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VALIDATION OF PROCESS SIMULATOR WITH NEW PLANT DATA FOR MEA AND CESAR1

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1. Introduction

Carbon capture and storage (CCS) is acknowledged as a necessary tool to support the energy transition and achieve carbon neutrality [1], [2]. Chemical absorption using amine-based solvents is the state-of-the-art process for post-combustion CO_2 capture with several plants under operation. Process simulators are often used to design, simulate and optimize such plants. In this work, the commercial process simulator ProTreat® is used to simulate data points obtained in 3 different plants, namely: (i) TNO's mini plant I and (ii) II both using 30wt% MEA and (iii) RWE pilot plant using CESAR1. Although the plants studied in this work have different characteristics as shown in Table 1, they share the same basic absorption-desorption loop shown in Figure 1.

Table 1: Studied plant's data.

		TNO mini plant I	TNO mini plant II	RWE pilot
Absorber				
Packing type	-	Sulzer BX SS	Sulzer BX SS	Confidential
Packing height	m	4.30	4.25	(4x) 4.5
Diameter	m	0.045	0.045	0.60
Inter cooler		No	No	Yes
Stripper				
Packing type	-	Sulzer BX SS	Sulzer BX SS	IR40
Packing height	m	2.04	1.53	(2x) 5
Diameter	m	0.045	0.045	0.45
Absorber water wash				
Packing type	-	N/A	Sulzer BX SS	Confidential
Packing height	m	N/A	1.53	3
Diameter	m	N/A	0.045	0.60

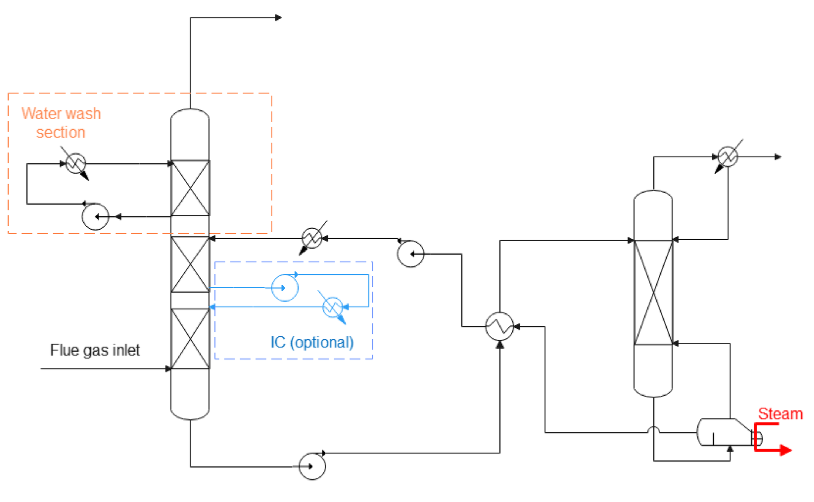

Figure 1: Simplified flow diagram from a typical CO_2 capture plant.

2. Methodology

In total 16 experimental runs were validated: 7 from TNO mini plant I, 4 from TNO mini plant II and 5 from RWE pilot plant. The simulations were performed considering every plant characteristic. The direct contact cooler was not modelled in this work, and the absorber gas inlet input was taken at the corresponding gas conditions. For the cross-heat exchanger, the rich outlet temperature was set.

3. Results

The mass balance check was performed for all experimental runs. The CO_2 produced was calculated via both the gas and liquid phases. The mass balance calculated from RWE agrees within 1% deviation. For TNO's mini plants the deviations are somewhat higher. However, as shown in Figure 2, most of the results agree within 20% deviation (dashed lines) which is acceptable for small pilot plants. Given the small size of the pipes, heat losses are practically unavoidable which could lead to e.g. condensation, thus affecting measurements (e.g., gas flow rate).

