DEVELOPMENT OF A NUMERICAL SOLVER FOR PHASE-CHANGE AND TWO-PHASE FLOW IN POROUS MEDIA

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ABSTRACT

Porous media are used in several thermal management systems, such as loop-heat-pipes, to control the temperature of electronics and other components. It is important to understand the mechanisms of flow and phase-change in porous media to better control/increase the performance of those systems. In this work, we develop a unique computational fluid dynamics (CFD) solver in the object-oriented OpenFOAM architecture that can simulate most of all the relevant physics of flow and phase-change in porous media. Available commercial and open-source solvers lack many of the capabilities to simulate important characteristics of flow and phase-change in porous media. The developed solver is based on a flow solver in which the IMPES (Implicit Pressure, Explicit Saturations) method is employed to solve the pressure and saturation equations due to the nonlinearity of the capillary and relative permeability models. The solver is then modified to include the energy equation and phase-change models (empirical and interface equilibrium models) that can simulate temperature and phase-change, respectively. Hydrodynamic and thermal coupling of flow and phase change in porous media is complex numerically, and, this complexity is achieved in the present study by coupling between all the governing equations and the phase-change models using the VOF (Volume of Fluid) approach. Different effective thermal conductivity models are implemented to calculate an effective thermal conductivity between the three phases (solid, liquid, and vapor) in every cell. The solver also uses temperature-dependent properties for density, thermal conductivity, and viscosity. The results obtained from this solver are compared with a one-dimension semi-analytical solution to validate the solver. Results from flow and phase-change simulations in the porous media of a loop heat pipe will also be presented.