CONJUGATE NATURAL CONVECTION IN A PARTIALLY POROUS VERTICAL CYLINDER: A COMPARISON STUDY OF DIFFERENT MODELS

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Keywords: Porous medium, conjugate natural convection, Darcy-Boussinesq model, Brinkman-Boussinesq model

Section: Natural and forced convection in porous media

ABSTRACT

Natural convection in porous enclosures has many engineering applications such as electronic cooling, ceramic processing, nuclear waste management, geothermal power plants and so on. In the present investigation we attempt to simulate flow structure and heat transfer due to a convective cooling from an outside in a partially porous vertical cylinder with a fluid layer.

The composite system of interest is a porous vertical cylinder having a fluid layer with heat-conducting solid walls. The porous medium is homogeneous and isotropic. The external boundary of the bottom wall is supposed to be adiabatic. The convective heat exchange with an environment is modeled on other external borders of solid walls. An environmental temperature is supposed to be less than an initial temperature of the domain of interest. The porous medium is considered to be in local thermal equilibrium with the fluid. The natural convection in the cylinder is considered to be laminar and unsteady. The thermophysical properties of the fluid, porous material and solid walls are taken to be constant except for the density variation in the buoyancy force, which is treated by using the Boussinesq approximation. The unsteady equations for the porous medium and fluid layer, in dimensionless terms of the stream function, vorticity and temperature, within the Darcy-Boussinesq and the Brinkman-Boussinesq approaches for the porous medium and the transient heat conduction equation for the solid walls have been solved by a finite difference method. Particular efforts have been focused on the effects of the Rayleigh, Darcy and Biot numbers, the thermal conductivity ratio, the thickness of solid walls, the size of fluid layer and the dimensionless time on the flow regimes and heat transfer.

This work was supported by the Russian Foundation for Basic Research (grant No. 11-08-00490-a) and by the Grants Council (under the President of the Russian Federation), grant No. MK - 5652.2012.8.