Intensified post combustion solvent based CO_2 capture using a RPB absorber and rotating regenerator

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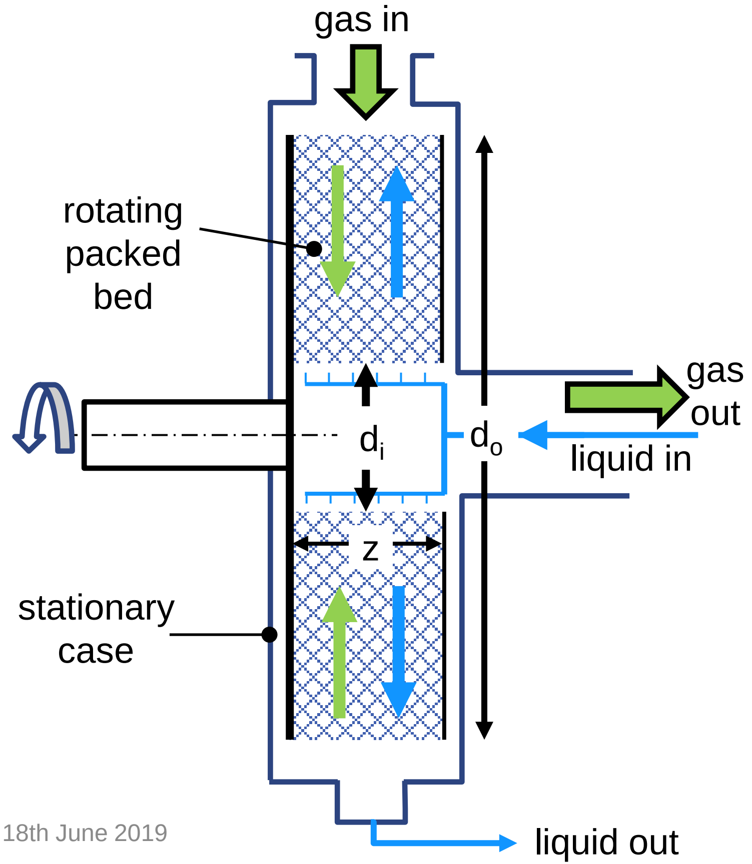
Talk Outline

- What is a rotating packed bed.
- Carbon capture using rotating packed beds.
- Effect of flow configuration on CO_2 absorption.
- Integrated solvent regenerator and reboiler
- Conclusions
- Future work

What is a Rotating Packed Bed (RPB)?



