Equilibrium Assumptions in Multiphase Flow Revisited

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Motivation

Thermodynamic Equilibrium in Multiphase Flow

\[ x_{n, \text{equil}} = x_{n, \text{emul}}(p_n, T) \]

\[ T_R = T_m = T_s \]

Modelling Non-Equilibrium

- Limits of thermodynamic equilibrium assumption → confidence in existing models
- Being able to model situation of clear non-equilibrium → extending range of applicability

Thin Porous media / High Flow Velocities

High Temperature Gradients

Results

Energy Balance Equations

\[ \frac{\partial (\rho c_p S_n \alpha_n \rho_n \bar{u}_n)}{\partial \alpha_n} + \nabla \left( \alpha_n \rho c_p \nabla T_n \right) = \]

\[ - \nabla \cdot \left( \rho \nabla T_n \right) - \nabla \cdot \left( \rho c_p \nabla T_n \right) \]

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\[ - \nabla \cdot \left( \rho \nabla T_n \right) - \nabla \cdot \left( \rho c_p \nabla T_n \right) \]

Future Work

Micro Model Experiment

- Invasion process in Micro Model
- Temperature distribution via Infrared Camera
- Calibration / validation of the model

Scenarios

- Up to now rather academic examples have been simulated.
- Ideas for more realistic setting welcomed!

Sensitivity Analysis

- Many new parameters are in the model
- How to find out which one needs most attention?

Indicators

- It would be nice to know when a model is leaving its range of validity
- As little limitations / assumptions should go into the development of these indicators

Figure 1: Drying of paper (left) thermally enhanced remediation (right)

Figure 2: Capillary pressure - saturation relationship (left), capillary pressure - saturation - interfacial area relationship (right)

Figure 3: Sketch of the simulation setup (top), Temperature distributions for slow (middle, left) and fast (middle, right) injection, Reynolds number on boundary versus temperature difference (bottom)

Figure 4: Micro Model (top) and two invasion stages (bottom)

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