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Rising Velocity of a Non-Newtonian Liquids in Capillary Tubes

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Abstract : The capillary filling process is significantly important to study for numerous applications such as the under filling of the material in electronic packaging or liquid hydrocarbons seepage through porous structure. The approximation of the fluid being Newtonian, i.e., linear relationship between the shear stress and deformation rate cannot be justified in cases where the extent of non-Newtonian behavior of liquid governs the surface driven transport, i.e., capillarity action. In this study, the capillary action of a non-Newtonian fluid is not only analyzed, but also the modified generalized theoretical analysis for the capillary transport is proposed. The commonly observed three regimes: surface forces dominant (travelling air-liquid interface), developing flow (viscous force dominant), and developed regimes (interfacial, inertial and viscous forces are comparable) are identified. The velocity field along each regime is quantified with Newtonian and non-Newtonian fluid in square shaped vertically oriented channel. Theoretical understanding of capillary imbibition process, particularly in the case of Newtonian fluids, is relied on the simplified assumption of a fully developed velocity profile which has been revisited for developing a modified theory for the capillary transport of non-Newtonian fluids. Furthermore, the development of the velocity profile from the entrance regime to the developed regime, for different power law fluids, is also investigated theoretically and experimentally.

Keywords : capillary, non-Newtonian flow, shadowgraphy, rising velocity
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