6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Micromechanical model for chemical ageing in elastomers

Darcy Beurle[1], Markus André[2] and Udo Nackenhorst[1]

[1] Institute for Mechanics and Computational Mechanics, Leibniz Universität Hanover,
Appelstr. 9, 30167 Hanover, Germany,
Mail: darcy.beurle@ibnm.uni-hannover.de, web: http:///www.ibnm.uni-hannover.de
[2] Mechanical Engineering and Bioprocess Engineering Faculty, Hochschule Hanover,
Ricklinger Stadtweg 120, 30459 Hanover, Germany

Key Words: *Elastomer, micromechanical, ageing.*

Chemical ageing is the process by which the internal molecular structure of an elastomer is reformed during its service life resulting in a loss of material performance. The two fundamental chemical processes responsible are the chain scission (degradation) and the secondary network formation (post-curing) leading to stress relaxation and an increase in stiffness respectively [1]. Exposure to oxidising agents (e.g. oxygen) and elevated temperatures affect the rate that these chemical reactions proceed.

Previous models of the ageing process [2] have adopted a phenomenological approach that neglects the statistical nature of the underlying polymer network. Describing the ageing process of an elastomer through a micromechanically based model provides deeper insight into the material behaviour and the complex interaction mechanisms.

During the secondary network formation of in-service elastomers, new cross-links are created in the deformed configuration thereby introducing history dependent effects. This new model introduces chain scission and the secondary network formation behaviour on the micro-mechanical scale through a modified statistical mechanical description. From the entropy of a single chain, a free energy function can be derived [3]. This free energy function can be used for the computation of the stress and the material tangent operator using the microsphere model [4].

The proposed model captures the secondary network formation and the associated permanent set phenomenon. Results from a finite element simulation with this model will be presented.

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