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How can we manage aerosol emissions in the CO_2 capture process using the CESAR1 Solvent?

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Abstract

Chemical absorption using a blend of 3 M 2-amino-2-methyl-1-propanol (AMP) and 1.5 M piperazine (PZ) has gained attention due to its low energy demand and high degradation resistance [1]. However, solvent emissions remain one of the major challenges to its industrial-scale application. Solvent emissions, in particular amine aerosol emissions, need to be addressed since they constitute a risk to the environment and human health [2].

In this work, we will perform a parametric study to analyze how different process parameters influence solvent emissions, including both aerosol and volatile emissions. We focus on two different industrial flue gases: one with 10 vol% (Waste to Energy Plant) and one with 18 vol% (Cement). We investigate how the inlet size and number distributions of the aerosol affect the solvent emissions and how process parameters such as CO_2 lean loading, CO_2 removal rate and intercooling impact the overall emissions.

Svendsen et al. [3] developed a model to describe aerosol growth and emissions using the CESAR1 solvent and validated it on pilot plant data from RWE [4]. The model developed requires the liquid bulk temperature and concentration profiles in the absorber and water wash sections. In this work, a process model developed in Aspen Plus v14 was used to determine the operative conditions that minimize the reboiler duty and provide the necessary inputs for the aerosol model. We validated the developed Aspen Plus model on the data from Mangalapally et al. Figure 1 shows the comparison between the simulated and experimental results of the temperature and CO_2 concentration profile for one selected case. The model accurately predicts both the temperature and concentration profiles in the absorber, important inputs for the aerosol program. Additionally, Mangalapally measured the steady-state liquid amine concentration in the water wash recirculation liquid [5]. We used these measurements to evaluate the accuracy of the model for the water wash section, Figure 2. The model overestimates the amine concentration in the solvent loop for most of the cases. Experimental data on a pilot plant scale that differentiates between the AMP and PZ are needed to understand the source of the error. The Aspen model is used to provide input for the aerosol model, which describes the aerosol behaviour (size and composition) as the aerosol particles travel through the absorber and water wash sections. The results from the aerosol model are the emissions (volatile and aerosol) at various absorber designs and operating conditions.

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To conclude, at PCCC8, we will present a parametric study to highlight challenges and opportunities to optimize aerosol emission management. An in-house MatLab model simulating the aerosol growth and emission will be used together with a process model developed in Aspen Plus to generate the necessary inputs.

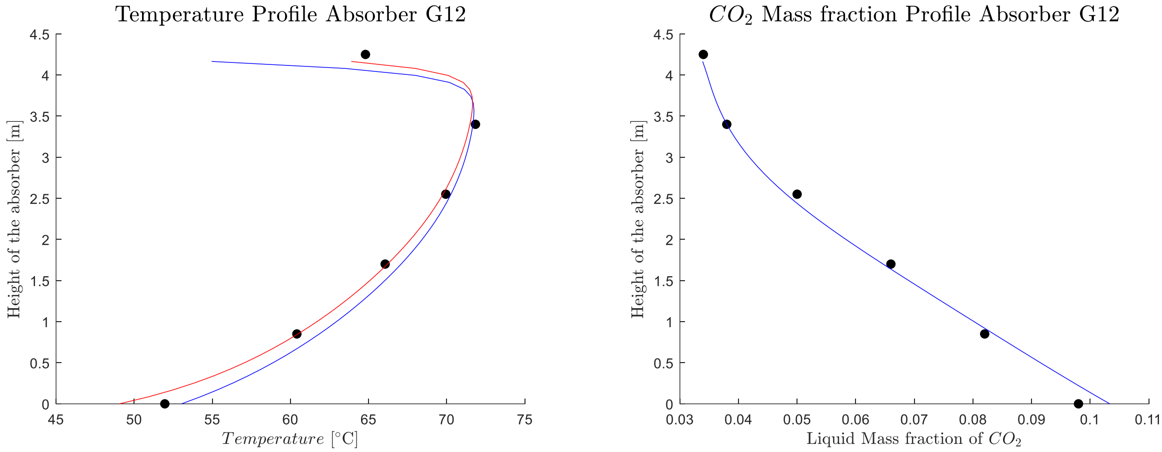

Figure 1: Comparison between the predicted and experimental temperature and liquid CO_2 concentration profile.

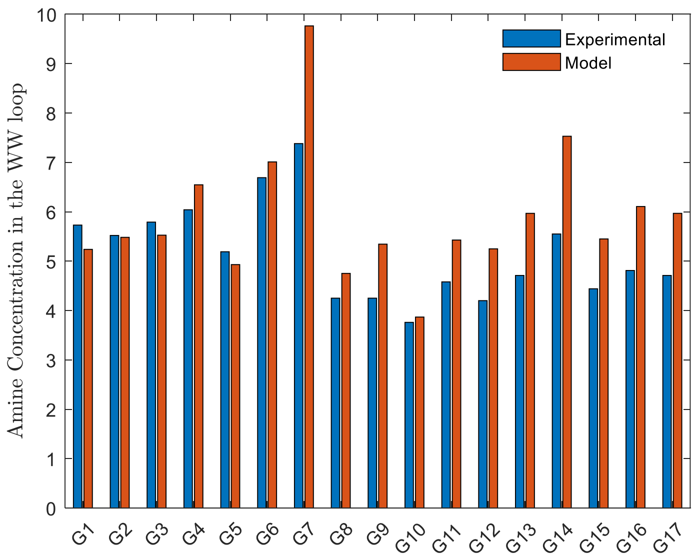

Figure 2: Comparison between the predicted and experimental total amine concentration in the water wash liquid loop.

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Keywords:Post combustion carbon capture; amine-based absorption; Emissions; CESAR1 Solvent; Aerosol Emissions;.

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