d_i depends on the outlet gas velocity

z depends on the flooding limit at d_i

d_o depends on the mass transfer duty

z is comparable to packed column diameter

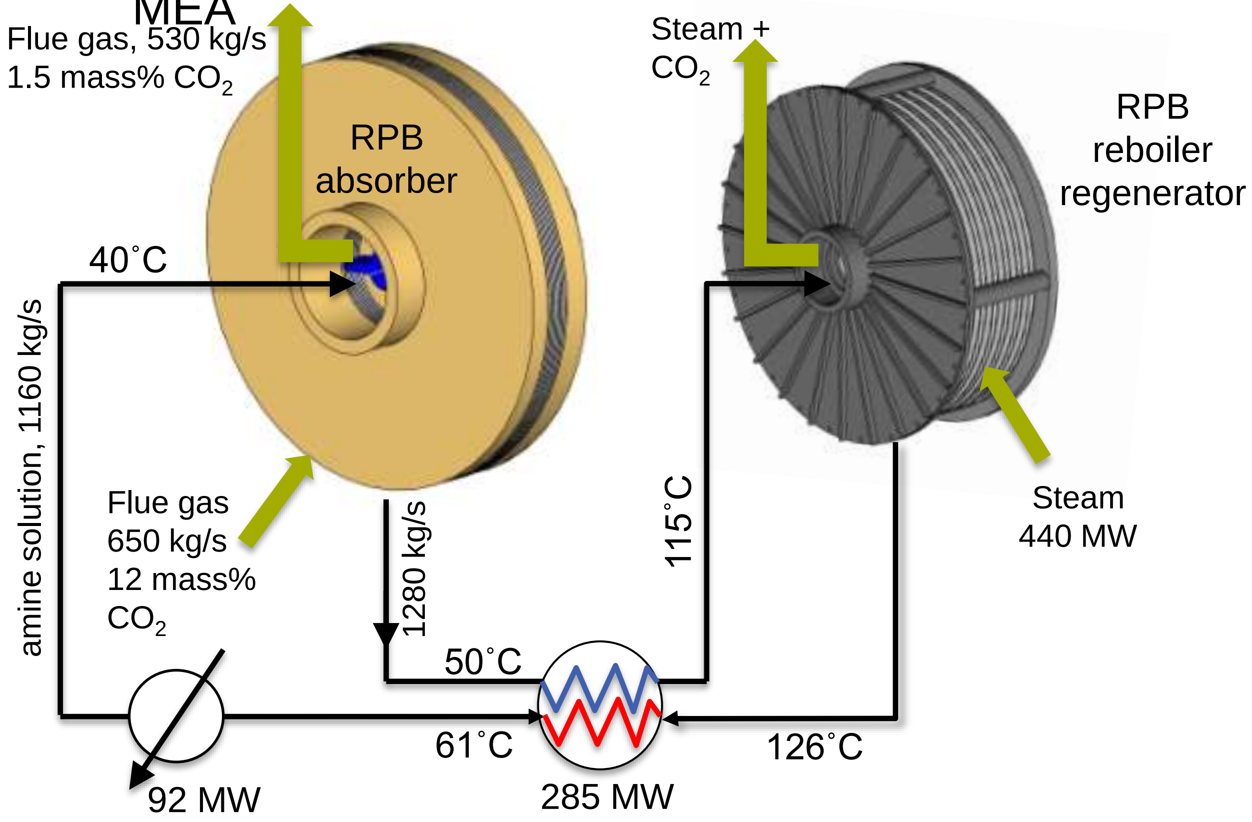
$d_o - d_i$ is comparable to packed column height

Rotation decreases both z and d_o, and reduces packing volume by 1-2 orders of magnitude

