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Modeling of the Mixing Process in Internal Mixer: the Case of The Case of Miscible Having Very Different Viscosities

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In a previous work, we have developed a dynamic model of an extrusion process in the case of homopolymerisation (Choulak et al., 2004). However, some extrusion processes require the mixing of fluids having very different viscosities like a monomer and a molten polymer. The objective of this paper is to study this type of mixing in order to extend our previous model. As a first step, we have performed mixing experiments in a Haake internal mixer.

The modeling of internal mixer experiments has been treated in the past at steady state for pure or mixed polymers. We propose to extend these works by using Polycarbonate and caprolactone monomer. The polymer is first introduced in the internal mixer. The torque increases because of the resistance of pellets and the melting process. When we introduce the monomer, a lubrication phenomenon appears which leads to a drop in the torque. Then, the torque increases to reach a steady state. Pictures of these different steps will be shown: a dye is used as a tracer to follow the transfer of the caprolactone.

After this qualitative part, we present a dynamic model based on a simplified view of the flow and on mass, energy and momentum balances. As far as the mass transfer is concerned, we consider simultaneously the mechanical action of the rotors and the diffusive process between the molecules of monomer and the polymer matrix. Heat transfer has to be considered because of the sudden introduction of the cold monomer and the viscous dissipation. Finally, a momentum balance allows us to calculate the velocity profile and the torque time evolution by considering that the viscosity is concentration and temperature dependant.

Simulation results will show a good agreement between the model and experiments.

Reference: S. Choulak, F. Couenne, Y. Le Gorrec, C. Jallut, P. Cassagnau, A. Michel, “A generic dynamic model for simulation and control of reactive extrusion” (2004), IEC Res., 43(23), 7373-7382