The double porosity model of single-phase flow in a fractured porous medium taking into account scattered fracture of matrix blocks

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Abstract:

The double porosity model of single-phase flow in a deformable medium with an elastic skeleton is generalized to the case of scattered matrix fracture. The medium consists of low-permeable (in the initial state) blocks and a connected system of mesoscale fractures, so that the poroelastic and flow characteristics are rapidly oscillating functions. The development of small-scale fracturing (scattered fracture) leads to an increase in the permeability of matrix blocks and the intensification of mass transfer between subsystems of double porosity media. By analyzing the inequality of dissipation, the thermodynamically consistent governing relations and the equation for evolution of the damage parameter in matrix are derived. The resulting system of differential equations includes, an equation expressing the condition of equilibrium of the medium, equations for pressures in the subsystems of double porosity, and an equation for the scalar damage parameter, consistent with the dissipation inequality.

Using the normal mode method, the conditions on the coefficients of the system is obtained that guarantee the stability of spatially homogeneous states. For the obtained system of equations a initial-boundary-value problem is formulated and solved numerically that models a coupled processes of flow, fracture and changes in the stress-strain state in a loaded cylindrical layer with double porosity, which was initially in equilibrium under high pore pressure. These processes are initiated by lowering the pore pressure at the boundary section (the inner boundary of the cylindrical layer modeling the well). The obtained solution describes the growth in time of the zone of scattered fracture and the associated increase in the filtration flow into the well. The field of practical application of the developed mathematical model is a description of the processes that accompany the extraction of oil from formations with a low permeable brittle matrix and an abnormally high reservoir pressure.