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Fatigue analysis of metals using damping parameter

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Abstract

A methodology for evaluating fatigue life of metals in both low and high cycles using the material damping parameter is presented. While most techniques for evaluation of fatigue life suffer from different types of restrictions —e. g., limitations to low-cycle fatigue tests or restrictions to the applications where a measurable temperature rise is a prerequisite— damping measurements can be used without such limitations. The results of series of experiments are reported to illustrate how the damping parameter changes during the fatigue test. The validity of the concept is confirmed by comparing results with those obtained by measuring the hysteresis loop. Also presented are discussions on how damping measurements can be modified to investigate the effects of inhomogeneity of the material and the crack initiation due to cyclic fatigue damage.

Keywords: Fatigue failure; Damping parameter; Life evaluation; Impulse Excitation technique

1. Introduction

Cyclic Fatigue is the most dominant mode of failure in nearly all components and structures. Failure is preceded by the initiation and formation of cracks, localized plastic deformation and the associated dissipation of energy. The fact that the energy dissipation can be related to the microstructural changes and the associated degradation has led many researchers to study the fatigue phenomenon by the energy-based approaches [1-9]. However, energy-based approaches are thought to be best suited to applications involving the low-cycle fatigue (LCF) where the strain energy can be more easily evaluated with the measurable plastic strain on a macroscopic scale [10]. Recent research results are also available on techniques to extend the energy approaches to the high-cycle fatigue (HCF) [11-13].

This paper aims to report the development of a method based on measuring damping parameter that can be used for assessment of the energy dissipation and prediction of fatigue life. This method offers good potential for application in both LCF and HCF. Previous theoretical speculations [14-15] and a series of experimentally obtained results [16-17] suggest that degradation of materials leads to considerable variation in damping value. To illustrate the concept, Lazan [14] used damping parameter to determine a relationship between the stress history and stress amplitude. Moreover, he showed that plastic strain energy can be evaluated if the damping parameter is known. Colakoglu [17] and Dorn [18] later utilized a monitoring method based on the concept of damping to measure energy dissipation and damping parameter