Thermal Homogeneity in Single Screw Channel Polymer Melt Flows

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Abstract. Single-screw plastication, used in extrusion and in injection moulding, is a major way of processing commodity thermoplastics. In injection moulding, a high level of reliability is usually achieved that makes this process ideally suited to mass market production. Nonetheless, process fluctuations still appear that make moulded part quality control an everyday issue. During the plastication phase, prior to the injection phase, the polymeric material is melted by the combined effects of shear -induced self heating (viscous dissipation) and heat conduction coming from the barrel. A combined drag and pressure difference flow is imparted on the molten polymer along the screw channel. The low thermal diffusivity of molten polymers implies that convection is dominant over diffusion and leads to very large Peclet numbers. However, the screw channel length is large enough for the flow to present significant diffusion effects. Therefore, the objective of this work is to study the capacity of this particular class of flows to dampen any transient inlet temperature disturbances occurring at the beginning of the metering zone of the screw channel. The integral transform method is applied to the transient energy conservation equation with the laminar velocity profile obtained for drag and pressure difference flow of a Newtonian fluid. We found that the knowledge of a single eigenvalue is sufficient to characterize the dampening efficiency of a flow and that a higher level of back-pressure is indeed improving the thermal homogeneity in the flow. Moreover, we found that for any given flow, the high frequency disturbances are dampened more efficiently than the low frequency disturbances.