Civil engineering costs eliminated

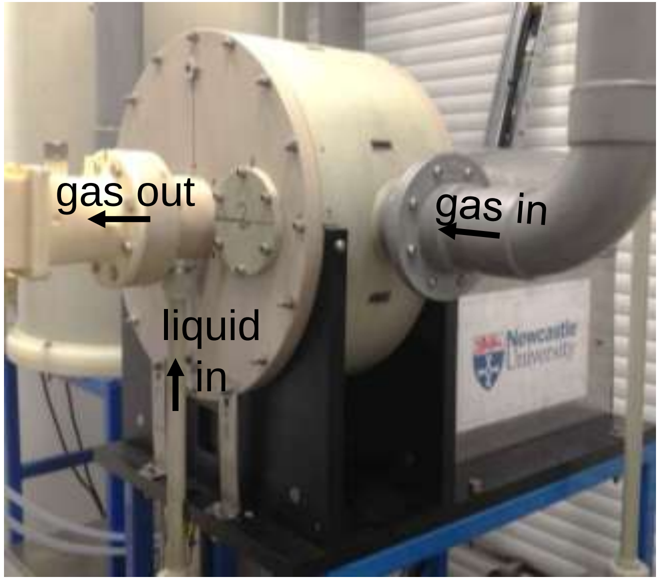
Carbon Capture Using RPB

500 MW_e power station, 30 wt% MEA

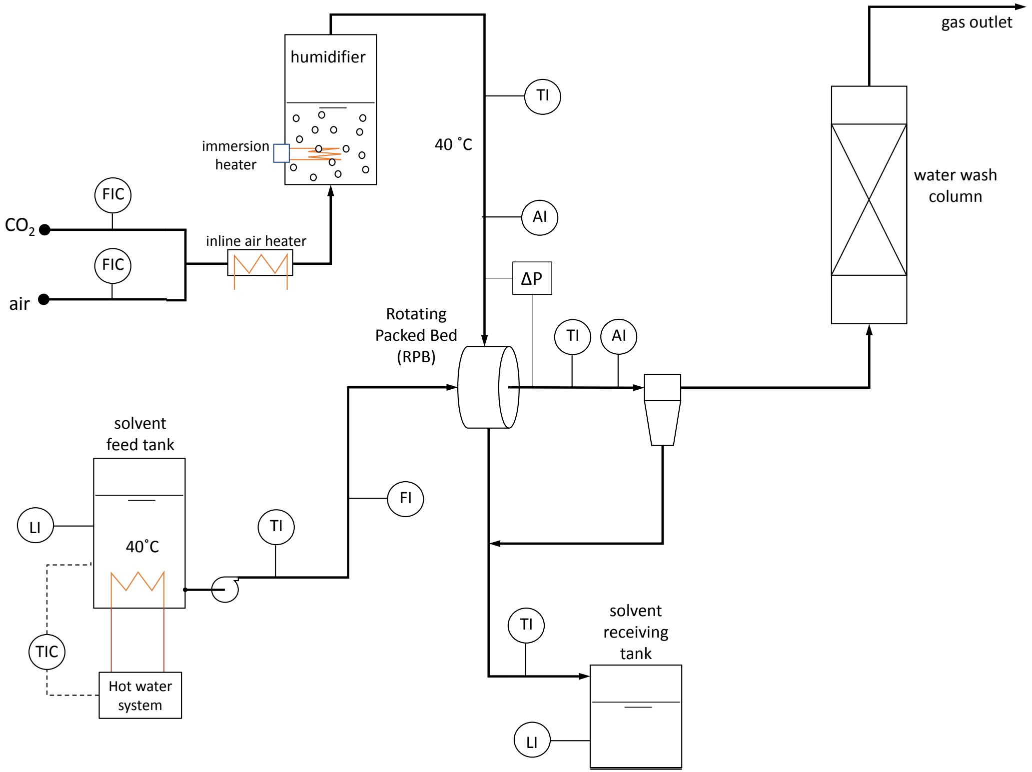


CO_2 Capture Using RPB

280 mm diameter gas absorption rig



Experimental Setup



Packing Materials

Stack of expanded SS316 mesh sheets

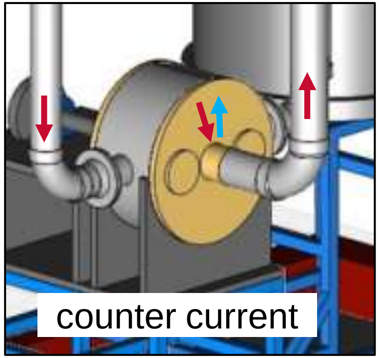
a_P =663 m^2 m^{-3} ε = 0.80

Montz structured packing – first prototype

