NUMERICAL SIMULATION OF 3D UNSTEADY NATURAL CONVECTION IN A POROUS ENCLOSURE HAVING FINITE THICKNESS WALLS

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ABSTRACT

Natural convection in porous media has received growing attention due to the practical importance of phenomenon in various industrial and environmental applications including geothermal systems and petroleum reservoirs, high-performance building insulations, cooling of electronic devices, etc. The purpose of the present work is a numerical simulation of 3D unsteady natural convection in a porous enclosure having heat-conducting solid walls of finite thickness and a local heat source of constant temperature at the bottom of the cavity in conditions of a convective heat exchange with an environment.

The domain of interest is a three-dimensional cubic cavity with heat-conducting solid walls of finite thickness filled with a porous material and saturated with a Newtonian incompressible fluid. The porous medium is homogeneous and isotropic. The heat source of constant temperature is located on the bottom wall of the cavity. The external surface of the bottom wall is supposed to be adiabatic. The convective heat exchange with an environment is modeled on other external surfaces of solid walls. The natural convection in the cavity is considered to be three-dimensional, laminar and unsteady while the heat conduction in the solid walls is assumed to be transient and three-dimensional. The porous medium is considered to be in local thermal equilibrium with the fluid. 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 three-dimensional equations for the porous medium, in terms of the temperature – vector potential functions, within the Darcy-Boussinesq approach and the transient three-dimensional heat conduction equation based on the Fourier hypothesis for the solid walls with corresponding initial and boundary conditions have been solved by a finite difference method. Particular efforts have been focused on the effects of the Rayleigh and Darcy numbers, the thermal conductivity ratio, the thickness of solid walls and the dimensionless time on the flow regimes and heat transfer. Comprehensive Nusselt numbers data are presented as functions of the governing parameters mentioned above.

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