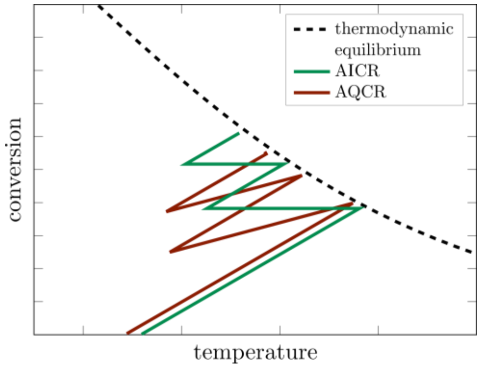
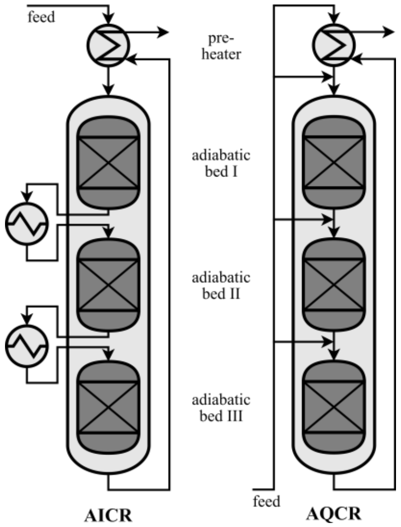
TU Clausthal

Dynamic Modeling and Optimization of an Ammonia Synthesis Reactor (English / German)

As the share of renewables is consistently increasing, **Power-to-X concepts** for converting renewable electricity into **chemical energy carriers** are gaining growing importance. **Ammonia** is considered a particularly promising energy carrier, as it is carbon-free and can be stored and transported under significantly milder conditions than hydrogen. Consequently, a **load-flexible ammonia synthesis** capable of accommodating the fluctuating availability of renewable energy sources represents a key component of future energy systems.



Due to its central role in fertilizer production, ammonia is already one of the most important industrial chemicals worldwide and has been produced for decades on a large scale under steady-state conditions using the HABER–BOSCH process. The synthesis is typically carried out in **adiabatic multi-bed reactors with intermediate cooling**. As a result of the released reaction heat, the temperature in the first bed increases significantly, causing the reaction path in the temperature–conversion diagram to rapidly approach thermodynamic equilibrium. By applying intermediate cooling between the beds, the temperature is reduced, allowing the reaction to proceed in the subsequent bed with renewed driving force.



Achieving **load-flexible operation** requires a **detailed understanding of the reactor's dynamic behavior**. Therefore, the objective of this thesis is to **develop a dynamic model of an ammonia synthesis reactor with intermediate cooling**. The intermediate cooling may be implemented either indirectly via heat exchangers or directly by quenching through the addition of cold reactants. Based on the developed model, temperature and conversion profiles as well as the impact of intermediate cooling on the dynamic operating behavior will be systematically investigated, analyzed, and, where appropriate, optimized. **The exact scope of the work can be adapted to the your individual interests**.

Type of thesis: Bachelor's / Master's thesis

Start of work: Immediately, by arrangement

Method: theoretical

Location: ICVT, Clausthal-Zellerfeld

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