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CONTINUUM MODELLING AND SIMULATIONS OF PRESSBOARD WITH TEMPERATURE/MOISTURE EFFECTS

Denny Tjahjanto*[1], Anna Ask[2], Orlando Girlanda[2], Sören Östlund[1], Johan Ekh[2]

[1] Department of Solid Mechanics, KTH Royal Institute of Technology, Teknikringen 8D, SE-10044 Stockholm, Sweden,
[2] ABB AB, Corporate Research, Forskargränd 7, SE-72178 Västerås, Sweden

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Pressboard is a cellulose-based material that constitutes a high-density network of cellulose fibers, which is considerably thicker (more than 1 mm thick) and denser (with mass density between 800 and 1300 kg/m^3) than typical paper/board materials. Pressboard components have been widely used in *e.g.* power transformer applications, thanks to the excellent electrical insulation properties as well as good mechanical performance [1]. As a cellulose-based polymeric material, pressboard is however very sensitive to moisture and temperature, which affect the mechanical performance of the materials [2]. The present work is aimed at investigating the effects of moisture and temperature on the stationary and transient mechanical responses of pressboard.

For this purpose, a continuum material model is developed for describing the mechanical response of high-density pressboard under various environmental (temperature and moisture) conditions. In the model formulation, the overall deformation is decomposed into a (visco)elastic part and a (visco)plastic part. Moreover, for the in-plane deformation behavior, the basic concepts used in the model formulation follow from anistropic elastic–plastic models for cellulose-based materials used in [3, 4], whereas the model assumptions for the out-of-plane behavior are based on the through-thickness model for paperboard materials described in [5].

In order to properly capture important characteristics of the mechanical behavior of cellulose-based materials, the present model incorporates the following features: (i) An anisotropic hardening law with kinematic hardening effect is particularly adopted in order to capture the peculiar stress–strain hysteresis typically observed in polymeric materials, whereas (ii) the effects of material densification associated with through-thickness compression of the material are taken into account [6]. In addition, (iii) the temperature and

moisture dependence of the overall elastic–plastic properties at the continuum scale are described using simple phenomenological laws. The values for the parameters used in the model are obtained through systematic calibration procedures using the results of basic experimental testing.

The viscoelastic–viscoplastic model is numerically implemented into a standard finite element program as a user-material subroutine. In order to demonstrate its predicting capacity, the model has been used for in engineering scale numerical simulations for analyzing the evolution of the mechanical properties of pressboard components under different combinations of mechanical loads and temperature/moisture conditions. Comparisons with the results of the corresponding experimental measurements are presented and discussed.

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