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Thesis Title	Rheometer Design Characteristics on Extrudate Swell and Flow Properties of Polymer Melts
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Abstract

This research investigated the effect of rheometer design on the flow properties and extrudate swell behaviour of natural rubber, the sizes of die and barrel as well as their assembly being of main interest. A special rate-constant capillary rheometer was designed. The first part of work involved the use of two dies located along the barrel and the flow patterns and extrudate swell of natural rubber were studied through a colored tracer as the visualization technique. The results suggested that the flow of the rubber in the upper barrel was dependent on the piston/barrel action and changed with piston displacement, whereas the complexity of the flow in the lower barrel was dependent not only on the piston displacement, but also on the geometry of the upper die design. The flow patterns that developed in the whole barrel were dependent of the die located at the bottom of the barrel. In addition, the change in extrudate swell was associated with the flow occurring in the barrel, residence time, elastic characteristic, and the temperature rise during the flow. It was concluded that the general style of the flow patterns of the natural rubber was greatly dependent on the die geometry that the material had previously moved past.

The second part investigated the effects of the actual diameters and diameter ratios of the barrels and dies on the elastic swell (B) and entrance pressure drop (ΔP) of natural rubber compound in the capillary rheometer. In this case, either the barrel or the die diameter was altered so that different D_B/D_D ratios were obtained, both barrel and die diameters being also varied simultaneously. It was found that the extrudate swell and entrance pressure drop were dependent not only on the ratio of the barrel/die diameter, but also on the actual diameter of the

barrels and dies used. For fixed D_B/D_D ratio, the change in the extrudate swell was linearly influenced by the entrance pressure drop at low actual barrel/die diameters (D_B/D_D from 20/4 to 30/7 mm/mm), but was associated with the size of vortex flow (hight/radius ratio of the flow) at the die entrance when using high barrel/die diameters (D_B/D_D from 35/7 to 40/8 mm/mm). When the die diameter was fixed, the relationship between the entrance pressure drop and the extrudate swell was linear up to a certain value of the barrel diameter of greater than 30mm. Beyond this critical barrel value, the relationship became non-linear, and associated with the shearing stress generated due to a formation of the semi-pluglike flow patterns, the size of vortex flow, and the residence time of the material. For a constant barrel diameter, the flow patterns were not found to change with die diameter. The smaller the die diameter the greater the extrudate swell due to the increases in the extensional deformation and wall shear rate coupled with a reduction in the material residence time.

The final part studied the effect of die materials (mild steel, bronze and copper dies) on the flow properties and extrudate swell of various types of thermoplastic melts including PS, PVC, LDPE and HDPE melt. The obtained results were still inconclusive and further work in this area are to be carried out.

Keywords: Polymer melt/ Capillary rheometer/ Flow pattern/ Die swell/ Rheometer design.