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Numerical Simulation Study on Pore Scale Seepage of Porous Media Based on Finite Volume Method

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Abstract: The numerical simulation of pore scale seepage in porous media is of great significance for the development of new energy sources, such as shale gas and geothermal energy. In the past few years, many scholars have developed the numerical method including finite volume method (FVM), Lattice Boltzmann Method (LBM) and molecular dynamics to achieve this simulation in different levels. It is easy for us to understand the basic idea of FVM, and then we can give a direct physical explanation for the above phenomena. FVM has stronger advantages in CFD (computational fluid dynamics) since the conservation law is meet in the whole computational domain. Based on the FVM, a large number of models on multi-phase flow and non-Newtonian fluid have been developed and it has showed more advantages in the aspect of solving complex pore flow problems. However, there are two shortcomings in the process of using FVM: (1) Due to the complexity of the pore geometry in the porous media and irregularly curved pore walls, the quality of the generated grid is not high; (2) It is relatively difficult to deal with a large number of pore boundaries in the porous media. To cure the above problems, a simple processing method is proposed as follows in this paper: On the one hand, in porous medium, both the penetrating space and solid frame are regarded as the fluid region, while, to describe solid boundary approximately, the viscosity of the solid skeleton structure is set to infinite. On the other hand, the whole region is discretized through the Cartesian orthogonal grid and the Immersed Boundary Method(IBM) is adopted to describe the smooth and complexed boundaries between the penetrating space and solid frame. In this paper, the proposed method stated above is conducted on OpenFOAM by the finite volume method in which the convection term is discreted in the QUICK scheme. After that, the corresponding systematic evaluations of the proposed method are performed and results illustrate that the method is of great accuracy and robustness. It can be used to study the flow in complex porous media.

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