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Heat and mass transfer by natural convection in porous media due to opposing buoyancy effects with Boundary Domain Integral Method

Summary

A numerical study of double diffusive natural convection in porous media due to opposing buoyancy forces is reported, using the Boundary Domain Integral Method (BDIM). There have been several reported studies dealing with natural convection in porous media, mainly because of its importance in several industrial and technological applications. Less attention, however, has been dedicated to the so-called double diffusive problems, where density gradients occur due to the effects of combined temperature and concentration buoyancy. The current investigation is focused on the special problem, where the thermal and solutal buoyancy forces are opposing each other.

The mathematical model of fluid flow in porous media is derived from the classical Navier-Stokes equations for pure fluid considering the fact that only a part of the volume is available for the fluid flow. The equations represent the basic conservation laws for mass, momentum, energy and species, where in the momentum equation additional Brinkman viscous term is included.

The obtained set of partial differential equations is solved with use of BDIM, which is an extension of classical Boundary Element Method. To use the BDIM for the solution of the obtained set of equations, the governing equations first have to be transformed with use of velocity-vorticity formulation, which consequently separates the computational scheme into a kinematic and kinetic computational parts. In the next step all transport equations have to be written in an integral manner with use of suitable Green functions or weighted residual technique. Finally all integral equations are discretized over the solution boundary and domain and solved by obtaining suitable boundary and initial conditions.

The results for a double diffusive natural convection in a square cavity fully filled with fluid saturated porous media, where the vertical walls are maintained at different temperatures and concentrations, while the horizontal walls are adiabatic and impermeable, are presented. The case of negative sign of buoyancy coefficient N, which indicates that the thermal and solutal buoyancy force are opposing each other, is considered. The obtaind results are compared to some published studies, which prooves the accuracy of the BDIM and states that it is a good alternative to other numerical methods.