MAHE – François

Statistical mechanical framework for discontinuous composites: application to the modeling of flow in SMC compression molding

Résumé

Sheet Molding Compounds (SMC) are composite materials made of chopped fiber bundles and thermoset resin, processed by compression molding. SMC materials are known to have complex rheological behaviors during the compression molding, which are difficult to model and are coupled with the evolution of the fibrous reinforcement of the composite material.
Observations by tomography of different SMC materials highlight several transformation mechanisms of the fibrous network depending on its characteristics. It reveals the importance of contacts and friction forces between fiber bundles during the processing of these materials. These mechanisms are often neglected in current modeling approaches.
A new framework of statistical mechanics is developed to model the behavior of discontinuous and random SMC fibrous reinforcement, from the microscale of the fibers, to the mesoscale with the formulation of descriptors based on the integral geometry, to the macroscale of the process. The behavior of this composite material is described analytically by a probabilistic approach and validated by numerical simulations.
This framework applied to SMC materials leads to a mixed fluid/friction model governed by the probabilistic contact forces between the fiber bundles. An experimental characterization protocol is proposed to identify the rheological parameters of this model.

Mots-clés : SMC, process modeling, composite, statistical mechanics, characterization, simulation