An elasto-plastic material model for paper and paperboard at finite deformations.

Lilian Aurora Ochoa Ontiveros*[1], Nadir Kopic-Osmanovic[2], Erik Prume[3], Sebastian Felder[4], Greta Kloppenburg[5], and Jaan-Willem Simon[6]

[1]Computational Applied Mechanics, University of Wuppertal, Pauluskirchstraße 7, 42285 Wuppertal – Germany

[2]Computational Applied Mechanics, University of Wuppertal, Pauluskirchstraße 7, 42285 Wuppertal – Germany

[3]Institute of Applied Mechanics, RWTH Aachen University, Mies-van-der-Rohe-Str. 1, D-52074 Aachen – Germany

[4]Institute of Applied Mechanics, RWTH Aachen University, Mies-van-der-Rohe-Str. 1, D-52074 Aachen – Germany

[5]Computational Applied Mechanics, University of Wuppertal, Pauluskirchstraße 7, 42285 Wuppertal – Germany

[6]Computational Applied Mechanics, University of Wuppertal, Pauluskirchstraße 7, 42285 Wuppertal – Germany

Abstract

Paper and paperboard are materials commonly used in the packing industry. Due to their high sustainable nature, they are preferred to less eco-friendly options. However, their complex behavior has postponed their wider usage. In order to achieve a clearer insight on the material's performance, it is necessary to address phenomena like the anisotropic elasto-plasticity, temperature- and moisture sensitivity, damage occurrence and wrinkling, to mention some.
During the manufacturing process, the paper and paperboard endure considerable elasto-plastic deformations. The conventional yield criteria by Hill, does not capture in an adequate way the material response. The evolution of plasticity leads to the alteration of elastic properties and in conjunction with the anisotropic plastic hardening, the material's behavior advances in complexity.

Therefore, a novel material model was developed. The fundamental framework was derived consistent with the thermodynamic principles ensuring its applicability to finite deformations. The anisotropy of the material was introduced via the concept of structural tensors. Accounting for the densification effect, the elastic domain was made dependent on the plastic deformation via the strain energy function formulation. Additionally, a distinguished yield criterion was modified to be in concordance with the principles of finite-elastoplasticity. Furthermore, inconsistencies regarding the initial yield stresses and plastic strain ratios were considered. Lastly, a set of internal plastic hardening variables were defined to consider the present anisotropic plastic hardening.
A comparison between the presented formulation and Hill's yield criterion is demonstrated for the creasing and folding examples.

*Speaker