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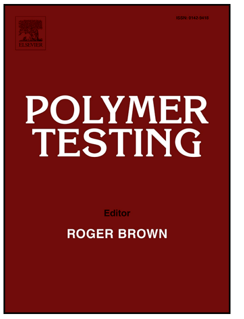

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Investigation of different influences on the fatigue behaviour of industrial rubbers

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Abstract
Load conditions used typically for fatigue life investigations can differ strongly from the conditions for real rubber products. For example, the frequency of the laboratory measurements is increased and the product load curve is simplified to a sine. In this paper, industrial rubber blends (SBR/BR/NR blends) under tension–compression load are used. First, the influence of a higher frequency (5Hz) compared to the product relevant frequency (1Hz) is investigated. A higher frequency does not influence the fatigue life but certainly the sample temperature and material behaviour. This is further investigated by varying the ambient temperature for 1Hz measurements and the strain rate. Second, a non-sinusoidal wave form depicting the product loading case is selected. The load oscillates between tension and compression with dwell periods in every cycle. The results are comparable to those of a sine wave with the same frequency.

Keywords: fatigue analysis, rubber, frequency, wave form, tension–compression load

1. Introduction

Due to their outstanding properties, rubbers are often used for applications where they are subjected to cyclic loads. Under these loads, rubber products may fail due to the formation and growth of cracks. As for all materials, the fatigue behaviour of rubber products under time-varying loads is a critical issue. The fatigue behaviour depends on various parameters, for example loading conditions, environmental factors, formulation, and processing of the rubber compounds. For preselection and comparison of materials, the fatigue behaviour is measured in the laboratory using dynamic testing machines and uniform test specimens usually subjected to pure tensile load. For these measurements, the predominantly used load curve is a sine wave. It is easy to implement and the resulting hysteresis curve gives information about the dissipated and stored energy during a cycle. Frequency and deflection are chosen so that the measurements are finished within a reasonable time (hours or some days).

In general, the product has a different geometry than the laboratory test specimens and is also subjected to a cyclic load which can deviate from the laboratory curve regarding frequency and wave form. In the course of this work, a specific product is considered namely a handrail of an escalator. A handrail of an escalator is subjected to concave and convex bending at the drive rolls, which leads to a load oscillating between tension and compression giving a load ratio (minimum load by maximum load) $R<0$. The typical dimensions and load speed of a handrail result in a frequency for the tension–compression alternation of 1Hz. Fatigue life in laboratory measurements under product-relevant strains can be above 2 000 000 cycles which are more than 23 days at 1Hz. Therefore, the preferred frequency in the laboratory is 5Hz giving a time saving factor of five.
Literature predicts no significant dependence of the fatigue life on the frequency between 1Hz and 5Hz which would justify an increase of the testing frequency [1]. However, this is only true for small specimen geometries and a certain frequency range since one has to consider that a higher frequency (and deflection) also lead to higher sample temperature due to the pronounced heat build-up of rubber under cyclic loading [1,2]. Furthermore, investigations in the literature are mostly done with moderately filled