A STABILIZED VOLUME-AVERAGING FINITE ELEMENT METHOD FOR FLOW IN POROUS MEDIA AND BINARY ALLOY SOLIDIFICATION SYSTEMS

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A stabilized equal-order velocity-pressure finite element algorithm is presented for the analysis of flow in porous media and in the solidification of binary alloys. The adopted governing macroscopic conservation equations of momentum, energy and species transport are derived from their microscopic counterparts using the volume-averaging method. The analysis is performed in a single-domain with a fixed numerical grid. The fluid flow scheme developed includes SUPG (streamline-upwind/Petrov-Galerkin) and PSPG (pressure stabilizing/Petrov-Galerkin) stabilization terms as well as a stabilization term for Darcy flow terms in variable porosity media. For the energy and species equations a classical SUPG-based finite element method is employed. The developed algorithms are tested with classical problems in natural and double diffusive convection in porous media and compared with results obtained from an implementation of the fractional step finite element algorithm. The developed stabilized FEM model is finally tested in the simulation of directional binary-alloy solidification processes with an example of high Rayleigh number melt flow.