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The transverse mobility of yield-stress fluids in fibrous media SETAREH SHAHSAVARI, GARETH H. MCKINLEY, MIT — The pressuredrop/flow-rate relationship for fluids that exhibit a yield stress and a shear dependent viscosity flowing through fibrous media is studied numerically. The Cauchy momentum equation along with the Bingham or Herschel-Bulkley constitutive equations are solved for flow transverse to a periodic array of fibers and systematic parametric studies are used to understand the individual roles of geometrical characteristics and fluid rheological properties. We develop a scaling model to predict the fluid mobility as a function of the medium porosity and the Bingham number. In addition, using this scaling model we estimate the width of the unyielded region between two adjacent fibers. Numerical computations are combined with the scaling model to obtain a criterion for the critical pressure gradient required to drive flow. Variations in the size of the yielded zones, the velocity profiles and the resulting stress fields are investigated for the limiting cases of (i) densely packed fiber arrays and (ii) very sparsely distributed fibers, and the hydrodynamic transition between these configurations is investigated. While this work focuses on the flow of inelastic fluids, the methodology can be extended to consider more complex rheology such as flow of elasto-visco-plastic fluids.

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