Modelling an Adsorption Process in a Shell and Tube Heat Exchanger Type Adsorber

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Introduction: Mitigation of CO₂ emissions from the combustion of fossil fuels by temperature swing adsorption is known from literature¹. A novel approach for capturing CO₂ is using indirect heated adsorbers with heat integration and heat recovery strategies.

Computational Methods: A 2D model (Adsorber tube) and a 1D model (heat exchange fluid) were coupled using COMSOL Multiphysics®. Multiple cycles were simulated using the LiveLink™ for Matlab® in order to reach cyclic steady state.

Results: The simulated flue gas consists of 15 vol% CO₂ and 85 vol% N₂. Using heat integration and heat recovery strategies a specific energy consumption of ~ 3.6 MJ/kg_CO₂ with a CO₂ recovery of ~ 90% is obtained using the given geometry.

Conclusion: An indirect heated adsorber is modelled and simulated. The first results regarding the energetic requirements are still higher than the reference process (amine wash) but a reduction of the energetic requirement by optimization is expected. The results have to be validated with experimental data.

References

Fig. 1: Schematic representation of a shell and tube heat exchanger type adsorber

Fig. 2: Model and physics used in COMSOL Multiphysics®

Fig. 3: Temperature profile of heat exchange fluid

Fig. 4: Specific energy requirement

Fig. 5: CO₂ recovery

Fig. 6: CO₂ purity