Mass transfer in a small scale post-combustion flue gas absorber; experiment and modelling

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Introduction

In this study experimental data of a post-combustion CO_2 capture pilot plant have been compared with a rate-based absorption model. In this model the mass transfer, thermodynamics and kinetics are included. An aqueous solutions of 50 wt.% MDEA has been used to capture the CO_2.

Experimental set-up

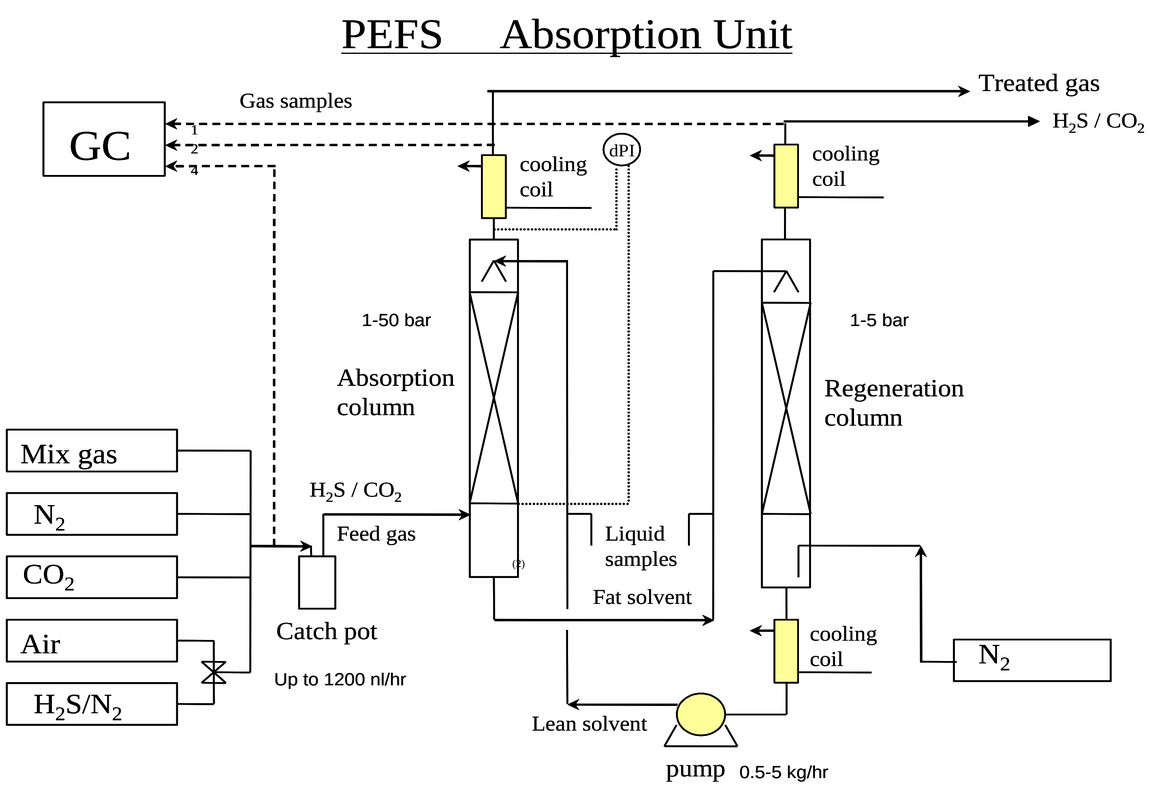

Figure: Flow sheet of the CAPTECH pilot plant unit at Shell Global Solutions

Absorber:

- **Size: D x L = 2.5 x 1450 cm;**
- **Sulzer EX laboratory packing;**
- **Aqueous 50 wt.% MDEA;**
- **Max gas flow: 1.3 $Nm^3.h^{-1}$;**
- **Max liquid flow: 6 $kg.h^{-1}$.**

Rate Based Model

Tray to tray procedure for amine blends;

- **Mass transfer with complex, reversible chemical reactions;**
- **Ideal thermodynamic model;**
- **Mass transfer parameters (k_L, k_G and a) from literature correlations;**
- **Following amines are included: MDEA, DMMEA, DEMEA, TEA (tertiary amines) and MEA, DEA, MMEA, DIPA, DGA, AMP (primary / secondary amines).**

Model output:

- Absorber dimensions;
- Temperature profile in the absorber;
- Concentration profile in the absorber;
- Profile of the speciation in the liquid phase.

Results

Length absorber in pilot plant: 1.45 m;
Calculated by the rate based model: 1.6 m.

