寿命预测研究。结果表明:高温LCF强度同缺口几何形状关联不大,但具有强的 K_t 相关性;无论是将尖锐缺口试件作为校准试件还是对临界距离进行平均处理,传统TCD的点方法(PM)及线方法(LM)其寿命预测大于5倍分散带,且预测能力同缺口应力集中程度相关;改进TCD的点方法和线方法可得到小于2倍的分散带,且其预测精度与缺口几何形状无关。由于SWT参数可考虑平均应力(应力比)影响,故根据光滑试件和某 K_t 下缺口LCF试验数据便可以采用改进TCD预测其他缺口试件在不同应力比下的疲劳寿命,其应用简单、方便。

关键词: 低循环疲劳 临界距离理论 SWT参数 Manson-Coffin方法 定向凝固镍基高温合金

Abstract:

Experimental investigation is carried out in this paper on the low cycle fatigue (LCF) behavior of directionally solidified (DS) Ni-based superalloy DZ125 at 850℃ with differential notch geometries and theoretical stress concentration factors (K_t). The stress-strain field at notch roots is obtained based on the elastic-plastic finite element analysis. Life prediction of notched specimens is then performed by the introduction of conventional and K_t -modified theory of critical distance (TCD) to SWT parameters. The results show that, the resistance of LCF has little to do with the geometrical shape of notch specimens but is heavily K_t -dependent. No matter by taking sharp specimens as calibration samples or dealing with critical distances by the statistical averaging method, both point method (PM) and line method (LM) of the conventional TCD exhibit that the life prediction ability related to the stress concentration factor is larger than the five times scatter band. However, a highly improved scatter band within two times can be obtained by both point and line methods of K_t -modified TCD, and the two methods are notch-geometry independent. The SWT parameter may be used to consider the effect of mean stress (stress ratio). Therefore, accurate life prediction, based on the test data of LCF of smooth specimens and just one kind of notched specimens, can be carried out using this modified TCD for other notched specimens at different stress ratios, and its application will be simple and convenient.

Keywords: low cycle fatigue theory of critical distance SWT parameter Manson-Coffin method directionally solidified nickel-based superalloy

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