

Conjugated Heat Transfer Simulation of the Discharging Process of a Metal-based High-Temperature Latent Heat Thermal Energy Storage Test Bench with Direct Evaporation

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Motivation

Within the scope of the joint project »TheMatIK« (Thermische Speichermaterialien zur Flexibilisierung von industriellen Kraftwerken), options of integrating latent heat thermal energy storages (LHTES) into industrial power plants for the use of process steam production are investigated. A LHTES with the ability of direct evaporation has been designed and down-scaled to test bench scale.

	Charging	Discharging
Temperature (K)	683.15	569.15
Pressure (bar)	55	43
Duration (h)	48	0.33

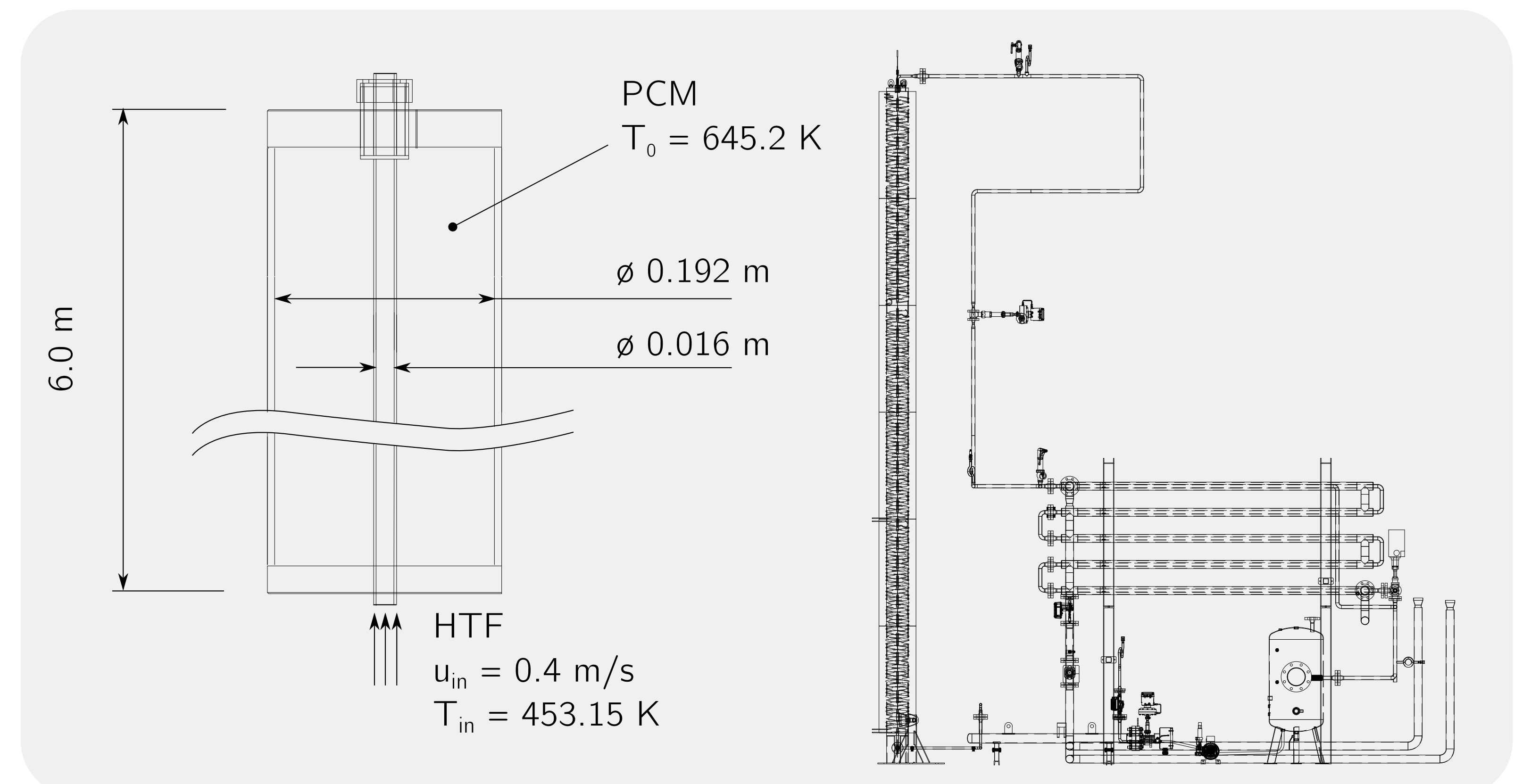
LHTES design goals

Phase change temperature (K)	645.15
Latent heat of fusion (kJ/kg)	120
Density (kg/m ³)	6870
Thermal conductivity (W/m-K)	130

Thermophysical properties of ZnAl6

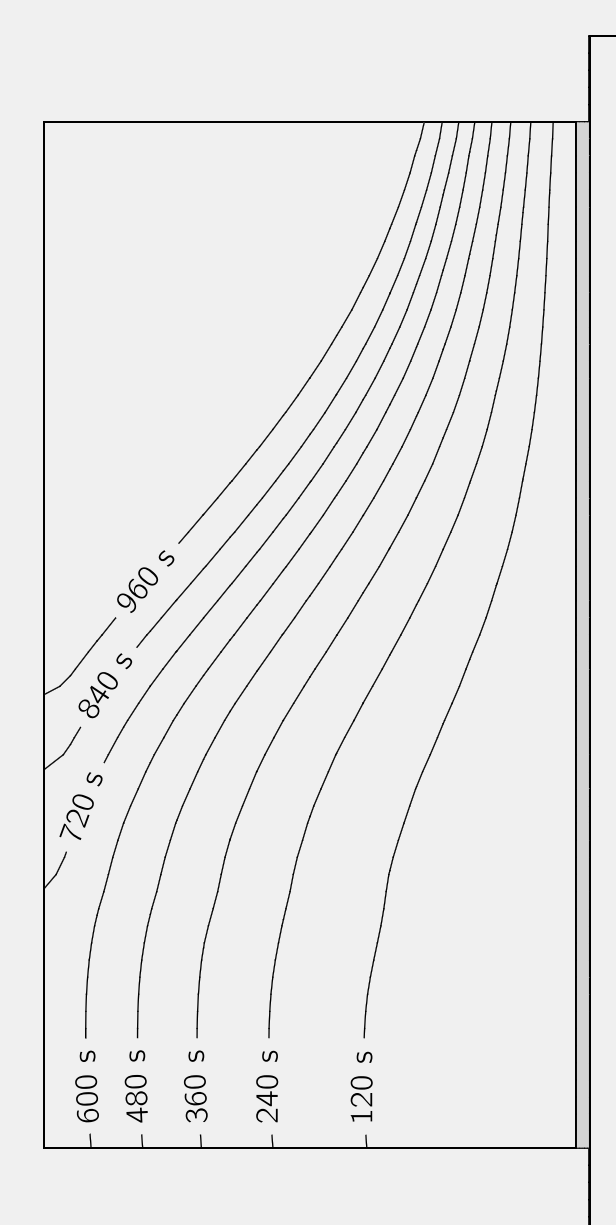
Methodology

The melting/freezing in the PCM is described by a Navier-Stokes solver with an enthalpy-porosity method; heat conduction in the HTF pipe wall is modeled by a Laplace equation solver; the flow of the HTF is computed by an Euler-Euler multiphase solver with interfacial exchange terms for evaporation/condensation. The solvers are coupled by a sequential mechanism with Robin-Robin interface conditions, consistent mapping and sub-cycling. The model is implemented in the open-source FVM library OpenFOAM®. The time steps are determined adaptively to meet a Courant number of 0.2; the simulation is run for 1000 s. Second-order spatial discretization is utilized, while temporal terms are discretized by backward Euler schemes.



Test bench layout

Results and Outlook



- New (and first?) model for CHT simulations of a LHTES with direct evaporation has been implemented, first tests were carried out
- First results show that the down-scaled LHTES supplies slightly superheated steam during desired discharging duration
- Validation experiments
- Grid convergence
- Scale-up

