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L-III | Development of Economic Electric Swing Adsorption Processes

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Electric Swing Adsorption (ESA) is a promising technology for dynamic and energy efficient separation of high adsorption enthalpy molecules. Compared to the common temperature swing adsorption it enables the individual adjustment of heat flow and purge gas flow. For economic application it is important to operate ESA plants with commercially available and cheap adsorbents like granular or pelletized activated carbon. These investigations have been carried out by simulation and experiments.

MODELLING AND SIMULATION OF AN ELECTRIC HEATING EXPERIMENT

A thermodynamic model for the ESA was developed considering e.g. the heat balance and the nitrogen flow through the vessel. The model was used to calculate the temperature distribution for the whole apparatus regarding the substantial temperature effects e.g. natural convection on the outside of the vessel, electrical heating and heat conduction.
The model relies on real property data and the real geometry of the vessel. The result of the stationary simulation is the shown temperature distribution (see figure 1, a). The results are within the range of expectations.
To compare the simulation results (figure 1, b) with the measurement data five measuring points were defined. The results are in agreement with the measured temperatures but show certain deviations. It is assumed that these deviations occur due to inhomogeneities in the activated carbon bed. Additionally, the electrical and thermal properties of the fixed bed are assumed to change during the measurement (see figure 2).

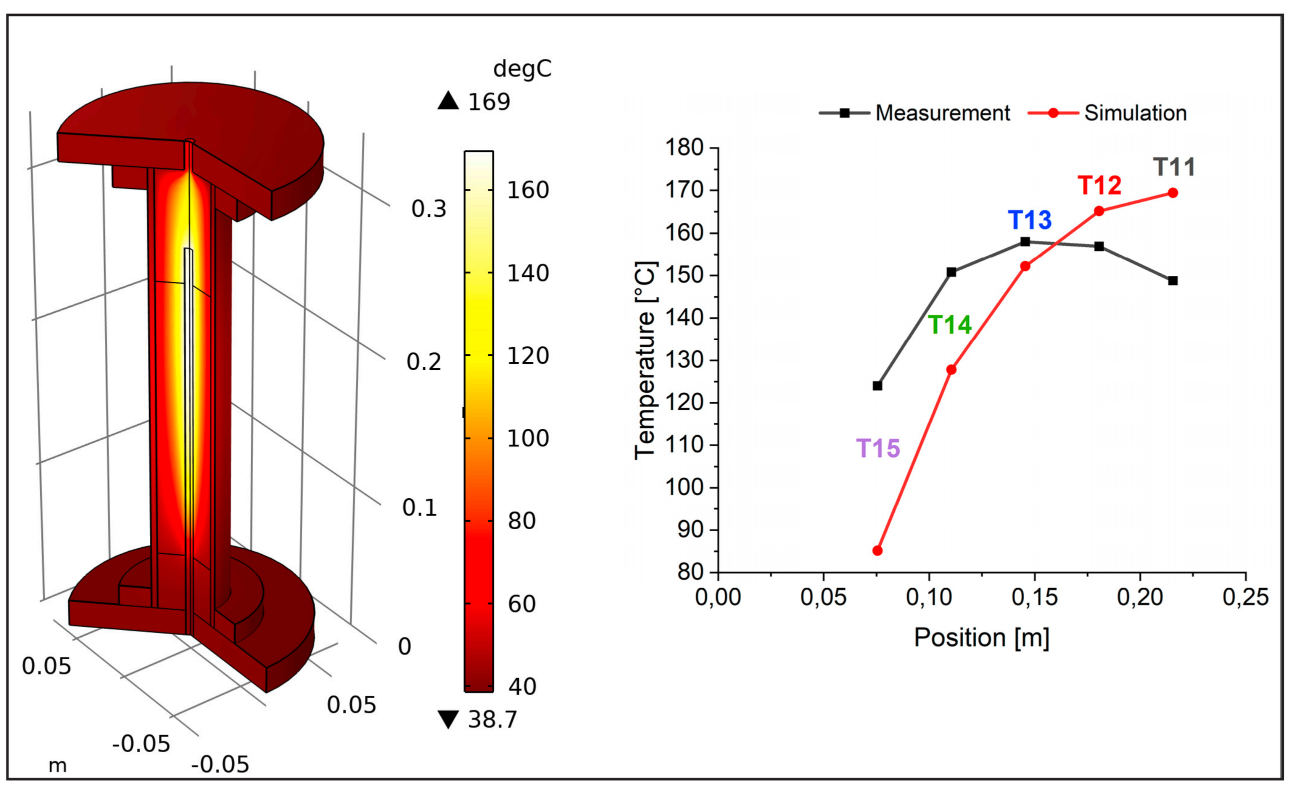

Fig. 1: a) Simulated temperature distribution of the whole setup considering e.g. natural convection, electrical heating, gas flow and material properties.
b) Simulated stationary temperatures at the measuring points (see also figure 2, T11 – T15) compared with the measurement data.

