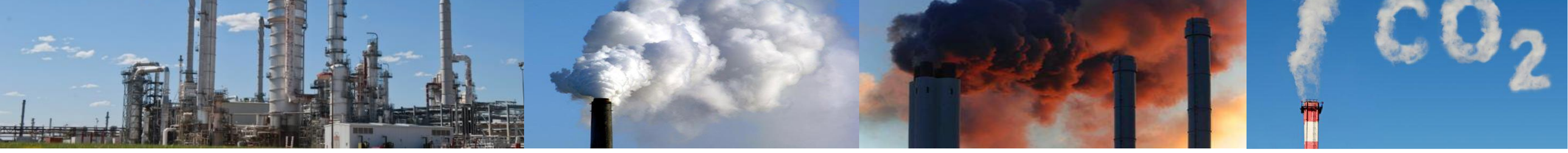

Process Intensification of Carbon Capture: Study of CO_2 capture using rotating packed beds

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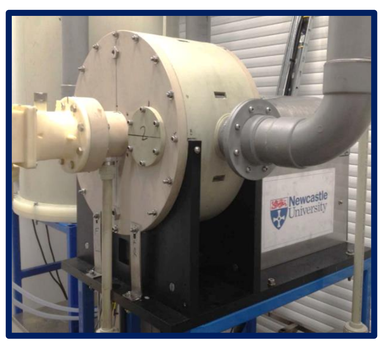
Background

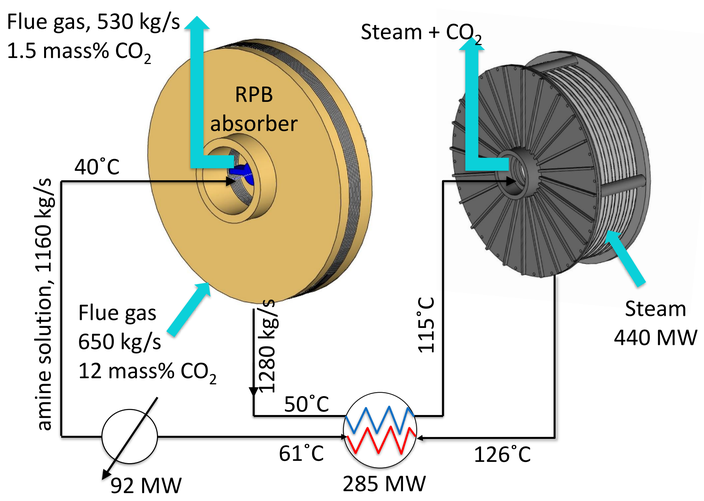
Rotating packed beds (RPBs) have been proposed for post-combustion carbon capture. RPBs can reduce the size and cost of full-scale carbon capture systems through process intensification. At Newcastle University, we have built a pilot-plant scale facility using RPBs for absorption and regeneration of aqueous amine solutions. In this facility, solvent testing in RPBs were carried out under realistic conditions, representative of industrial carbon capture process. This poster presents results from absorption and regeneration experiments using aqueous monoethanolamine solutions (MEA) conducted in the pilot plant.

Pilot Plant Facility

- Flexible RPB absorber designed to be run in three gas flow configurations: counter-current, co-current and cross-flow.
- Rotational speeds of up to 1500 rpm to intensify mass transfer.
- Flue gas humidification and practical liquid-gas ratios provide realistic conditions.

Absorber





Solvent based carbon capture system for 500 MWe power station. Values are for 30 mass% mono ethanol amine solution.

Regenerator

- Uses a RPB to intensify solvent regeneration.
- Thin film heat transfer on a rotating surface is used to intensify the reboiler.
- Heat and mass transfer are integrated in a single unit to reduce energy losses.

CO_2 Absorption Experiments

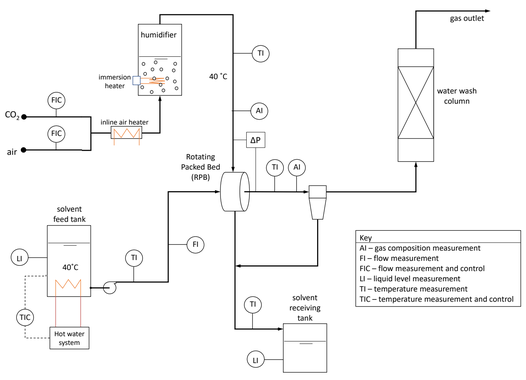


Fig 1: PFD of absorption experiment

- Synthetic flue gas is generated by mixing air and CO_2, preheated to 40°C and humidified.
- MEA is preheated to 40°C and $\alpha = 0.2$ $\frac{mol_{CO_2}}{mol_{MEA}}$ preloading.
- The inlet flow is monitored using a Coriolis flow meter.
- Gas analysers used to monitor inlet and outlet CO_2 molar concentration
- Two packing types tested: Montz and Expament

