VISCOPLASTIC FLOW DEVELOPMENT IN ANNULAR TUBES IN THE PRESENCE OF WALL SLIP

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ABSTRACT

We solve numerically the entry flow of Newtonian and viscoplastic materials in concentric annular tubes assuming that Navier slip occurs at the walls. The entrance length, i.e., the length required for the flow to adjust from a uniform to the fully-developed profile is usually defined as the distance, L_c, required for the maximum velocity to attain 99% of its fully developed value [1]. Such a definition is not applicable in the case of viscoplastic materials, i.e., yield stress fluids, due to the presence of the unyielded core (which moves with maximum velocity). In the present work, the entrance length is calculated as a function of the radial coordinate, and its maximum value is considered as the global entrance length, L_g [2,3]. Numerical simulations are carried out for Newtonian and Herschel-Bulkley fluids using the open-source finite element software FeniCS[4] for Reynolds numbers up to 1000 and various values of the Bingham and slip numbers, the power-law exponent, and the radii ratio. The difference between the two entrance lengths (L_c and L_g) becomes more important at high Reynolds numbers. The numerical results reveal that flow development may be slower near a wall than in the unyielded region and that the effects of wall slip are more pronounced for small values of the radii ratio.

KEYWORDS: Entry Flow, Herschel-Bulkley Fluid, Annular Tube, Entrance Length,

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