INFLUENCE OF PARTICLE SIZE ON TEMPERATURE DISTRIBUTION

The development of a different electrode concept compared to the axial electrical current flow was the key to a homogeneous temperature distribution in the adsorber vessels filled with activated carbon. The setup was changed to a radial current flow with a centric inner electrode and a coaxial outer electrode near the wall of the adsorber vessel.
Experimental investigations showed that the particle size has an impact on the axial temperature distribution measured at axis of rotation at 5 different height in the fixed bed.

Figure 2 shows the temperature distribution for the four particle sizes which has been tested in the setup. For all tests the controller setpoint was 150 °C for the average bed temperature.The graphs show that with smaller particles the temperatures are more stable and homogeneous.

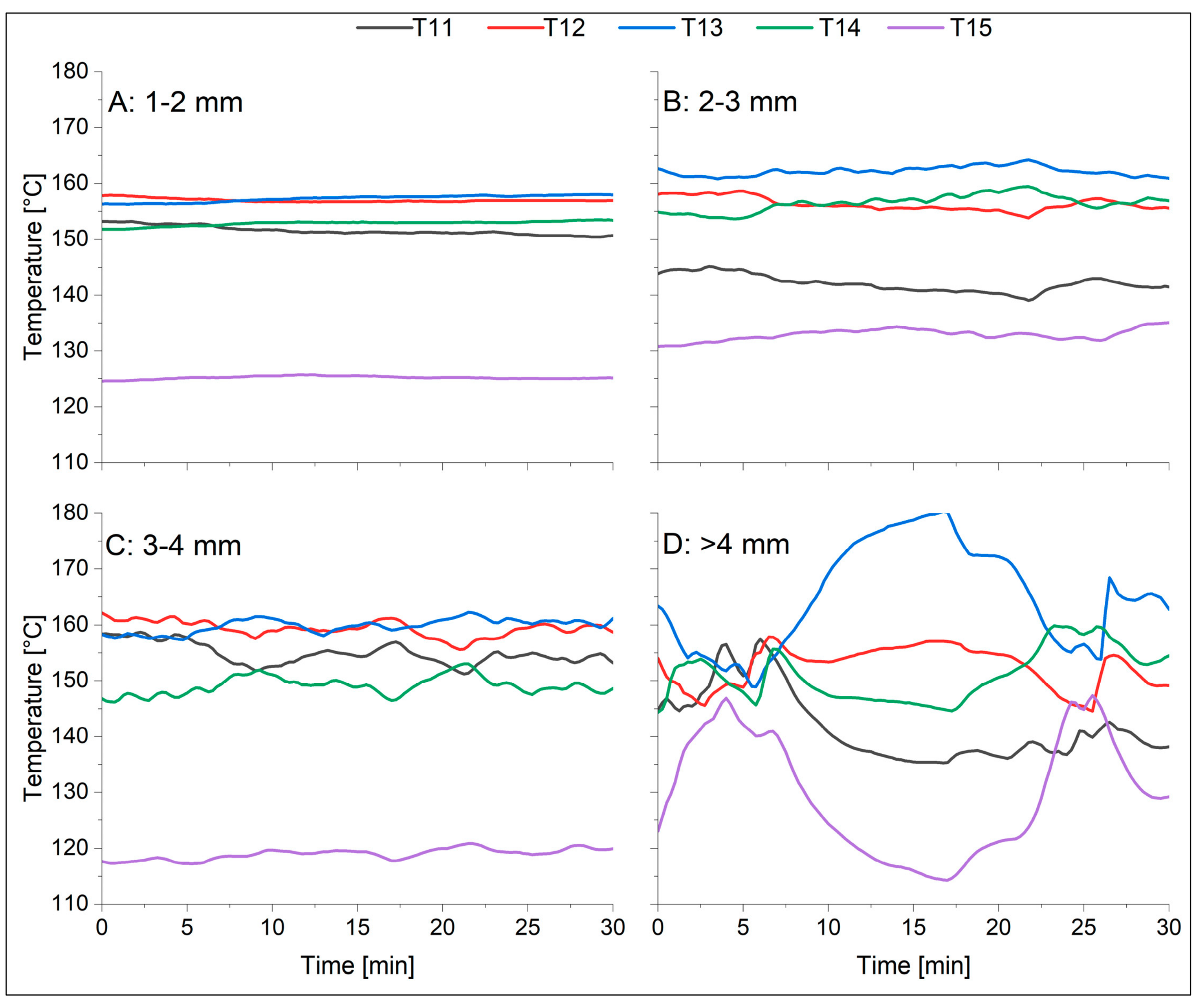

Fig. 2: Temperature distribution of the four particle sizes (A-D) during heating experiments (T11: top; T15 bottom).

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