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Geometrical effects on secondary flows of viscoelastic fluids in curved ducts of rectangular cross-section

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ABSTRACT

The use of curved ducts in industry is wide spread and these geometries are characterized by the development of secondary flows that depend on the geometry of the curve, and in particular on the duct cross-section aspect ratio and the curvature ratio. Published studies with Newtonian flows have shown that the variation of geometry leads to non-linear changes in both critical Dean number (Dn_c, defining the transition from one to multiple pairs of vortices) and secondary flow patterns [1-3]. By changing the geometry, the effect of confinement will compete with the centrifugal instability that generates secondary flow: when confinement does not prevail, the resistance to secondary flow decreases and Dn_c decreases, but when confinement dominates, the resistance to secondary flow increases and so does Dn_c. For non-Newtonian fluids literature is scarcer, but it has already been established [4] that the rheological properties of viscoelastic fluids delay or speed up the transition leading to establishment of secondary flow. However, the effects of the variation of aspect ratio and curvature ratio have not been yet widely explored for this kind of fluids.
In this work, the effects of aspect and curvature ratios are analysed for viscoelastic fluid flows in 180° curved ducts, for varying rectangular cross-section dimensions. The equations of motion and the FENE-CR rheological constitutive equation are solved numerically using the finite volume method on a collocated mesh. The other relevant independent parameters investigated are the Reynolds number (defining the level of inertia) and the Weissenberg number (defining the level of elasticity). A preliminary analysis of the results reveals similarities with the Newtonian case.

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