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L-III | Gas Purification with Electric Swing Adsorption

ESA on a laboratory scale with GC system to measure minor components.

Background

Within the Carbon2Chem® joint project, technologies are being developed to reduce CO_2 emissions at large industrial sites by using gases with CO and CO_2 as a source of raw materials for the chemical industry.

The focus lies on forming cross-industrial value cycles and increasing energy efficiency by establishing cross-industrial networks for a climate-neutral production.

This will be shown using the steel production location Duisburg in North Rhine-Westphalia as an example.

Objective

Subproject L-III aims to develop and experimentally test concepts to purify and prepare steel mill gases for the planned downstream chemical syntheses.

The ability of Electric Swing Adsorption (ESA) to efficiently provide high temperatures for desorption should be used as part of the project to separate high-boiling hydrocarbons from coke oven gas and separate CO und CO_2 from gas flows containing nitrogen. Suitable adsorbents should be developed for this and tested on a laboratory scale as well as transferring the processes on a pilot-plant scale.

> "It is not possible to use gas flows containing CO_2 from a steelworks without suitable gas treatment."
>
> Dr.-Ing. Barbara Zeidler-Fandrich
> Head of the Carbon2Chem®-subproject "Synthesis Gas"

Carbon2Chem®

Tasks

Temperature swing adsorption processes are used as standard when regenerating adsorbents with the occurrence of high adsorption enthalpies. Thermal regeneration can take place in various ways: Compared to indirect heating of the adsorber bed (rinsing with hot gas, heating jacket), direct heating using electricity (Electric Swing Adsorption plant) can be significantly more efficient than conventional heating.

Advantages:

- High energy efficiency
- High process dynamics
- Use of electricity from renewable energy sources

Working points:

- Commissioning of the pilot plant station system to examine real gases
- Adsorbent development and testing
- Indicative tests in the laboratory
- Transfer of the results on a pilot-plant scale
- Simulation and model development for the ESA based on the experimental results

Milestones

- Operation of the laboratory facility with extensive GC analytics, particularly for minor components containing sulfur and nitrogen
- Planning, procurement and construction of a basic pilot plant station system
- Commissioning of apparatus to analyze chemisorption in the laboratory
- Development and in-depth examination of different electrode and adsorber designs
- Identification of suitable adsorbents to separate high-boiling components from synthetic coke oven gas and "proof of principle"
- Development of a multi-scale model to simulate the ESA process
- Implementation of methods to take into account competitive adsorption within a complex gas mixture
- Consideration of real effects in multi-component adsorption

Project duration

The green light for the Carbon2Chem® project was given on March 15, 2016. In the second project phase (start: June 1, 2020, duration: 4 years), the pilot plant station system is first being modified according to the special demands of real gases so that the results from the first project phase on the separation of higher hydrocarbons can be transferred on a pilot-plant scale.

At the same time, the separation of CO_2 and CO from gases containing nitrogen is also being investigated. Adsorbents are being developed and tested for this. Promising adsorbents should then be transferred on a pilot-plant scale, where the achieved results are validated with regard to the characteristics of the real gases.

Further information

Other project partners in L-III

- Linde GmbH (coordination)
- thyssenkrupp AG
- Clariant Produkte GmbH
- Ruhr University of Bochum

Project website
www.umsicht.fraunhofer.de/carbon-cycle

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