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Interplay of Inertia and Elasticity, Enhanced Heat Transfer and Change of Type of Vorticity in Tube Flow of Nonlinear Viscoelastic Fluids

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— The effect of the interplay of elasticity and inertia on heat transfer enhancement in pressure gradient driven laminar flow of nonlinear viscoelastic fluids in straight tubes of non-circular cross-section at constant wall temperature is discussed. The coupling between viscoelasticity and inertia is crucial to enhancement. Heat transfer enhancements of an order of magnitude larger as compared to their Newtonian counterparts are predicted. Enhancement is a convex function of the second normal stresses. The rate of enhancement decreases with increasing second normal stresses and asymptotically tends to an upper limit. The implications on the enhancement of the change of type of the vorticity equation are discussed. There is a supercritical region away from the wall where the vorticity is hyperbolic with the viscoelastic Mach number M exceeding one. M becomes larger and the radius of the hyperbolic region becomes smaller with growing Re as the elasticity number E stays smaller than one. Vorticity in this hyperbolic region is rapidly damped, the larger the Weissenberg number Wi the smaller the rate of damping. There is a cause and effect relationship between the leveling off of the enhancement with increasing Wi and the gradual shrinking of the hyperbolic region together with the damping of the vorticity with increasing Wi and M.

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