A FIXED STREAMTUBE MODEL AND LOCAL REFINEMENT OF THE SUPERELEMENT MODEL OF PETROLEUM RESERVOIR

Potashev K.A., Mazo A.B.
Kazan Federal University, Kazan

A feature of the hydrodynamics of a stratified petroleum reservoir opened by vertical wells is that the pressure gradient and the direction of the flow velocity are determined by the arrangement of the wells and are weakly dependent on the vertical coordinate z. Therefore, the projections of the velocity vectors onto the horizontal plane xOy form a family of streamlines that are the same for all z values, and the stream tubes are bounded from below and from above by the base and roof of the formation, and on the sides by vertical surfaces. At each point l of the stream line passing inside the stream tube, it is possible to determine the function $W(l)$ - the relative width of the stream tube. If the development of a section of the reservoir is carried out without radical changes during a certain period of time, the geometric configuration of the flow remains stable. This makes it possible to use a steady-state mathematical model of single-phase flow (XY model) averaged over the thickness of the reservoir to determine the stream lines and $W(l)$ functions in the selected section of the reservoir, while the stream tubes themselves are considered fixed during the solution of the local problem. In this case, the original three-dimensional model of flow can be decomposed into a series of two-dimensional problems in vertical sections of the formation (lWz models) constructed along the stream lines between the injection and production wells.

This approach reduces computational costs by an order of magnitude, allows the use of high resolution grids (with a step of about 1 meter horizontally and 0.1 meters vertically), necessary, for example, in modeling "thin" processes of multicomponent filtration in heterogeneous formations.

In the work, the model with a fixed stream tube is used for local (in the section of the formation) detailing a large-scale superelement solution of

the problem of flooding the oil field. An external superelement solution is used in the formulation of a third-kind boundary condition simulating the interaction of the section with the outer region of the deposit, as well as the initial conditions for the saturation distribution in the lWz model. At the same time, special procedures for downscaling are used to transfer the solution from a large grid to a small one.

A series of calculations was carried out to determine the limits of the applicability of the model with a fixed stream tube and the XY model averaged over the thickness of the formation. Successful application of the proposed approach is demonstrated in the examples of reservoir simulation in different variants of perforating the production well and injecting an aqueous solution of the polymer in the framework of the two-phase flow with an active admixture, taking into account the sorption of the polymer.