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RHEOLOGICAL AND DIE SWELL BEHAVIOUR OF NATURAL RUBBER MELTS

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Studies on rheological and die swell behaviour of natural rubber melts were carried out in a Davenport Capillary Rheometer. Two types of rubber, a Standard Malaysian Rubber (SMR-L) and a viscosity stabilised form of SMR (SMR CV 70) were masticated in a two-roll mill at 50°C for different time intervals. The extent of mastication is expressed as plasticity, measured from Wallace rapid plastimeter. Both type of rubbers have shown pseudoplastic behaviour with the value of non-Newtonian index, n, varying between 0.1675 and 0.2695 under different levels of mastication. Die swell increases with plasticity and shear stress, but decreases with increasing levels of mastication. The value of non-Newtonian index first decreases with plasticity and then increases. The apparent viscosity is found to decrease with the rate of shear and the extent of mastication. It is also established that the power-law model describes the behaviour of both masticated and unmasticated rubber.

Key words — Rheology, Die swell, Natural rubber, SMR–L, SMR–CV, Extrusion rheometer, Mastication, Plasticity, Shear stress, Rate of shear, Apparent viscosity.

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INTRODUCTION

The knowledge of rheological behaviour of rubbers is of considerable importance in mixing, extrusion, calendering and moulding operations. Die swell measurements are very useful in the control of spinning, extruded sheet thickness, blow moulding and product surface finish. Considerable research has been carried out on both these aspects for various synthetic elastomers and plastics but studies on natural rubber melts have been very scanty. Rheological behaviour of polymer melts, in general, has been reported to vary with temperature (Williams *et al*, 1955; McKelvy, 1962; Brydson, 1981), molecular weight and its distribution (Peticolas and Walkins, 1957; Beynon and Glyde, 1960; Allen and Fox, 1964; Shaw, 1977), degree of branching (Bueche, 1964; Shaw, 1977) and many other factors like pressure (Westover, 1961; Cogswell, 1973) and filler loading (Newman and Trementozzi, 1965; Miagawa and White, 1976). The die swell behaviour of polymer melts also depends on different factors like shear rate (Beynon and Glyde, 1960) and preshearing (Teh *et al*, 1984), length to diameter ratio of capillary (Bagley *et al*, 1963; Rogers, 1970), residence time in the flow channel (Kruse, 1964; Rogers, 1970; Teh *et al*, 1984), temperature (Beynon and Glyde, 1960), molecular weight (Kubota, 1975; Rogers, 1970), $\overline{M}_w/\overline{M}_n$ ratio (Guillet *et al*, 1965) and molecular chain branching (Peticolas and Walkins, 1965). The observations and studies published concern mostly synthetic elastomers and plastics and very little on natural rubber (Brydson, 1981; Kirschke, 1984; Vinagradove and Malkin, 1980).