SL 6.5

On-line Rheometry of an EPDM Rubber using Parameter Fitting

A. Rippl, J.F.T. Pittman and J. Sienz.
Centre for Polymer Processing Simulation and Design,
School of Engineering, University of Wales Swansea, SA2 8PP, UK.

The flow properties of rubber are sensitive to processing conditions, and on-line rheometry can provide data that is more relevant to processes such as profile extrusion than classical laboratory testing. An on-line rheometer has been developed and used to capture flow behaviour under processing conditions. The rheometer incorporates interchangeable capillaries and by-pass overflow valves allowing examination over a range of shear rates. The rheometer is instrumented with pressure and temperature transducers, and mass flow rates and pressure drops for capillaries of various lengths and diameters were measured for several extruder operating speeds. Classical methods for interpretation of the data could not be used because it was not possible to control rubber temperature independent of extruder speed. A parameter fitting method was therefore used to determine the set of parameters in a chosen flow model. This includes three elements: shear viscosity, extensional viscosity and wall slip. Power law forms, with exponential temperature dependence, are used for all three; thus nine parameters are involved. Based on this model an analytic expression for pressure drop in the capillary is developed, and combined with an expression for the pressure drop in the converging flow into the capillary, based on the analysis due to Binding. The objective function measures the departure of this analytic pressure drop from the experimental values, and is minimized using the Levenberg-Marquart algorithm. The resulting parameter set indicates the significant influence of wall slip and extensional viscosity. A study of the literature shows little or no previous work where all three elements of the flow behaviour have been separately quantified. Their incorporation into a CFD code for analysis of extrusion is judged to be essential.