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Mechanics of Polytetrafluoroethylene (PTFE) Paste Flow

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Summary

In this paper, the fundamental theoretical and experimental aspects of PTFE paste extrusion are discussed. Several resins of different molecular structure were tested. Experiments were conducted using several rheometers, including a capillary equipped with barrels of different diameters and dies of various design, an extensional and rotational rheometer. Analyses of the structure formation during flow were performed using a differential scanning calorimeter (DSC), scanning electon microscope (SEM) and micro-Raman spectrometer. The tensile properties of paste extrudates were determined using a universal Instron mechanical testing machine. Based on the experimental results, a constitutive rheological equation is proposed for the paste extrusion of polytetrafluoroethylene (PTFE) that takes into account the continuous change of the microstructure during flow, through fibril formation. The mechanism of fibrillation is captured through a microscopic model for a structural parameter, . This model essentially represents a balance of fibrillated and unfibrillated domains in the PTFE paste through a first order kinetic differential equation. Finite element simulations using the proposed constitutive relation predict accurately the variations of the extrusion pressure with the apparent shear rate and die geometrical parameters.