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Case Studies of CO_2 Capture Columns based on Fundamental Modeling

John Arild Svendsen[a,*], Dag Eimer[b]

[a]Statoil Research Centre, NO-3908 Porsgrunn, Norway
[b]Tel-Tek & Telemark University College, Porsgrunn NO-3918,Norway
*Corresponding author E-mail address:johnsv@statoil.com

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Introduction

A fundamental absorption-desorption model has been developed based on mass transfer kinetics. It is primarily a research tool to test new ideas. It has been used to carry out sensitivity analyses with respect to selected parameters. Figure 1 shows a typical absorption-desorption process. A base case has been defined where the total inlet gas flow to the absorber is 80000 kmol/hr containing 4 mol% CO_2. This corresponds to the flue gas from a gas fired power plant of about 400 MW. The amount of CO_2 in the inlet gas to the absorber is thus about 1.2 million tonnes/year.

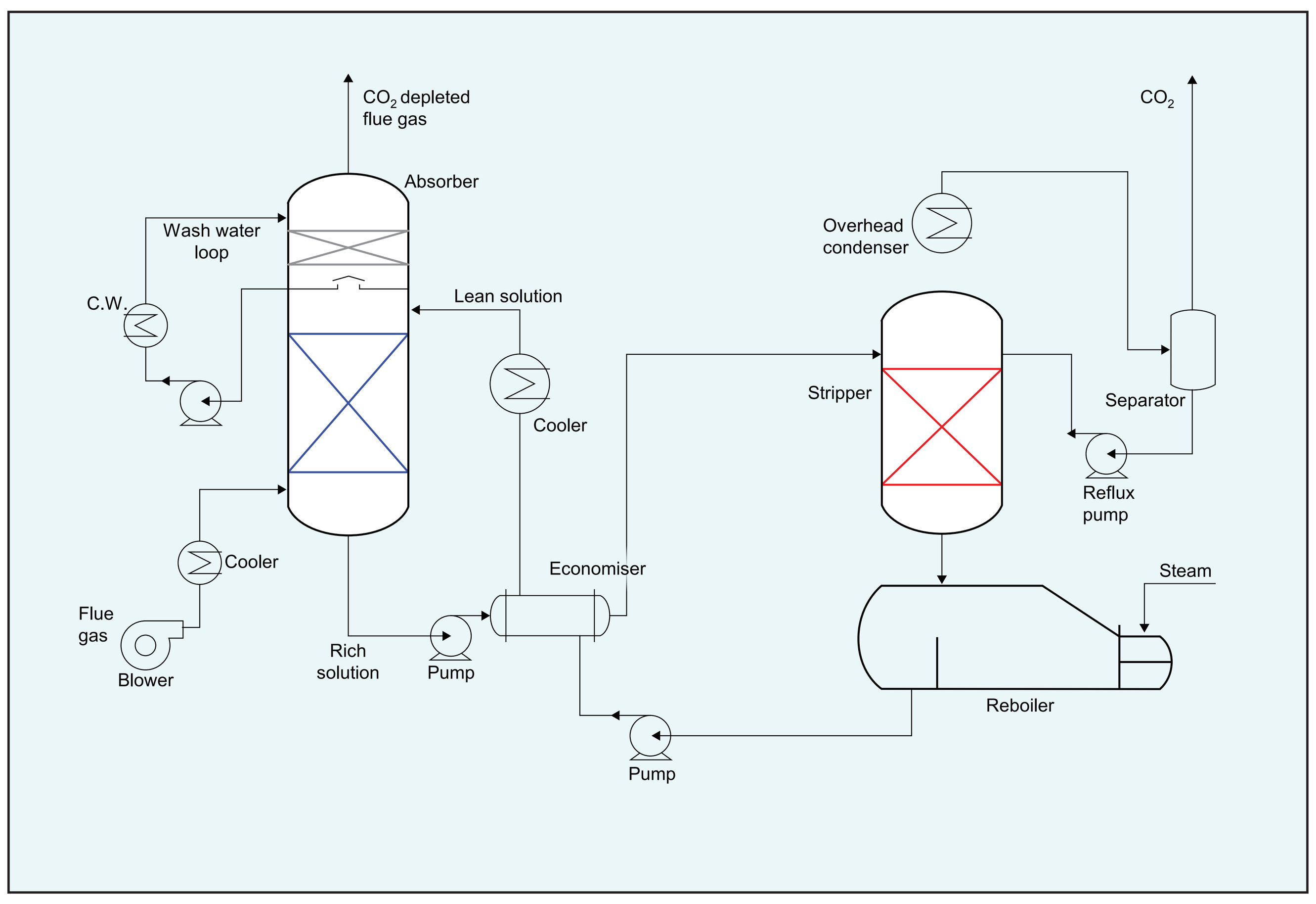

Figure 1 An absorption-desorption process. Model covers the packed sections indicated in blue and red.

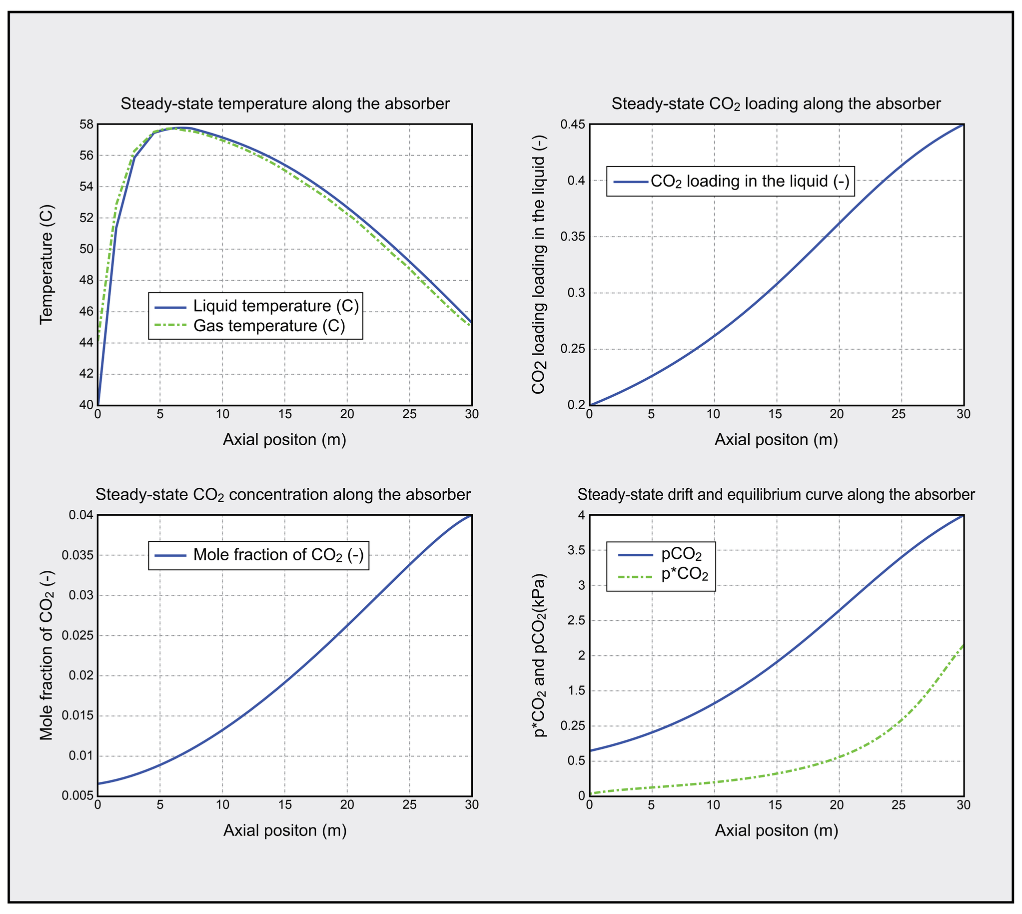

Figure 2 A 4-plot of Case 1, the base case. CO_2 removal efficiency is 85.6 % for this case.

Table 1 Fixed and varied main input parameters in the simulations and the base case value.