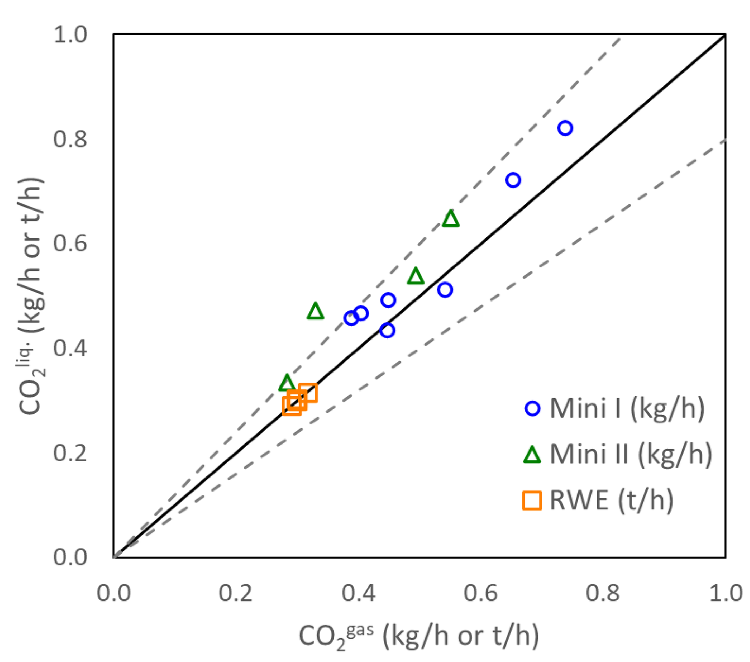

Figure 2: Mass balance check for the experimental runs. Solid line (y=x), Dashed lines: ±20%.

This could explain why, in general, the results from the mini plants seem to predict a higher CO_2 production from the liquid phase. The ratio between calculated and experimental measurements are shown in Figure 3, for the RWE campaign, and in Figure 4 for TNO mini plants. Good agreement is seen for the calculated variables.

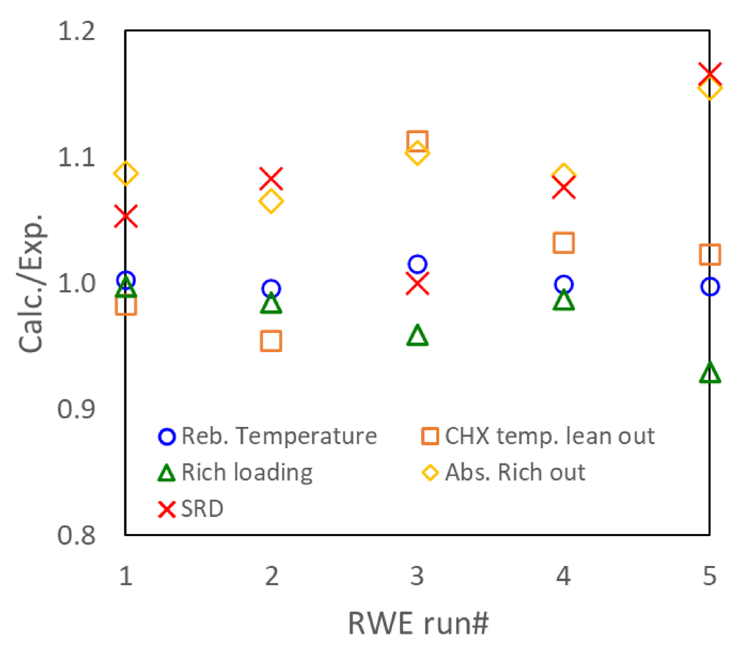

Figure 3: RWE pilot plant simulation results for CESAR1.

