11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

CRACK GROWTH IN INCOMPRESSIBLE, VISCOELASTIC MATERIALS AT LARGE DEFORMATIONS

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Key words: *Material Force Approach, Fracture Mechanics, Elastomers, Viscoelasticity, F-Bar Elements, Incompressibility.*

Evaluation of a general fracture criterion and complex fracture patterns of elastomers is of great interest in engineering applications to increase the fatigue life and service time of a product. However, the correlation between physical interpretation and numerical studies is not well established due to the complexity of the problem. The physical structure of these materials consists of a dense network of polymer chains giving rise to a high degree of elasticity, incompressibility, and time-dependent behaviour. The nature of cracks in rubber-like materials is comparably different from those in brittle materials such as glass, ceramics, concrete, etc. More precisely, rubber-like materials exhibit very large deformation and a high degree of distortion near the crack tip field. Therefore, it is necessary to use elements that are specially designed to avoid volumetric or incompressible locking [1]. Another important point to note is to find a fracture criterion to initiate crack propagation. To this end, approaches based on energy concepts are commonly used when dealing with fracture of materials exhibiting a time-dependent non-linear material behaviour. The main advantage of using such approaches is that the knowledge of the singularity field around the crack tip is not required. In this contribution, the crack driving force and the crack direction are predicted by the material or rather configurational force approach for the description of the viscoelastic fracture response of rubber-like materials at large strains. The only difficulty of the material force approach in history variable based material behaviour is that additional terms derived by the gradient of the history variables must be introduced into the formulation. This procedure requires a projection of the variables from Gauss points to nodes in the global system and a high-quality mesh where the gradient of the variables has to be reliable [3].

In addition, to predict the failure mechanisms of the structures, an r-adaptive crack propagation scheme is presented. Tetrahedral elements with an object based data structure are used as already introduced in by Miehe et al. [2]. Key feature of this procedure is restructuring the overall system by duplication of crack front degrees of freedom based on minimization of the overall energy via the Griffith criterion. The presented framework enables to study fracture behaviour of elastomers at different deformation rates under mixed mode loading as shown in the Fig. 1.

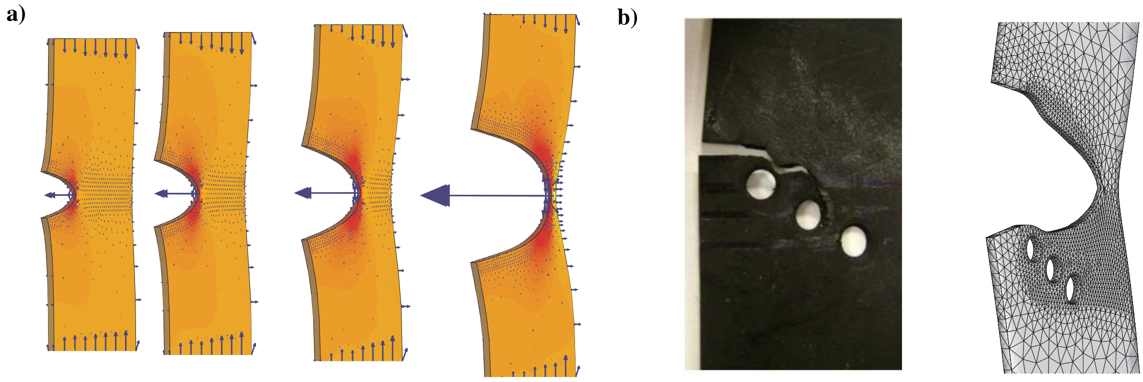

Figure 1: **a)** Nodal material forces during crack advancement. **b)** Comparison of a numerical study of a single edge specimen under mixed mode loading to experimental one.

The objects of this contribution are threefold. First, the material force approach is generalized for the F-bar method based tetrahedral elements and the effects of incompressibility on the material force approach under large deformation is studied by using a phase transition problem. Secondly, the separation of the total dissipation in terms of the change in elastic energy and in terms of the material dissipation by a configurational change obtained from the global energy momentum balance is investigated in the same structure. And finally, a study is carried on crack propagation on a single edge precracked specimen to predict the crack propagation mechanism of the structure.

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