Input parameter		Base case value
Total inlet gas flow (kmol/hr)	(fixed)	80000
CO_2 content in inlet gas (mol%)	(fixed)	4
Packing material (metal Pall ring 2")	(fixed)	2"
Weight percent MEA (w%)	(fixed)	30
Equilibrium model	(fixed)	Li & Mather
Inlet liquid flow (m^3/hr)	(varied)	2200
Height of packing (m)	(varied)	30
Inner diameter of column (m)	(varied)	16
Liquid temperature (°C)	(varied)	40
Gas temperature (°C)	(varied)	45
Lean loading (mol CO_2/mol MEA)	(varied)	0.20

Case studies

Thirteen case studies have been done based on the variable parameters listed in Table 1. Base case is shown in Figure 2. Positive axial direction is top down. The results of the sensitivity analyses are presented in the figures 3-8 below. The equilibrium model used is that of Li & Mather [5], and the mass transfer model used is that of Onda [1]. Chilton-Colburn analogy [3] was used for calculating heat transfer between gas and liquid.

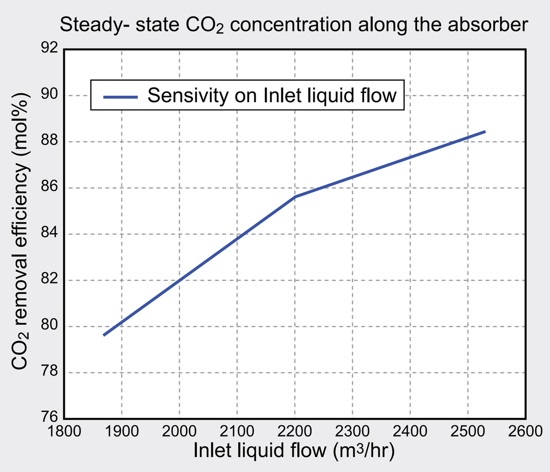

Figure 3 Sensivity of CO_2 removal efficiency on changes in inlet liquid flow.

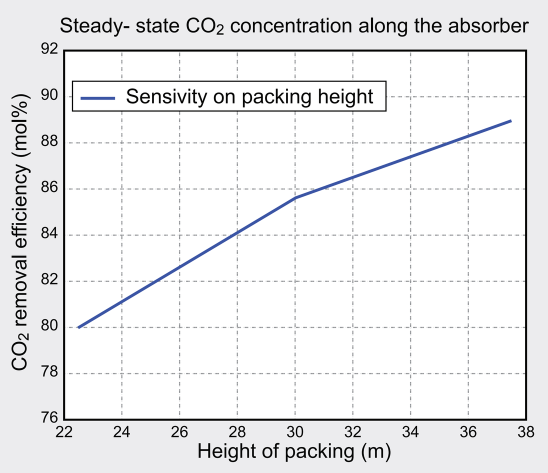

Figure 4 Sensivity of CO_2 removal efficiency on changes in packing height.

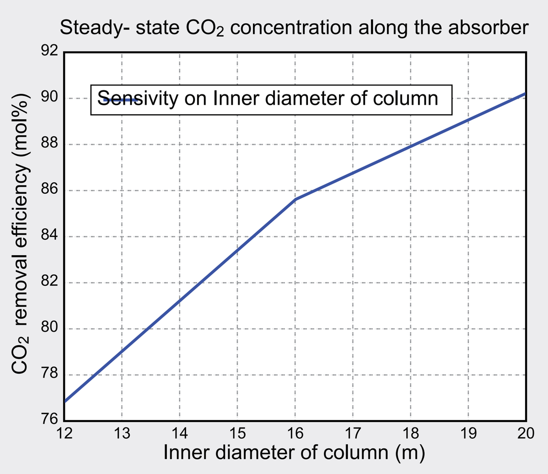

Figure 5 Sensivity of CO_2 removal efficiency on changes in Inner diameter of column.

