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Mathematical models of oil reservoir

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Mathematical models of oil reservoir are very important from both theoretical and practical points of view. So far, one of the most popular models is the Backley-Leverett model [1]. Probably the next known model could be the Muskat problem. Each of these models is a phenomenological macroscopic mathematical model. A phenomenological mathematical model is a set of certain postulates, describing the physical process in consideration at the macroscopic level, where the characteristic size is tens of centimeters or meters. Only adequate modeling can optimize the process of field development, and only with adequate modeling is the main goal of any hydrodynamic simulator achieved. Are the mathematical models underlying the prototypes of the existing and proposed simulators adequate to the physical process? The positive or negative answer depends on what does the adequacy of the physical process of any mathematical model of this process mean. To do this, it is necessary to formulate the criteria for the adequacy of the mathematical model. In the case of phenomenological models, which are mathematical models of already existing hydrodynamic simulators of an oil reservoir, the criterion of adequacy can be only an experiment. Whether this criterion is a criterion of adequacy? The answer is no. The phenomenological models do not distinguish between the microstructure of a continuous medium, while all fundamentally important changes occur at the microscopic level corresponding to the average size of pores or cracks in rocks, while any of the proposed macroscopic models operate with completely different scales and therefore does not distinguish either the free boundary or the features of the interaction of liquids. There is a great variety, depending on the tastes and preferences of the authors of the models. It is quite understandable, since the main mechanism of the physical process is concentrated on an unknown (free) boundary between two different liquids and is not spelled out in any way in the proposed macroscopic models. In contrast to the macroscopic level, there is also a microscopic level, where the characteristic scale is tens or hundreds of microns. This is the scale, and only the scale, at which we can distinguish each component of the continuum media. The corresponding mathematical models are called microscopic mathematical models of the physical process. They proposed the following scheme: 1) the physical process under consideration is described at the microscopic level by equations of classical continuum mechanics (exact model), 2) a set of small dimensionless parameters is selected, 3) the macroscopic mathematical models are the exact asymptotic limits (homogenization) of exact mathematical models at the microscopic level, when the selected small parameters tend to zero. We follow this scheme and suggest the set of exact mathematical models describing the oil reservoir, which may be a base for new adequate prototype of hydrodynamic simulator of oil reservoir.

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References

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