Simulation and Optimization of Post Combustion Carbon Capture using Absorption Process

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1. INTRODUCTION

CO_2 is the main greenhouse gas which has significant impact on environment. Coal-fired power plants are the main source of carbon emission. Carbon capture technologies are divided to three main technologies including: (1) Post combustion CO_2 capture; (2) Pre-combustion CO_2 capture and (3) Oxy-fuel combustion capture. Chemical absorption of CO_2 by means of monoethanolamine (MEA) solvent is recognized as the most suitable technology to reach this goal. Aspen Plus simulation of the absorber column and effect of different liquid to gas ratio has been done by Lawal et al.(2009) using Radfrac column as the absorber. The aim of this study is to simulate mathematically the equilibrium based model of the process and show the effect of liquid to gas ratio.

• 2. Model development

- **Equilibrium based approach**
- Equilibrium stages were considered. The performance of each stage was modified using an efficiency correction factor. MEA electrolyte solution chemistry is used to predict the equilibrium mass fraction in both vapour and liquid phases. Also, Henry's constant was considered for CO_2 in MEA (Lawal et al.,2009)
- Another simulation is being carried out in gPROMS in order to simulate the absorber. The absorber is simulated mathematically assuming equilibrium stages considering mass and energy balances by using the equations in the paper written by Mores et al.

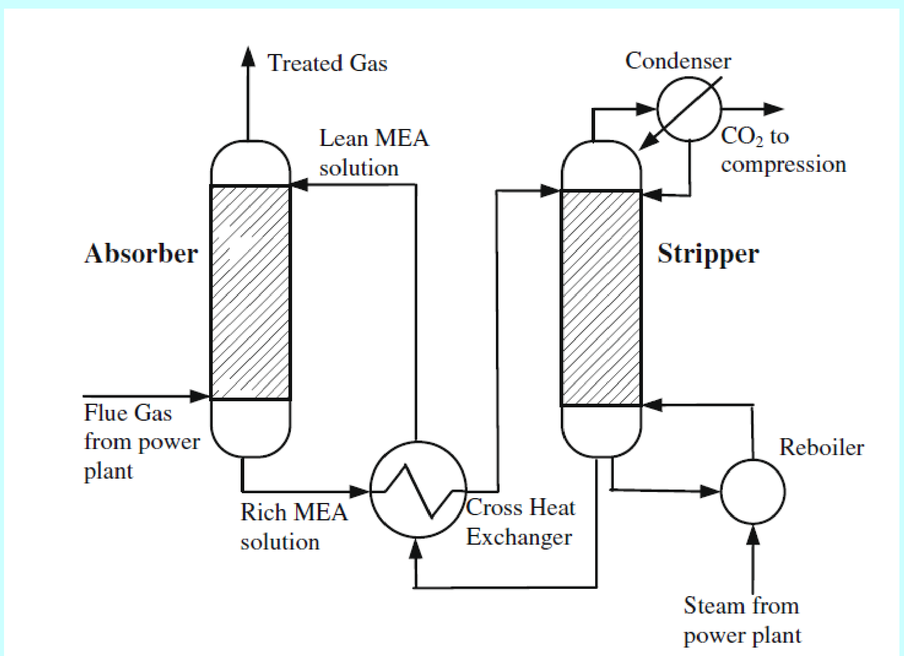
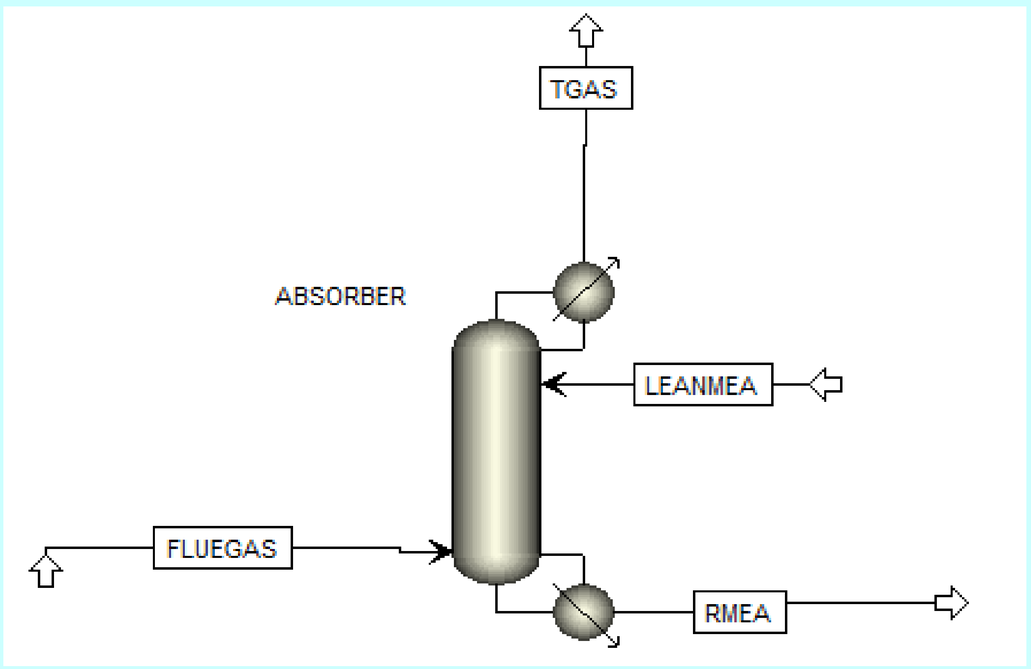


