Through-thickness water transport and hygro-expansion in a paper sheet

Nik Dave[†,‡,*], Ron Peerlings[†], Thierry Massart[‡], and Marc Geers[†]

[†] Eindhoven University of Technology, 5600 MB, Eindhoven, The Netherlands
E-mail: n.dave@tue.nl, r.h.j.peerlings@tue.nl, m.g.d.geers@tue.nl
Web page: https://www.tue.nl/

[‡] Université Libre de Bruxelles, Avenue F.D. Roosevelt, 50 B-1050, Brussels, Belgium
E-mail: thmassar@ulb.ac.be
Web page: http://batir.ulb.ac.be

* Corresponding author: n.dave@tue.nl (Nik Dave)

ABSTRACT

Paper, a hydrophilic material, is notably susceptible to deformations due to variations in moisture content, which develop over time. Understanding the moisture transport through the thickness of a paper sheet and the time-dependent mechanics allows us to study the curling behaviour of paper.

In this work, the time-dependent factors involved in deformation of a paper strip that is fully or partially wetted from one side and subjected to different boundary conditions is studied with a 1D numerical model. The different time-scales involved, in the process of imbibition in the inter-fibre pores and absorption (or water uptake) by the fibres, are analysed. The resulting hygro-expansion due to swelling of the wet fibres is then solved to predict the deformation and bending response of the paper strip.

We provide a phenomenological model here to describe the dynamic water flow through the thickness of a paper strip using the unsaturated flow theory. The numerical analysis shows a fair qualitative agreement with experimental observations.

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