Analysis of a Split and Recombine Mixer for Polymer Melts

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Moon and Migler [1] developed a novel microfluidic mixer for high temperature polymer melts based on the use of split and recombine flow channels formed from the stacking of stainless steel shims (50 μm thickness) that uses only 20 μL of material per sample. The device produces an exponential 2^n multilayer domain morphology (where n is the number of units in series) in a direction either perpendicular or parallel to the plane of the shims. Effective mixing is produced as the layer thickness approaches the molecular length scale. The device also has potential as an alternative to coextrusion for the production of multilayer laminates in the case of limited material quantity. Flow in the mixer is analyzed using two techniques. First, numerical simulation using the finite element method (FEM) is combined with multi-species particle tracking to produce Poincare diagrams of the mixing in the outflow cross-sections of each serial unit. In a second technique, multiphase flow equations based on a Cahn-Hilliard type free energy model are solved. Results for the two techniques are compared with experimental results and suggestions for future work are discussed. The two major challenges to producing uniform laminates using the shim flow channel design are generating equal splits, and recombining flow streams without producing rotation of the laminate layers.
[1] Moon, D., and K.B. Migler, "Microfluidic Mixer for Polymer Melts," Annual Technical Conference Proceedings, Society of Plastics Engineers, Chicago, IL, pp. 1838-184, (2009).