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Experimental characterization and modelling of rubberlike materials hyperelastic behavior with damage

Y. Merckel [1], JF. Witz[2], J. Diani[3], P. Lecomte[4], and M. Brieu[5, *]

[1] ECLille, LML-UMR 8107, F-59650 Villeneuve D'Ascq, France, yannick.merckel@ec-lille.fr
[2] LML-UMR 8107, Cité Scientifique, Villeneuve d'ascq – France, jean-francois.witz@ec-lille.fr,
[3] PIMM-Arst et Métiers ParisTech, Paris – France, Julie.diani@ensam.eu
[4] ECLille, LML-UMR 8107, F-59650 Villeneuve D'Ascq, France, pauline.lecomte@ec-lille.fr
[5] ECLille, LML-UMR 8107, F-59650 Villeneuve D'Ascq, France, mathias.brieu@ec-lille.fr

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ABSTRACT

Rubber-like materials are polymers constituted of very long cross-linked macromolecular chains randomly distributed. Such a microstructure leads to remarkable elastic properties that are useful for suspensions tasks and/or bonds in mechanical systems. It is common to add fillers within rubber materials to increase their stiffness and their resistance to crack propagation. However, when fillers are introduced, a significant softening, known as the Mullins softening appears upon first stretch.

The present work aims at characterizing and modelling the behaviour and damage of rubber-like materials under large strain multiaxial loadings. This work is based on the use of experimental resources developed (figure 1) to apply biaxial loadings in order to study the Mullins softening general loading conditions (figure2). Original experimental results were obtained thanks to an original procedure providing access to the resumption of the Mullins softening during successive loadings. Finally, the use of several styrene butadiene rubbers (SBR) with various amount of fillers and various crosslink densities allowed us studying the impact of these microstructural parameters on the behaviour and damage of rubbers. The original experimental results obtained under cyclic loading conditions provide direct evidences supporting the use of directional models for the constitutive behaviour of hyperelastic rubbers with an account for the Mullins softening. A general criterion for activation of the Mullins softening for any loading history has been enounced and a directional constitutive behaviour framework has been proposed that is versatile enough to adapt to a wide range of filled elastomers (figure 3).

Fig. 1 : Experimental equipments for non proportional loading, biaxial tension

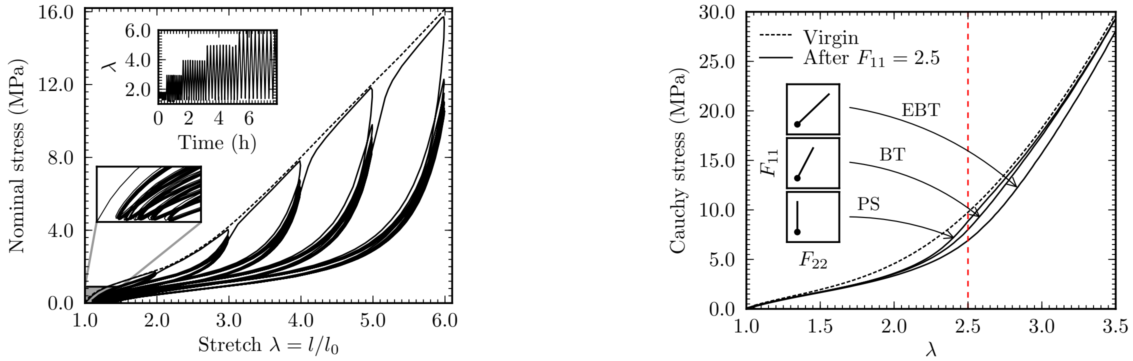

Fig2. Response of rubber-like materials under uni-axial loading (left hand) and evidence of anisotropy induced by Mullins effect during multi axial loadings (PS: pure shear, BT: biaxial tension, EBT equi biaxial tension) (right hand)

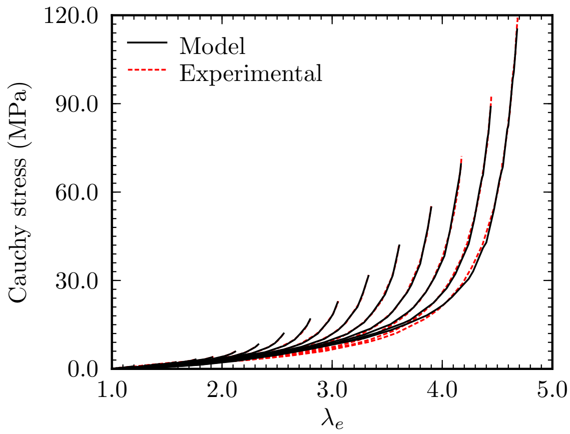

Fig. 3: Predictivity of the proposed directional model

REFERENCES

[1] Y. Merckel, J. Diani, M. Brieu, P. Gilormini, J. Caillard. J. Appl., Polym. Sci., 123:1153-1161, 2011

[2] Y. Merckel, M. Brieu, J. Diani, J. Caillard. J. Mech. Phys. Solids, 2013

[3] Y. Merckel, J. Diani, S. Roux, M. Brieu. J. Mech. Phys. Solids, 59:75-88, 2011