Pilot scale demonstration of solid sorbent CO₂ capture technology at a biomass power station

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Abstract

The availability of cost efficient CO₂ capture technologies remains to be one of the main challenges for successful implementation of CCS. In the recent years, adsorption based post combustion CO₂ capture technologies have been highlighted as promising alternative to already existing technologies as they have a great potential to lead to significant cost reductions in the CO₂ capture step. Adsorption processes utilize solid sorbent materials that have the capability to selectively adsorb CO₂ from flue gas streams and that can subsequently be regenerated, preferably in a temperature swing operating mode. In the past years, significant effort has been put into the development of suitable solid sorbent materials, while on the other hand only little work has been dedicated to the development of suitable reactor designs and into process demonstration.

In a joint effort, Shell and TU Wien elaborated a design of a continuous solid sorbent temperature swing adsorption (TSA) process that consists of interconnected multi-stage fluidized bed columns. In 2013, the feasibility of the process design was successfully demonstrated in a fully integrated TSA bench scale unit. Moreover, the process was extensively studied and further optimized in several hundreds hours of operation which helped to identify the key challenges for further process scale up. In 2015, the collaborative research project ViennaGreenCO₂ was started which aims to scale up and demonstrate the considered TSA CO₂ capture process at pilot scale. Since then, efforts from individual work packages were taken to de-risk the main challenges the come along with scale up of the technology and have led to the detail design of the TSA pilot unit that should be presented in this work.

The TSA pilot unit is located in Vienna/Austria at the power plant site of the regional power supply company Wien Energie. The TSA pilot plant treats a flue gas slip stream from a 60 MWth biomass CHP and is designed for a total capacity of 1 tonnes of CO₂ captured per day at a target CO₂ capture efficiency of 90%*. An offgas recycle stream from the pilot unit provides that the CO₂ concentration in the adsorber feed gas can be adjusted from below 4 %-Vol. to up to 15 %-Vol. Furthermore, steam from the auxiliary steam system of the host site is used as stripping agent and heating medium in the desorber of the TSA pilot unit. Both, the adsorber and the desorber consist of five individual fluidized bed stages that are equipped with in-bed heat exchangers to keep control of the desired operating temperatures. The planned experimental campaign will be used to validate previously developed process simulation tools and to further optimize key performance parameters such as the overall process energy demand or the adsorber pressure drop.

The TSA pilot unit is currently under construction and is planned to be operational in the first half of 2018. This work will thus also present first results and findings from experiments conducted in the summer of 2018.
* The scale up of the technology to commercial scale is discussed in a separate paper “Process Development for large scale solid sorbent post combustion CO₂ capture technology for application to natural gas fired power stations” by Sander van Paasen, Anjana Bhalodi, Katerina Grigoriadou, Melina Infantino, Jolinde van de Graaf