Model not sensitive for k_G:

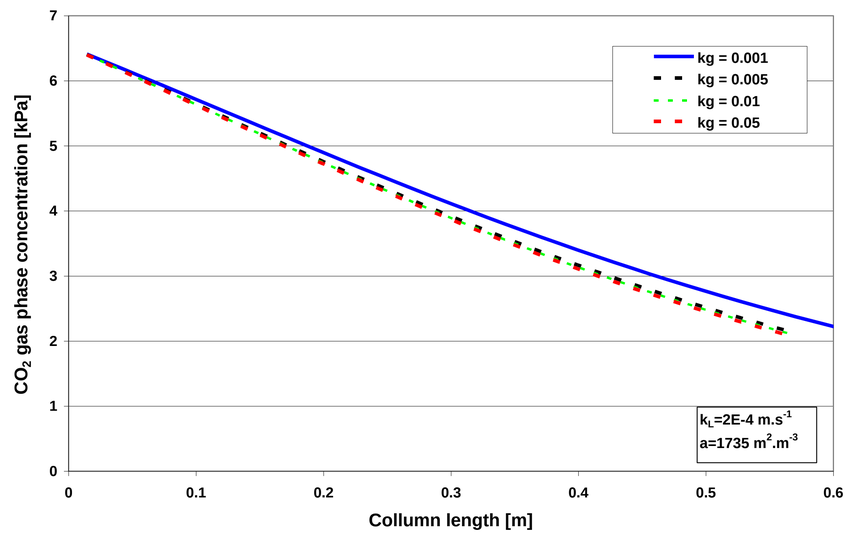

Figure: Influence of k_G ($m.s^{-1}$) on the calculated absorber dimensions.

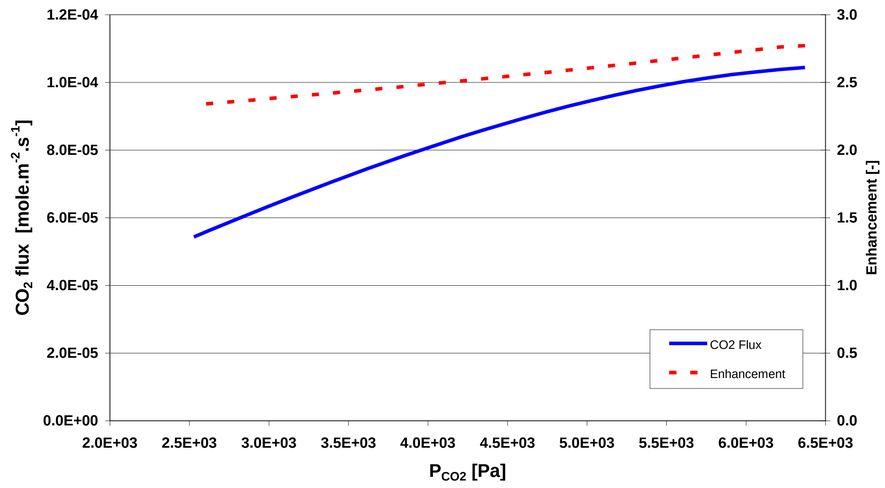

Figure: Calculated CO_2 flux and chemical enhancement in the absorber.

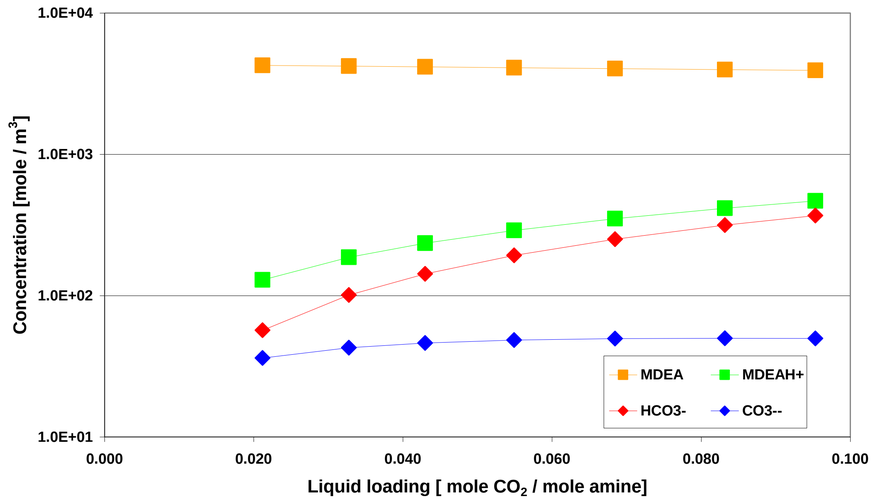

Figure: Calculated liquid speciation in the absorber as function of liquid loading.

Conclusion

Pilot plant data of a post-combustion CO_2 capture plant have been compared with a rate-based model. With this model it was possible to predict the size of an absorber within an accuracy of 10 %. CO_2 flux, chemical enhancement and liquid speciation were calculated with the model.

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More information can be found on www.co2-captech.nl. Shell Global Solutions is greatly acknowledged for their contribution to the experimental part of this work.