Regeneration Tests Using Rich MEA Solutions

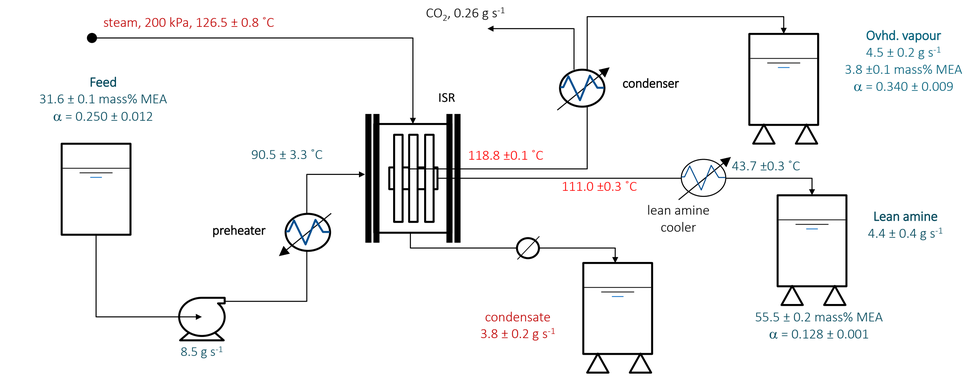


Fig 2: PFD of regeneration tests

- Pre-heating to 90^{O}C to be representative of industrial condition.
- Thermocouples and weighing balances log data over time, providing accurate data for heat transfer.

Absorption Mass Transfer Performance

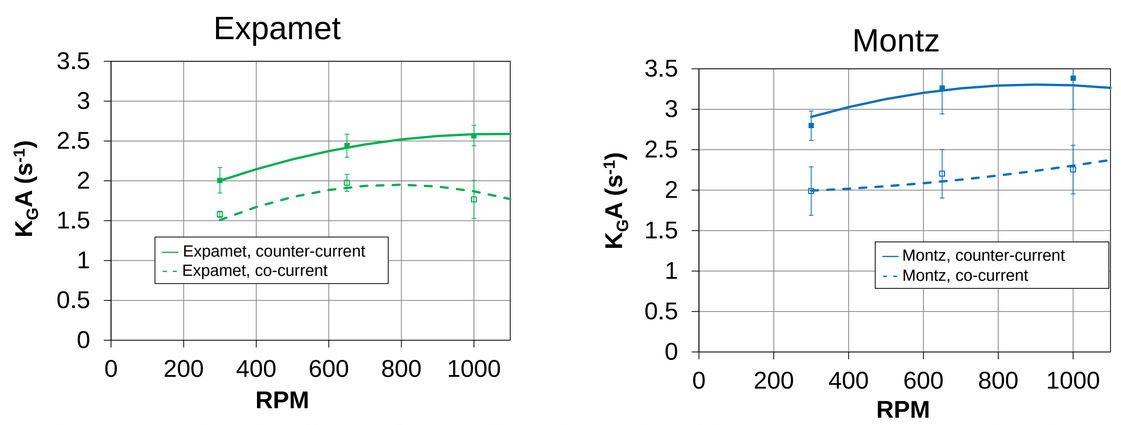
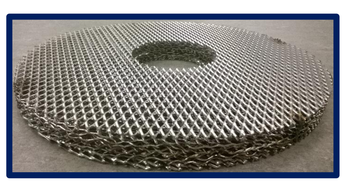


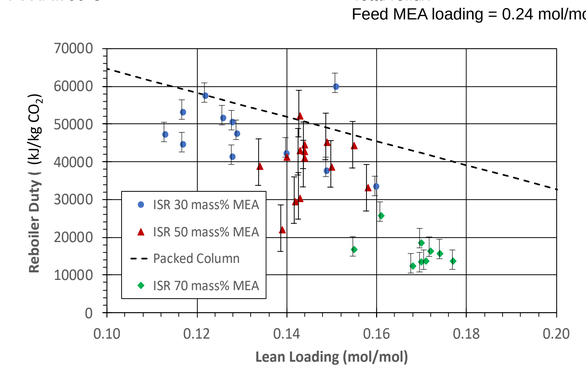
Fig 3: Comparing the effect of flow configuration and packing at 45 mass% MEA, L/G ratio = 4.



Packing	
Expamet 196S	Montz
expanded metal mesh sheet packing	Redacted
a_p = 663 m^2/m^3	
ε = 0.801	

- Montz packing outperforms Expamet packing: improved K_GA; less sensitive to fall in performance with lower RPM; lower pressure drop.
- Counter-current flow configuration consistently produces better mass transfer than co-current configuration

Results for MEA Regeneration



Compared to packed column data from Sakwattanapong (2005):

- 30-50% reduction in loading in comparison
- Reboiler duty decreases with increasing MEA solution strength due to decreasing reflux flow.
- For 30 mass% amine there is a saving of 13% on the reboiler duty compared to a packed column and separate reboiler.

Conclusions

- The solvent regeneration column and the reboiler have been successfully integrated into one unit.
- Energy consumption is reduced by 13% compared to a packed column.
- Counter-current gas flow configuration of the RPB absorber provides better mass transfer results.
- The pilot-plant is capable of conducting solvent testing for CO_2 absorption and regeneration under realistic conditions.

Acknowledgements

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Sakwattanapong, R. Aroonwilas, A. Veawab, A. 2005. Behaviour of reboiler heat duty for CO2 capture plants using regenerable single and blended alkanolamines. Industrial & engineering chemistry research. 44(12) pp.4465-73.