WALL SLIP BEHAVIOUR OF NATURAL RUBBER MELTS

Polymer melts have shown increased volumetric flow rates compared to low molecular weight fluids of the same viscosity at the same pressure drop. This is basically due to the fact that these melts do not wet the solid surface completely thereby giving a finite positive value of velocity at the solid boundary. The mathematical formulation to calculate the slip velocity was derived by Mooney (1931). This equation for the flow of melt through a capillary is:

$$\dot{\gamma}_{wa} = \frac{4\,Qs}{\pi\,R^3}$$

$$= 4\,V_r\,\frac{1}{R} + \frac{4}{\tau^3_w}\int_{\tau}^{\tau_w}\tau^2\dot{\gamma}\,d\tau \qquad (1)$$

where Qs is the volumetric flow rate under slip condition, R is the radius of capillary, V_r is the slip velocity, τ_w is the wall shear stress, $\dot{\gamma}$ is the shear rate and $\dot{\gamma}_w$ is apparent wall shear rate.

This equation corresponds to an equation of a straight line when apparent wall shear rate is plotted against 1/R at constant shear stress. The slope of the line gives four times the slip velocity. The wall slip behaviour of different polymer melts like LDPE (Lupton & Regester, 1965; Benbow & Lamb, 1963; Worth *et al.*, 1977); polystyrene (Brydson, 1981); unplasticised PVC (Chauffoureaux *et al.*, 1979; Knappe *et al.*, 1986); uncrosslinked EP polybutadiene (den Otter, 1975); polyacrylamide solutions (Mueller *et al.*, 1987); HDPE (Uhland, 1979); HPG gels (Jiang *et al.*, 1986) and EPDM blends (Jespen *et al.*, 1988) had been investigated and reported. The slip velocity is generally found to increase with wall shear stress but some authors reported a discontinuity in the curves (Lupton *et al.*, 1965; Worth *et al.*, 1977). Pressure and temperature were also reported to influence the wall slip behaviour. It is interesting to note that no systematic investigation has been reported on natural rubber melts. The present study, therefore, has been undertaken to investigate natural rubber melts. The effects of mastication and the L/D ratio of capillary have been included in the studies.

System — unmasticated Standard Malaysian Rubber (SMRCV-70) and that masticated for 10 min.

Apparatus — Davenport Extrusion Capillary Rheometer.

Temperature of melt — 120°C.

Capillaries — Two sets of capillaries having L/D ratio of 5 and 20 were used. Each set consisted of three capillaries of different length and diameter as shown below:

L/D: 5		L/D: 20	
Length mm	Diameter mm	Length mm	Diameter mm
12.5	2.5	50	2.5
10.0	2.0	30	1.5
5.0	1.0	20	1.0

Procedure — Small pieces of rubber were fed to the barrel of the rheometer and