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Coupled pressure and velocity distributions in a pressure-driven flow inside a long pipe with fluid injection through porous walls. ALEXANDER L. FRENKEL, UA, LEONID BOLSHINSKIY, UAH — We are studying steady flows of Newtonian liquids in pipes with porous walls. One end of the pipe is closed; the ambient liquid is injected through the pipe wall under the Darcy-Weisbach law and exits at the open end with a pressure that is kept below the uniform fluid pressure outside the pipe walls. The inside pressure varies with the axial coordinate and is coupled with the varying axial velocity averaged over the cross-section of the pipe. For a long pipe, the Karman-Polhausen averaging of Navier-Stokes equations is used for both laminar and turbulent flow regimes. We obtain a boundary value problem for a nonlinear second-order differential equation governing the velocity distribution and explore numerous flow regimes by numerically solving it. Hence, the pipe pressure is found as a quadratic expression in terms of the velocity derivative. At sufficiently high Reynolds numbers, quite unlike the standard pipe flow with uniform velocity, even the turbulent friction turns out negligible in comparison with the pressure gradient required for accelerating the liquid toward the exit. The inertial approximation allows for an analytic solution. The nonzero-gravity generalization is obtained, and applications to channels with fine-mesh screen walls utilized for the delivery of liquid propellant to the engine at low gravity, are discussed.

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