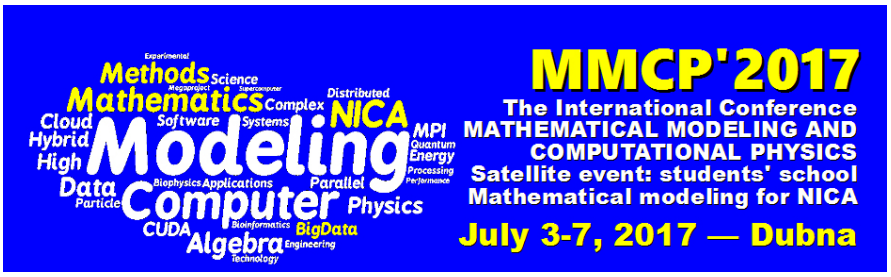

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Algorithm of the explicit type for porous medium flow simulation

Monday 3 July 2017 16:00 (15 minutes)

Development of mathematical fundamentals and software for simulation of complex fluid flows in the subsurface is one of urgent tendencies of industrial mathematics. Among applications of such flow modeling there are oil-and-gas industry problems, in particular, the development of perspective hydrocarbon recovery technologies, as well as ecological problems concerning the soil and groundwater contamination.

The present work is devoted to elaboration of an original mathematical model of porous medium flows constructed by analogy with the quasigasdynamic system of equations and allowing implementation via explicit numerical methods [1]. The model is generalized to the case of multiphase multicomponent fluid and takes into account possible heat sources. It also accounts for gravitational and capillary forces.

The distinguishing feature of the model is modification of phase continuity equations: they get regularizing terms and second order time derivatives with small parameters. The equations' type is changed from parabolic to hyperbolic, consequently they can be approximated by the three-level explicit scheme with rather a mild stability condition; convective terms are approximated by central differences. As the temperature of all phases and the rock is identical the system involves a single equation of the total energy conservation approximated also by an explicit scheme.

To ensure the critical accuracy of the solution of some large-scale oil-recovery problems it is necessary to execute computations with a very small space step what constrains a time step strictly. Then explicit schemes can gain in terms of the total computational time in comparison with implicit schemes. Besides algorithms of the explicit type are preferable as they can be easily adapted to modern HPC systems.

The proposed approach is verified by a number of test predictions. High parallelization efficiency is achieved on a hybrid supercomputer.

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[1] B.N. Chetverushkin, D.N. Morozov, M.A. Trapeznikova, N.G. Churbanova and E.V. Shil'nikov. An Explicit Scheme for the Solution of the Filtration Problems // Mathematical Models and Computer Simulations, 2010, Vol. 2, No. 6, pp. 669–677.

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