Fig. 1. Simplified process flow diagram of chemical absorption process for post combustion capture (Lawal et al.,2009).



In the simulation no condenser or reboiler was considered.

Table 1-Process condition for validation (Lawal et al.,2009)

	Case 47		Casse32	
	Flue Gas	Lean MEA	Flue Gas	Lean MEA
Temperature (K)	332.38	313.32	319.71	313.86
Total flow-rate (Kg/s)	0.158	0.642	0.13	0.72
H_2O % mass	1.93	63.34	1.48	63.34
CO_2 % mass	24.15	6.18	25.2	6.18
MEA % mass	0	30.48	30.48	30.48
N_2 % mass	73.92	0	0	0

3. RESULTS & DISCUSSIONS

- Effect of liquid to gas ratio

According to the results obtained by Lawal et al. (2009) as the liquid to gas ratio decreases, CO_2 absorption will decrease. However, the gPROMS simulation is still going.

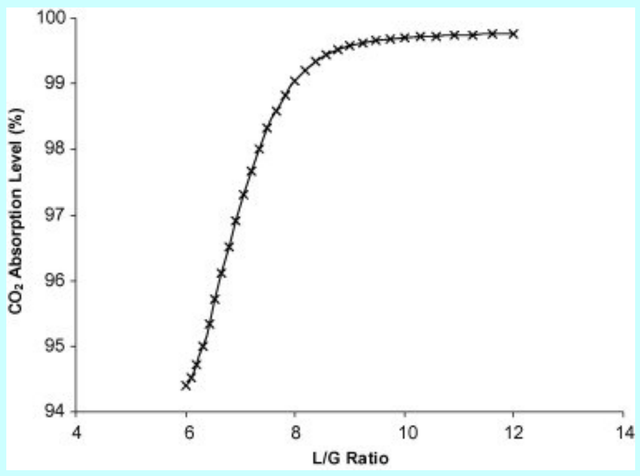


Fig. 2. *Change in CO_2 absorption levels with L/G ratio.*

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1)Lawal, A., Wang, M., Stephenson, P. and Yeung, H. (2009). Dynamic modelling of CO2 absorption for post combustion capture in coal-fired power plants. *Fuel*, 88(12), pp.2455-2462.

2)Mores, P., Scenna, N. and Mussati, S. (2011). Post-combustion CO2 capture process: Equilibrium stage mathematical model of the chemical absorption of CO2 into monoethanolamine (MEA) aqueous solution. *Chemical Engineering Research and Design*, 89(9), pp.1587-1599.