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Effect of swelling on fatigue life of elastomers

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Abstract

In a number of engineering applications, elastomeric components are exposed to aggressive solvent such as biodiesel. Since biodiesel is considered as a potential substitute for conventional fossil fuel, the study on the durability in service of elastomers exposed to biodiesel becomes essential. The present paper investigates the mechanical response of swollen elastomers, due to exposure to palm biodiesel, under fatigue loading conditions. To this end, fatigue tests are conducted on dry and swollen rubber specimens at various maximum strains and a zero strain ratio. The physical fatigue damage mechanism induced in swollen material is studied through FESEM analysis coupled with EDS. During the test,two definitions of specimen end-of-life are adopted: (i) the number of cycles required for a nucleated crack to reach 1 mm in length and (ii) the number of cycles required for a complete rupture to occur in the specimens. The fatigue lifetime curves are plotted where the maximum principal stretch is used as the predictor. It is shown that swollen rubbers have shorter lifetime compared to the dry ones. Moreover, FESEM results reveal that the swelling level has no effect on the morphology of crack nucleation and propagation, regardless of the imposed loading level.

Keywords: Elastomer, fatigue, swelling, crack nucleation, crack propagation

1. Introduction

In many engineering applications, elastomeric parts have to endure repetitive fluctuating loadings during the service. The ability of the parts to sustain loadings end when the component experiences rupture or fatigue failure [1] upon initiation and propagation of cracks in the material. The study of fatigue in elastomers is challenging in the mechanics of materials due to complex interactions between the matrix, fillers, plasticizers and other additives. Some of the degradation studies on elastomers under fatigue loading have already been conducted [2, 3]. Mars [4] found that elastomers underwent two distinct phases during the process of fatigue failure. The first phase is the duration of crack initiation from free observable macrocracks. This phase is followed by the propagation of the crack up to failure