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Instability of fluid flow over saturated porous medium

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We investigate the stability of a fluid flow over a saturated porous medium. The problem is of importance due to the applications to washing out of contaminants from the bottom layer of vegetation, whose properties are similar to the properties of porous medium. In the case of porous medium with the relatively high permeability and porosity the flow involves a part of the fluid saturating the porous medium, with the tangential fluid velocity drop occurring because of the resistance of the solid matrix. The drop leads to the instability analogous to Kelvin-Helmholtz one accompanied by the formation of travelling waves.
In the present paper we consider a two-layer system consisting of a pure fluid layer and a porous layer saturated by the fluid located underneath. The system is bounded by a rigid surface at the bottom and a non-deformable free surface at the top. It is under the gravity and inclined at a slight angle to the horizontal axis. The boundary conditions at the interface between the fluid and porous layers are the continuity of fluid velocities and the balance of normal and tangential stresses taking into account the resistance of the solid matrix with respect to the fluid flow near the interface [1-2]. The problem is solved in the framework of the Brinkman model applying the classical shooting algorithm with orthogonalization.
The stability boundaries of the stationary fluid flow over the saturated porous medium with respect to the small oscillatory perturbations are obtained for the various values of the Darcy number and the ratio of the porous layer thickness to the full thickness of the system d. It was shown that at the $d > 0.5$ with increasing the porous layer thickness (or with decreasing of the fluid layer thickness) the stability threshold rises. This is because of the fact that the instability is primarily caused by perturbations located in the fluid layer. At the $d < 0.5$ the reduction of the porous layer thickness leads to the stability threshold growth.
The numerical calculations were also conducted for nonlinear regimes of the flow applying the finite-element method. Flow characteristics are determined at supercritical values of parameters.
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