Measurement and Modeling of the Micromechanics of the Internal Bond in Wood Plastic Composites

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ABSTRACT

Wood plastic composites (WPC) are heterogeneous materials comprised of irregular wood flour particles dispersed in thermoplastic polymer matrices. Mechanical properties of the composite are determined by the micromechanics of the internal bonds between the particle and the matrix. The ability to model and predict this interaction is crucial for developing improved, more efficient composites. Existing theories and models for short fiber composites allow prediction of composite properties based on the morphology of the composite, mechanical properties of the components, and on the properties of the internal bond. These theories however idealize the internal bond based on these found in composites reinforced with glass or carbon fibers – solid, impermeable and of regular cross sections. Such idealization can hardly be extended to wood plastic composites, where wood particles are porous, permeable and irregular. In fact, the knowledge about load transfer between wood flour particles and the polymer matrix in WPCs is very limited.

The objective of this study is to characterize the deformation and strain distribution in and around wood flour particles embedded in a polymer matrix experimentally, and to use morphology-based material point method (MPM) numerical simulations to determine effective load transfer parameters for calculations and modeling.

The mechanical tests are performed in small-scale tensile loading stage on thin composite samples with very low concentrations of wood flour particles. The deformations and strains are measured using an optical measurement system with a stereomicroscopic lens focused on a small area of interest (2 mm x 2 mm) containing one particle orientated at various angles to the loading direction.

The tests are simulated by means of 3D morphology-based models of the tested specimens. The exact position of the particle in the thickness of the film is measured from x-ray computed tomography (XCT) scans. Composites with wire sections of the same scale as the wood flour particles are used as a reference material approximating the ideal short fiber composite morphology.

The outcome of the simulations is numerically compared with the strain maps measured on the specimen surface and the input parameters iteratively adjusted to minimize local errors. This procedure allows better definition of the micromechanical properties of the internal bond.

In this presentation, the methodological aspects of the project as well as experimental and numerical results will be discussed.