Numerical Computation of Two-Phase Flow in Porous Media

D. Droste[1], F. Lindner[1], C. Mundt[1], M. Pfitzner[1]

[1]Universität der Bundeswehr, Munich, Bavaria, Germany

Abstract

In this work we analyze the multiphase flow within a porous evaporator for a burner with small thermal output. The fuel for the combustion is injected in a liquid state and evaporates during its way through the pore network. This problem is described by two-phase flow with phase change in a macroscopic domain. Dominant forces are capillary interactions and two-phase heat conduction. As an oxidizer is absent, there are no chemical reactions within the porous medium.
In this study we implement a Multiphase Mixture Model (MMM) for flow and heat transfer in COMSOL Multiphysics®. For this approach we are using Darcy's Law and PDE interfaces.
We show two approaches of implementing the conservation of energy: using local thermal equilibrium and non-equilibrium. Local thermal equilibrium assumes equality of local fluid and solid temperatures within the porous medium. Assuming constant fluid temperature during evaporation, this obviously introduces an artificial thermal isolation in the porous domain. This model shows promising results, but its applicability is very limited.
The second approach using local thermal non-equilibrium expands the model by allowing for different temperatures of solid and fluid. Because of the phase change there are strong jumps in the coefficients for the energy equation, which may cause numerical problems. We use a form of smoothing to stabilize the convergence of the solution. The influence of smoothing on convergence and on the results is discussed.
The implemented model is verified by a MATLAB® model based on Finite Volumes and is compared to the literature. Variations of mass flux, heat flux and the material are discussed.