Multiscale CFD simulation of non-Newtonian Nylon-6 permeating into carbon fiber in composite impregnation process

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A multiscale approach is proposed for the production of unidirectional carbon fiber-reinforced thermoplastic composites (UD-CFRTCs), which covers the macro-scale CFD model of an impregnation die, the micro-scale CFD model for a representative element volume of tow, and the process-scale simulation for the whole impregnation process. The tow is assumed as sliding porous media in the macro-scale CFD model, while the real structure of carbon fibers is considered in the micro-scale CFD model. The macro-CFD model is treated as an one-phase steady state scheme, while the micro-CFD model as a two-phase unsteady state scheme. Finally, CFD data obtained from the micro-scale and macro-scale CFDs are collected in the process-scale simulation in order to predict the degree of impregnation (DoI) and rate of impregnation (RoI). The present multiscale CFD result on DoI shows a good agreement with a relative resin amount experimentally measured for the UD-DFRTC prepreg.