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Evaluation of Elastic-Plastic Response of Discontinuous Carbon Fiber-Reinforced Thermoplastics: Experiments and Considerations Based on Load-Transfer-Based Micromechanical Simulation

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Abstract

The present study investigated nonlinear elastic-plastic stress-strain relationships of discontinuous carbon fiber-reinforced thermoplastics (CFRTPs) using experiments and numerical simulations. In the experiments, we conducted uniaxial tensile tests and three-point bending tests for two types of CF/PA6 (carbon fiber/polyamide 6) specimen: injection-molded specimens with short fiber length and aligned fiber orientation, and compression-molded specimens with long fiber length and random fiber orientation. Comparison of the experiment results indicated that the injection-molded specimens exhibited a nonlinear stress-strain response, while the compression-molded specimens exhibited an almost linear response. These results implied that long discontinuous fibers effectively increased the yielding point of composites, even if the composites had random fiber orientation, which eliminated orientation dependence on mechanical properties of the composites. Furthermore, we attempted to simulate elastic-plastic stress-strain relationships of discontinuous CFRTPs in an effort to understand the effect of the microstructure, including fiber length. For this purpose, we employed fiber-based simulations to deal with the microstructure of fibers and matrix and the constitutive law of the matrix. The simulated results indicated that fiber length influences the nonlinearity of the stress-strain relationships of discontinuous CFRTP composites.

Keywords: A. Polymer-matrix composites (PMCs), B. Plastic Deformation, C. Modelling