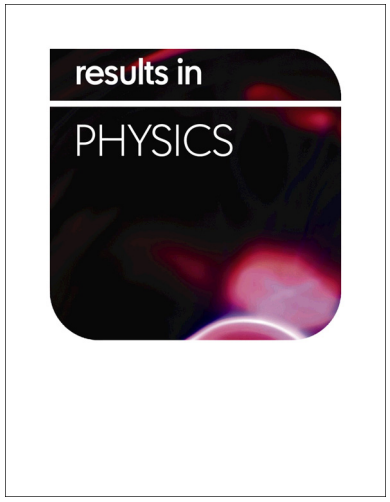

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Fatigue crack propagation characteristics of rubbery materials under variable amplitude loading

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Abstract: Fatigue failure is a critical issue frequently encountered by the rubber components in service. In this work fatigue crack propagation experiments with an edge-notched pure shear specimen under variable amplitude loading, which brings effectiveness in experiment time, are carried out. Based on the dispersed data of measured crack lengths versus number of cycles, an alternative method for dealing with the dispersed data is proposed and compared with two conventional methods used in constant amplitude loading. The comparisons of the three types of methods shows that the secant method and the incremental polynomial method are not applicable whereas the proposed method with one power function is superior to characterize the crack propagation characteristics of rubbery materials. The crack propagation rate (crack propagation length per cycle) is then calculated from the determined power function, and a fatigue life prediction model for filled natural rubbery materials is established as well as applied to calculate the fatigue life of dumbbell specimens under uniaxial tension fluctuating loading. The consistence between the calculated fatigue lives and the measured lives of the dumbbell specimens validates the proposed data processing method for dealing with the dispersed measured data of crack length versus number of cycles.

Keywords: Rubber; Fatigue crack; Propagation rate; Modeling; Experiment

1. Introduction

Rubbery materials have the advantage of withstanding very large strains but without permanent deformation or fracture, which make it ideal for many applications such as tires, vibration isolators, accessory drive belts and so on [1-2]. Rubber components are usually subjected to large static and fluctuating loads, and often fail due to the nucleation and propagation of defects or cracks. To prevent such mechanical fatigue failure, it is of prime importance to understand the deformation mechanisms involved during cyclic loading, and to study the fatigue crack propagation characteristics of rubbery materials.

The mechanical fatigue of rubbery materials is defined as the phenomenon that the mechanical properties of the material are gradually deteriorated due to the nucleation and propagation of the crack under dynamic loading. Some researchers found that fatigue failure of rubbery materials is due to the gradual propagation of small cracks in the rough materials under external cyclic loading [3-4], which necessitates investigations on the fatigue crack propagation characteristics of rubbery materials. Rubbery materials' crack propagation characteristic experiments were frequently conducted under constant amplitude loading [5-7], which concludes limited levels of loading and costs long experiment time. The variable amplitude loading are thus chosen to more effectively get the crack propagation measurements of the studied rubbery materials.

Establishing the mathematical model of crack propagation characteristics of rubbery materials based on the experimental data is a challenge task that is quite distinct from metal-like materials. For metal materials, Jia et al [8] and Meng et al [9] studied different data processing methods for determining crack propagation rate based on the directly measured crack length versus number of cycles, including seven incremental polynomial method [10], Smith method [8] and the integral method [9] derived from Paris formula [11]. However, rubbery materials' crack propagation data shows

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