IDENTIFICATION OF THERMO-MECHANICAL PROPERTIES OF NATURAL POLYMERS WITH A HYBRID METHOD

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1. Introduction

The topic of this work concerns studying thermo-mechanical properties of non-classical construction materials such as wood, oriented towards the needs of designing machines that carry out the process of shaping parameters of the surface and structure. It makes it possible to influence the increase in density and the decrease in hygroscopy of the top layer of the plasticised material as well as the increase in its strength.

This work includes the results of the tests carried out by means of the hybrid method involving experimental and numerical approach. The shear tests of the samples of beech wood in three anatomical, orthotropic directions have been performed (fig. 1). The tests take into account the influence of temperature and moisture. The hybrid method was used in order to experimentally verify the obtained average values: yield point, shear strength and Kirchhoff modulus, due to the possibility of large error. The FEM calculations of fields of stress and deformation using finite contact elements were performed. In numerical simulations the fully coupled thermal stress FEM analysis in the environment of Abaqus Standard software was used.

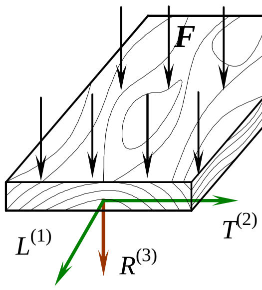

Fig. 1. Orientation of wood fibres (anisotropy): F – load, L – longitudinal direction, parallel to fibres, and two directions perpendicular to fibres: R – radial and T – tangent

In modelling the processes of plasticization and densification of materials such as wood we are interested mostly in material effort under which the plastic flow starts. The value of this strain is dependent on complex thermo-mechanical properties that characterize wood. Recognizing these properties, in so far as is necessary to formulate the yield criterion of the region characterized by porosity and anisotropy and accounting for the impact of temperature and moisture, is the main objective of these experimental tests.

The analysis of the material structure is the basis for determining important parameters in the process of shaping its geometric and construction properties, in connection with its specific composition and recognized properties. The profile of the properties of a material such as wood is determined by default by two categories: thermal and mechanical. In the thermal category these properties are mainly: thermal conductivity coefficient λ, specific heat c_p and density ρ directly dependent on porosity. These parameters determine diffusivity of the material in Fourier equation describing heat conductivity. In the mechanical category these properties are yield point dependent on orientation of fibers, temperature and moisture.

4. Study objectives

The results of the tests of thermo-mechanical properties of wood are used to formulate constitutive equations describing the process of its plasticization with a full and comprehensive description of the influence of temperature. On this basis it is possible to determine the effective force limit of plasticity. In order to achieve that anisotropic plasticity of porous materials, presented in the following works [3, 4, 6], was used. They account for anisotropy of the porous material and for the change in volume (first deviatoric stress invariant) under load. Taking this into account, Huber-Mises yield criterion for isotropic materials was used [2, 6, 7,], generalized onto anisotropic materials by Azzi-Tsai-Hill (ATH). The yield criterion so defined can be represented by the equation $A_{ij}\,\sigma_i\,\sigma_j = 1$, where σ_i denotes components of the stress tensor, σ_j components of the stress deviator, and A_{ij} modules of anisotropy.

Specified stresses and force limits are the values that are accounted for in design assumptions and the formulated models are used in simulations and numerical calculations [1, 2, 5].

6. References

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