A CAPILLARY MODEL OF A POROUS MEDIUM DEVELOPED USING CORE TOMOGRAPHY DATA

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An original methodology for constructing a model of porous medium has been proposed in the development of an approach to describing fluid flow in porous media [1]. This methodology is based on a well-known and widely used capillary model that considers the pore size distribution obtained through tomographic studies of porous media or visual analysis of core sample thin sections. The model porous medium is formed by dividing it into thin layers, each containing segments of capillaries that are conventionally assumed to be cylindrical. These layers are probabilistically connected, forming parallel capillaries with varying cross-sections. Under the assumption of inertia-free flow, the effective capillary diameter is calculated, and a pair of connected capillaries with different diameters is replaced by a new capillary with an effective diameter:

$$d_{1-2} = \sqrt[4]{\frac{2}{\frac{1}{d_1^4} + \frac{1}{d_2^4}}}. \tag{1}$$

The generated model capillary layers are repeatedly connected to each other, and the procedure is performed multiple times. In the limiting case, at a certain iteration (n), all capillaries within a layer will have the same diameter, d_{eff}. The final goal of the capillary layer averaging process is to determine this value. Since each iteration of capillary layer merging produces a hydraulically equivalent model, the set of parallel capillaries with diameter d_{eff} is considered hydraulically equivalent to the modeled porous medium.

The absolute permeability of the model porous medium, k_0 (in Darcy), is defined as the permeability of a bundle of N parallel capillaries with diameter d_{eff}:

$$k_0 = \frac{S_{eff}}{S_p} N k_{eff}, \tag{2}$$

where k_{eff} is the permeability (m^2) of a capillary with diameter d_{eff}, which, in the Poiseuille approximation, is expressed in terms of d_{eff} as:

$$k_{eff} = \frac{d_{eff}^2}{32}. \tag{3}$$

The algorithm for probabilistic connection of capillary layers in a porous medium has been numerically implemented, and its results have been compared with experimental data. Although the proposed methodology tends to overestimate absolute permeability, it provides a significantly more accurate representation of the porous medium than conventional capillary models. The main objective of this approach to constructing porous media models is to develop a theoretical framework that is both simple and more precise for simulating single- and multiphase filtration. The capillary model of the porous medium, built using this methodology, retains the key advantages of the classical capillary model, enabling the use of both analytical and numerical approaches in filtration studies.

References

1. **Simonov, O. A.** Review of modern models of porous media for numerical simulation of fluid flows [Text] / O. A. Simonov, Yu. Yu. Erina, A. A. Ponomarev // Heliyon. – 2023. – Vol. 9, No. 3. – P. 1–15. http://dx.doi.org/10.1016/j.heliyon.2023.e22292.