The impact of curing time and mold temperature on the fatigue behavior of nitrile butadiene rubber

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1. Abstract

To complement the present research results in the field of fatigue and fracture in elastomers, an analysis of the influence of curing time and mold temperature on the fatigue properties of a carbon black-filled industrial NBR compound was carried out. There was a significant difference in the crack growth rate with respect to the different manufacturing conditions.

2. Introduction

As early as 1941, Clark et al. [1] discovered that the hysteresis in elastomeric components decreases with increasing cross-linking time. This is related to an increasing cross-linking density, which also increases the stiffness of the material. Due to the increased stiffness and the reduced hysteresis, the fatigue behavior also deteriorates. However, if the cross-linking time is too short, it can lead to viscous flow and early chain breakage, which is also detrimental to the fatigue behavior. For this reason, an optimal cross-linking time must be found. [2,3]

3. Methods and Results

Pure shear test specimens were injection molded at various curing times and temperatures, and fatigue tests were performed with them according to a predetermined procedure. The results of the heating time series can be seen in figure 1 and are in line with the previously obtained expectations and can best complement the results of previous researchers. With increased heating time and temperature, the fatigue behavior of the NBR deteriorates, which is noticeable through faster crack growth at lower tearing energies. This is due to the reduced hysteresis caused by increased stiffness resulting of an increasing number of chemical cross-links. With increased temperatures, a deterioration of the fatigue properties is already observed at lower heating times.

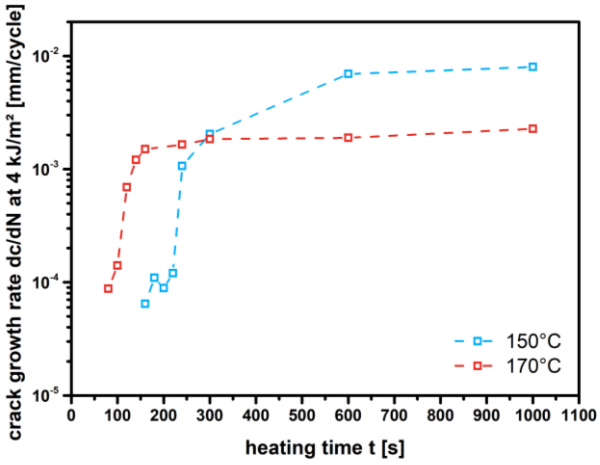

Figure 1 Crack growth rate at a tearing energy of 4000 J/m² for all heating times at 150°C and 170°C.

Depending on the temperature, the results of the fatigue crack growth settle at a plateau after a certain time. This indicates that from this point onwards most of the sulphur bridges have regressed from polysulfidic cross-links to di- or monosulfidic cross-links, which leads to reduced chain mobility and thus to weakened hysteresis. In addition, to better describe the differences in crosslinking states due to the various manufacturing conditions, the sulfur chain composition was investigated in more detail by means of mechanical and chemical test methods, e.g. tensile DMA, compression set, and swelling. With the help of these results, the fatigue behavior can be described more precisely.

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