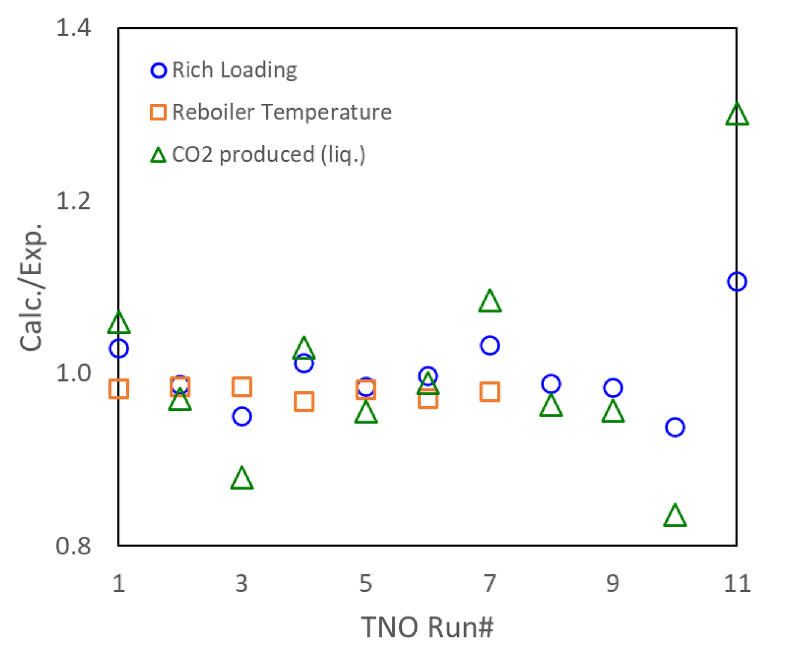

Figure 4: TNO mini plants simulation results for 30 wt.% MEA

The temperature profile of selected runs are given in Figure 5, for RWE and 6, for TNO miniplants. The simulation was able to capture the profile of the absorber temperature with reasonable accuracy.

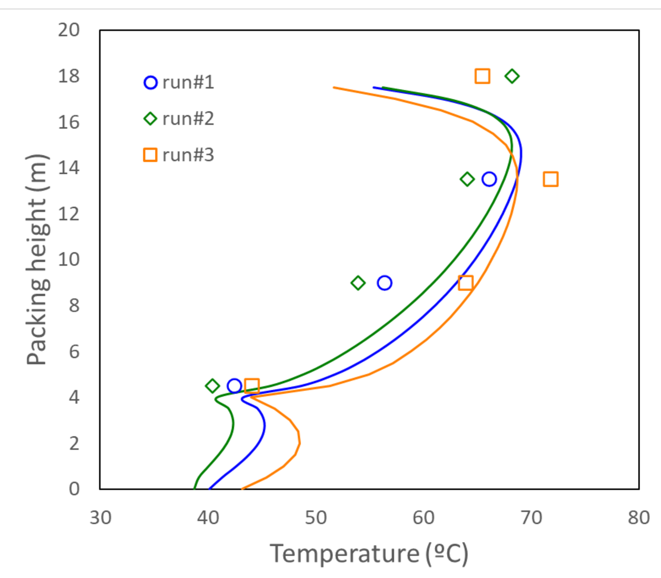

Figure 5: Absorber temperature profile for runs 1, 2 and 4 for RWE plant using CESAR1.

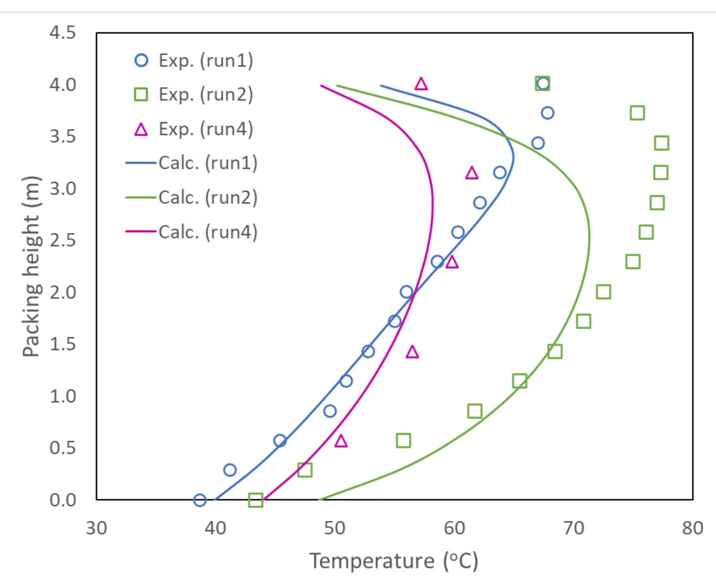

Figure 6: Absorber temperature profile for runs 1, 2 and 4 for TNO's mini plant I using 30 wt.% MEA

4. Conclusions

- In general, the calculated results presented good agreement with experimental data for all plants.
- In smaller plants heat losses and channelling effects are pronounced with potential impact on the measurements, especially when evaluating energy requirements.
- Larger plants are less affected by these effects. As a result, these plants can show more accurate the process energy requirements.
- The ProTreat® process simulator was used to model the experimental campaigns with good accuracy. Therefore, process design using it can be performed with a good level of confidence.
- ProTreat® showed exceptional speed and convergency rates for the cases studied and an easy user interface to set up simulations.

Acknowledgements

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[1] IEA, "The role of CO2 storage," 2019.
[2] Global CCS Institute, "Global Status of CCS 2020," Glob. CCS Inst., no. June, 2020.