Exergy Analysis of a Water Heat Storage Tank

Frank Dammel[1], Jella Winterling[1], Kay-Jochen Langeheinecke[2], Peter Stephan[3]

[1]Institute of Technical Thermodynamics, Technische Universität Darmstadt, Germany.

[2]IAV GmbH, Rockwellstr. 16, D-38518 Gifhorn, Germany.

[3]Institute of Technical Thermodynamics / Center of Smart Interfaces, Technische Universität Darmstadt, Germany.

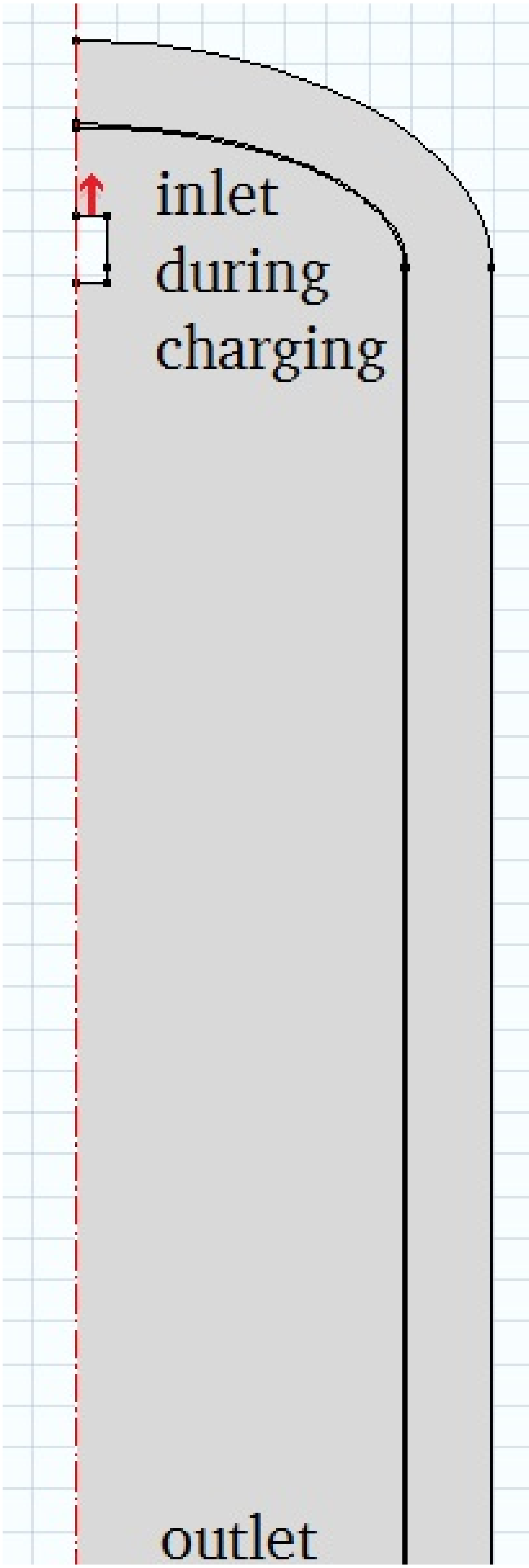
Abstract

A decentral combined heat and power (CHP) plant generates both electricity and useful heat. The overall efficiency is higher than for conventional power plants, which release the excess heat to the environment. A CHP plant should preferably run during times with a high demand for electricity. However, there is not necessarily also a demand for heat simultaneously. A heat storage tank enables a decoupling of electricity and heat delivery. In this study a cylindrical hot water storage tank with a volume of 934 liter is considered. Charging, holding time and discharging are numerically simulated applying COMSOL Multiphysics 4.2. The Navier-Stokes equations and the energy equation are solved in a time-dependent study in axi-symmetric cylindrical coordinates. The performance of the heat storage is evaluated by an exergy analysis. Exergy is the work potential of a given amount of energy and thus the "valuable fraction" of energy. During irreversible processes such as the mixing of hot and cold water during charging of the heat storage tank or heat conduction during the holding time the amount of exergy is reduced. In order to investigate the contribution of thermal conduction in the tank wall and heat loss to the environment on the exergy loss, three different simulations were carried out:

A) model without wall, adiabatic to the environment;
B) model including wall, adiabatic to the environment;
C) model including wall, heat transfer to environment considered.