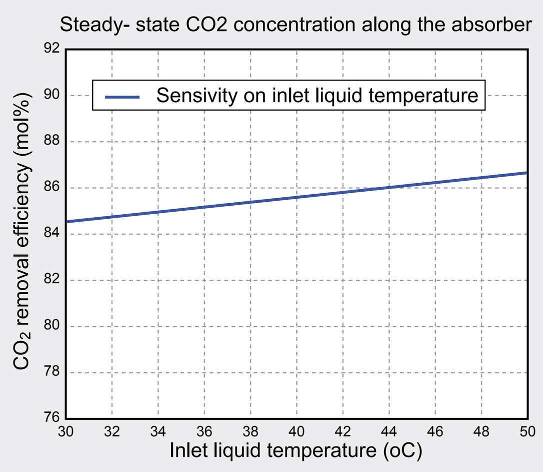

Figure 6 Sensivity of CO_2 removal efficiency on changes in inlet liquid temperature.

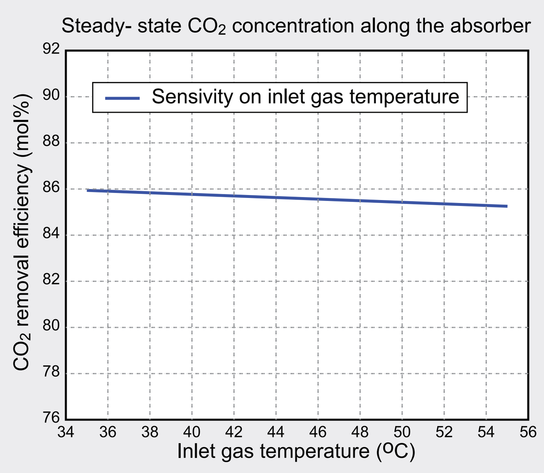

Figure 7 Sensivity of CO_2 removal efficiency on changes in inlet gas temperature.

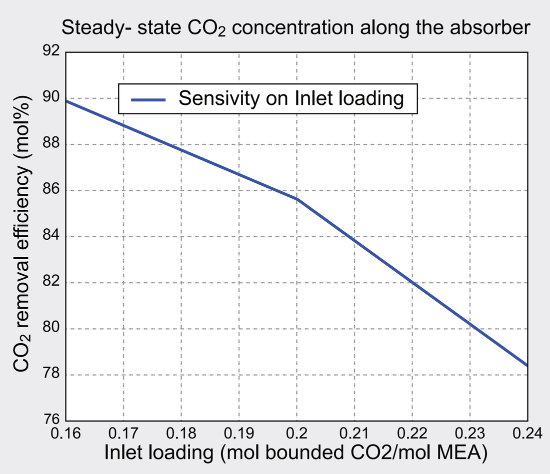

Figure 8 Sensivity of CO_2 removal efficiency on changes in inlet (lean) loading.

Table 2 Input parameters varied in the simulations and calculated CO_2 removal efficiency

Case no.	Inlet liquid flow (m^3/hr)	Height of packing (m)	Diameter of packing (m)	Inlet liquid temperature (°C)	Inlet gas temperature (°C)	Lean loading (mol/mol)	CO_2 removal efficiency (mol%)
1	2200	30	16	40	45	0.20	85.6
2	**1870**	30	16	40	45	0.20	79.6
3	**2530**	30	16	40	45	0.20	88.4
4	2200	**22.5**	16	40	45	0.20	79.9
5	2200	**37.5**	16	40	45	0.20	88.9
6	2200	30	**12**	40	45	0.20	76.8
7	2200	30	**20**	40	45	0.20	90.2
8	2200	30	16	**30**	45	0.20	84.5
9	2200	30	16	**50**	45	0.20	86.6
10	2200	30	16	40	**35**	0.20	85.9
11	2200	30	16	40	**55**	0.20	85.2
12	2200	30	16	40	45	**0.16**	89.9
13	2200	30	16	40	45	**0.24**	78.4

Conclusions

The simulations show that the CO_2 removal efficiency increases with increasing inlet liquid flow, height of packing, inner diameter of column and inlet liquid temperature. When inlet gas temperature or inlet loading is increased the CO_2 removal efficiency decreases.The calculated absorber height is high in view of other information available on column height [6]. It is observed that the model, due to Onda et al [1], estimates gas-liquid contact areas in the order of 50 % of the nominal packing surface area. Since this model dates from before 1970, it does not take into account the last 40 years of development in column packings. However, since the model is well known we chose to show the effect of using the Onda model. The sensitivity trends presented are not much affected by this choice.

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