Plane sudden expansion flows of viscoelastic liquids: effect of expansion ratio.

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Abstract

Although for Newtonian fluids creeping flow through contraction and expansion geometries is identical, for viscoelastic liquids the inherent non-linearity of the governing equations produces some striking differences between the two flows. Even though expansion flows have been considered to be much less interesting than the widely-studied contraction flow, we have shown recently [1] that the degree to which recirculation is in fact suppressed is far less than previous studies have suggested and that at high Deborah number a significant recirculation region still exists downstream of the expansion. In the current study we significantly extend those initial results by numerically investigating a series of different expansion ratios \(D/d = 1.5, 2, 3, 4\) and 10 where \(D\) is the downstream channel height and \(d\) is the upstream channel height). We make use of a finite-volume technique, together with the high resolution ‘CUBISTA’ scheme for the convective terms in the constitutive equations, to study the creeping flow \(Re = 0\) of the UCM and Oldroyd-B models and the linear form of the PTT model. For each expansion ratio the maximum \(De\) obtainable was approximately the same, about 1 for the UCM, and lower than that found for the “equivalent” contraction case using the same code. For small expansion ratios the length of the recirculation region, \(X_R\), first decreases then \textit{increases} with elasticity whereas for larger
expansion ratios $X_R$ levels out at high Deborah number. For all cases studied with increasing Deborah number a progressively strong convergence of the streamlines occurs immediately upstream of the expansion plane. The cause of this phenomenon, and its relation to the increase in $X_R$ for lower expansion ratios, will be discussed.

References


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