Characterisation of Crack Toughness Behavior of Unfilled and Filled Elastomers

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Introduction

Elastomer materials with their wide application range are generally loaded in a way that may lead to failure. This failure is caused by initiation and propagation of cracks from which the application of fracture mechanics concepts for material assessment has developed.

Materials

Statistically crosslinked polyurethane SEB 1500; styrene content: 23%; crosslinking with sulfur+sulfoxide accelerator; filler type carbon black N330, N332.

- Unfilled: sulfur content 2.8-2.9 phr (parts per hundred rubber).
- Filled: sulfur content 1.6-2.5 phr (with constant sulfur content of 1.6 phr).

Examinations

Cyclic Loading

- Test frequencies: 1 Hz, 1 pulse/second.
- Specimen configuration: single edge notched tension (SENT) specimens, dimensions: 64 x 15 x 1.5 mm, initial crack length: 4 mm.
- Critical values of testing energy Tc.

Impact Loading

- Instrumented tension-impact test (ITIT): pendulum hammer speed 2.9 m/s, maximum impact energy 4 J.
- Specimen configuration: double edge notched tension (DEN) specimen, dimensions: 64 x 15 x 1.5 mm, initial crack length: 4 mm.
- J-values related to resistance against unstable crack propagation calculated according to an evaluation method of Biggley and Landes.

Results

- Critical Testing Energies from the ITIT test and resistance against unstable crack propagation from the ITIT test as a function of sulfur and carbon black content.

As the sulfur content increases, the fracture toughness parameter Tc decreases, while the carbon black content decreases resistance against a stable crack propagation and unstable crack propagation.

- Crack resistance curves recorded with the single specimen method showing a very different behavior of the various CEF filled vulcanizates. On the right side results of the analysis of these curves.

As p can be seen, initiation and propagation values behave in different ways for the filled elastomers, the resistance against stable crack initiation is decreased with increasing carbon black content, whereas the resistance against a unstable crack propagation increases.

An increasing crack propagation is a continuously increasing crack rate. The slope of the fracture toughness resistance against unstable crack propagation shows a maximum value.

- Physical crack resistance curves determined by using the single specimen method.

Conclusions

By these tests reported here it is possible to describe the fracture behavior of such elastomer materials in connection with structural parameters (crosslink density, filler content).

The differences between initiation and propagation show that a multiparametric description of the fracture behavior is necessary.

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