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MODELING AND SIMULATION OF FREE FLUID OVER A POROUS MEDIUM BY MESHLESS METHOD

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In the surrounding of a boundary of a porous region with a high porosity adjacent to the free flow area, two modeling methods are known. In the first method, the Darcy filtration equation is used in the porous region while in the free flow area the Navier - Stokes equations are used. The Beavers - Joseph boundary condition is applied for the tangent component of the velocity vector between this regions [1]. In such modeling a slip constant in the boundary condition appears. In paper [1] this constant was determined in a physical experiment, however, in some papers this constant is determined in the numerical experiment. In the second modeling method, the Brinkman filtration equation is used in the porous region while in the free flow area the Navier - Stokes equations are used. The continuity of the filtration and the free flow velocity is assumed at the contact boundary of the considered areas [2]. In this modeling case, an effective viscosity in the Brinkman equation appears. Many authors assume that the effective viscosity is equal to the viscosity of the free fluid, however, there are some papers in which this viscosity is determined by numerical simulation [3].
In this paper, a combination of these two modeling approaches is proposed. For this purpose, it is assumed that in the porous area with high porosity there is a layer near the boundary in which the flow is governed by the Brinkman equation, while in the rest of the area the flow is governed by the Darcy equation. Then we consider three subareas. At the boundaries the continuity of the velocity vector is assumed. The problem in such a modeling is connected with the width of this layer and with the unknown effective viscosity. To demonstrating of the proposed new model the following numerical simulation is carried out. The longitudinal laminar flow in a parallel-plate conduit is considered. The first half of the considered region is a porous medium and the second one is a free fluid region. The porous medium is modeled as a bundle of parallel fibres arranged in a square array. Numerical simulations are conducted using the method of fundamental solutions (MFS) [4] and the special purpose Trefftz functions (SPTF).

REFERENCES

[1] G. S. Beavers and D. O. Joseph, Boundary conditionsat a naturally permeable wall, *J. Fluid Mech.*, **30**, pp. 197-207, 1967.
[2] H. C. Brinkman, A calculation of the viscous force exerted by a flowing fluid on a dense swarm of particles, *Appl. Sci. Res.*, **A 1**, pp. 27-34, 1947.
[3] J.A. Kolodziej, M. Mierzwiczak and M. Ciałkowski, Power law fluid flow through a bundle of regular fibers, *Appl. Math. Model.*, **39**, pp. 6425–6437, 2015.
[4] G. Fairweather and A. Karageorghis: The method of fundamental solutions for elliptic boundary value problems. *Adv. Comput. Math.*, **9**, pp. 69–95, 1998.