Impact of transient operation on amine emissions at the Niederaussem capture plant.

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Abstract

The chemical absorption of CO₂ with amines is a widely studied field in the carbon capture, utilization and storage (CCUS) process. In particular, monoethanolamine (MEA) is one of the most studied solvents and is conventionally used as a benchmark for comparison with other capture processes.

Nonetheless, depending on the operating conditions, trace amounts of MEA can be released to the environment because of its volatility at typical temperatures in the water wash section at the head of the absorber. This is relevant in scenarios where capture plants are integrated into power plants and industrial plants with flexible operation, which will most certainly be required and has also been identified as a source of additional revenue. Moreover, a clear understanding of emission behaviour is needed at all operating conditions including transient operation. Several authors have studied the volatility in steady state, however it had been concluded that an accurate dynamic emissions model validated with capture plant experimental data is still necessary [1]. Although dynamic models validated with pilot plant data have been developed [2-4], there is a lack of focus on the emissions and, in most cases, the volatility of the amine is not considered.

The aim of this work is to develop an emission model for MEA during transient operation to identify the high emissions scenarios and further develop strategies to avoid them. To do so, firstly, the main characteristics and parameters that could affect the MEA concentration in the flue gas, have been identified in a steady state simulation using the commercial software package Aspen Plus®. The focus of the study is illustrated in Figure 1 for a typical capture plant. It is shown that at steady state, the temperature profile in the absorber and the water wash and the amine loading are directly related to the emissions. Moreover, these temperature profiles are linked to the inlet flow and temperatures of the streams involved. Evidence of this has also been seen experimentally in steady state at the Esbjerg pilot plant [5]. The development of the dynamic model is based on the in-house developed code for differential mass and energy balances over time using the mathematical software MATLAB®. Solvent physical and chemical properties are retrieved from Aspen Plus®, and have been validated against the steady state performance of the solvent for over 3000 hours of operation at RWE’s Coal Innovation Centre in Niederaussem.
The validation of the model will be based on step perturbations in the parameters related to the inlet streams of the absorber and the water wash section. The inlet temperatures, the loading of the lean solvent, the CO\(_2\) and impurities concentration and the temperature of the recirculation water of the water wash section are varied during transient operations at the Niederaussem pilot plant and compared to the predictions of the model. The results help to obtain a better understanding of the MEA emissions in off-design operating conditions and, therefore, help in preventing them.

Furthermore, this work can be extended by including ammonia emissions adding more solvents to the study, such as CESAR-1 [6], to enable solvent comparisons. In addition, more scenarios would also be added to study the impact of other relevant off-design operations.

**Keywords:** CO\(_2\) capture, MEA, emissions, Dynamic modelling, Pilot plant, Dynamic validation Dynamics.

**Acknowledgements**

ACT ALIGN CCUS Project No 271501

This project has received funding from RVO (NL), FZJ/PtJ(DE), Gassnova(NO), UEFISCDI (RO), BEIS (UK) and is cofounded by the European Commission under the Horizon 2020 programme ACT, Grant Agreement No 691712

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**Figure 1. Illustration of a typical pilot plant for the carbon absorption and focus of the dynamic study**
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