During charging the influence of both heat conduction in the wall and heat losses to the environment is almost negligible, and the exergy loss is between 2.7% (A) and 4% (C). Figure 3 shows that the exergy loss during holding time is higher when the wall is included in the model (B) and considerably higher when additionally heat losses to the environment (C) are accounted for. Additionally, the mass flow rate, the inlet temperature and the inlet tube geometry were varied. The influence on the exergy loss of all three factors is rather small.

Figures used in the abstract


inlet
during
charging
outlet

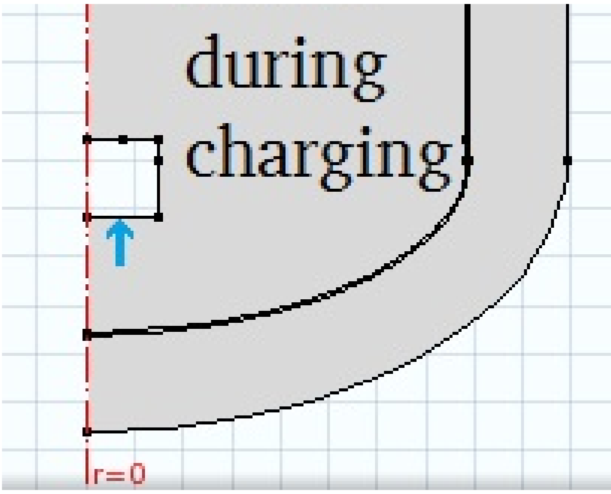


Figure 1: Model

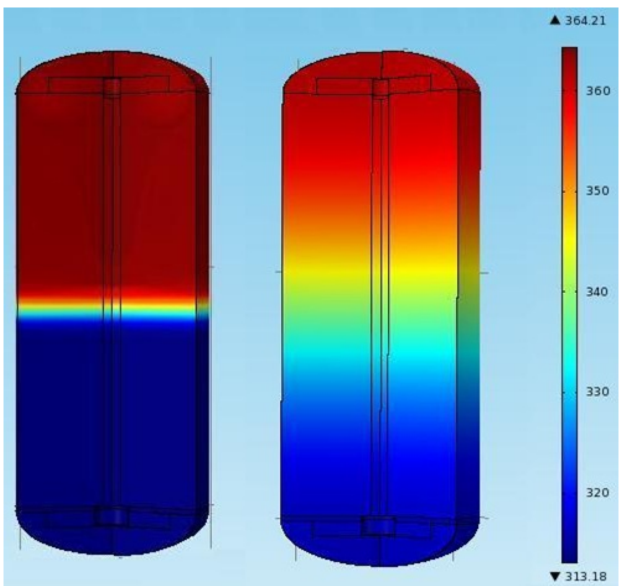


Figure 2: Temperature distribution in [K] immediately after charging (left) and after 10 days holding time (right)

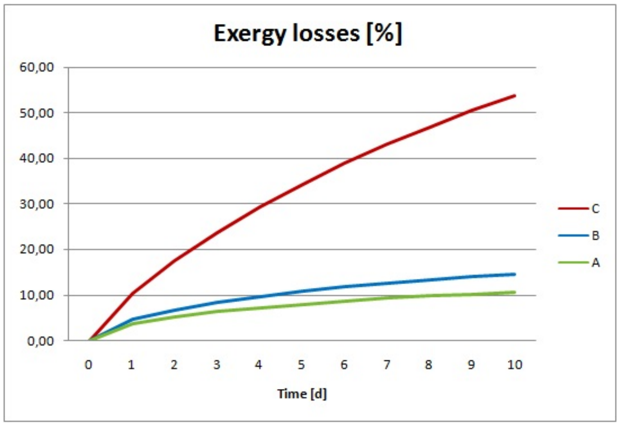


Figure 3: Time history of exergy loss for models A, B and C during holding time