Energetic analysis of unsteady dynamic crack growth: experimental study on elastomer membranes

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ABSTRACT

The issue of dynamic fracture of a elastomer membrane from an experimental point of view is considered here. The aim is to provide some insight to predict the speed of cracks in highly stretched membranes.

An experimental procedure involving two cameras is developed in order to perform full-field measurements based on digital image correlation during crack propagation. This set-up permits to retrieve the material configurations of the sample all along crack growth, which is a crucial step toward a complete mechanical analysis of the problem. In addition to the kinematic fields, both strain energy density and stress fields are estimated thanks to a hyperelastic model.

Tested with polyurethane, rapid crack growth has been observed, even reaching the intersonic regime [1] for large prescribed deformations of the membrane. The crack kinematics are observed in both deformed and reference configurations. In particular, the analysis of unsteady crack growth close to the edges of the sample underlines the importance of working in the reference configuration for large strain and dynamic fracture problems.

The method proposed allows to compute the kinetic and stored stain energy density fields along crack growth. Therefore, the total mechanical energy can be estimated through integration over the whole sample. With the instantaneous crack speed in the reference configuration, the energy release rate can be estimated all along unsteady crack growth from its global definition. This energetic analysis confirms the role of the energy release rate as a quantity independent of crack acceleration. The master curve, wich is usually obtained with steady-state experiments [2], is retrieved in a continuous way. However, its role as a driving quantity might be discussed at high crack speed as our kinematic results suggest a change in the scale of the driving quantities [3] in the intersonic regime.

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