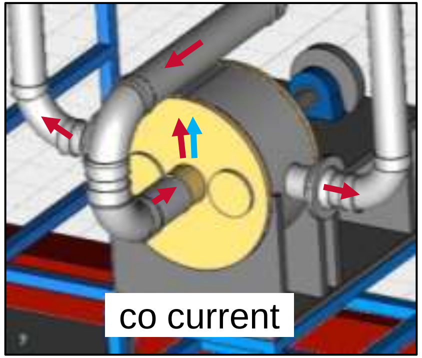
a_P =830 m^2 m^{-3} ε = 0.94

Gas-liquid flow configurations

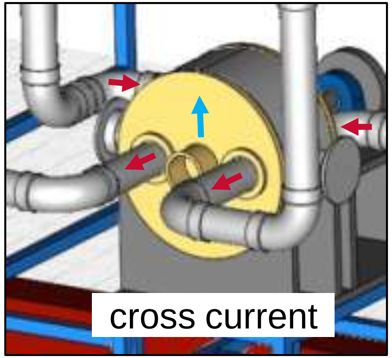
liquid flow → gas flow →



- High K_GA
- High ΔP
- High $Power_{liq}$



- Low K_GA
- Low ΔP
- High $Power_{liq}$



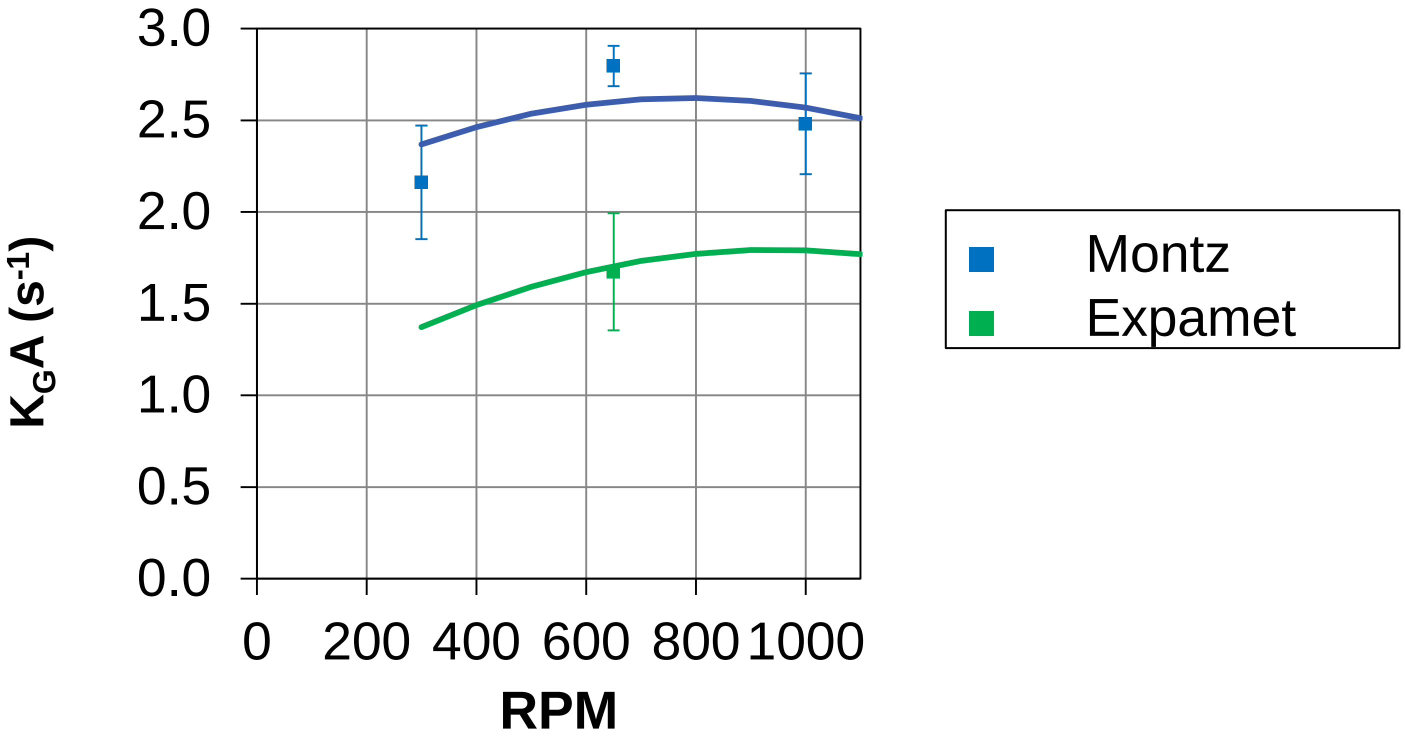
- Intermediate K_GA
- Low ΔP
- Lower $Power_{liq}$

Design of Experiments: 3-level face centered composite

rpm - 300, 650, 1000 $(L/G)_{mass}$ - 2, 4, 6 MEA - 30%, 50%, 70%

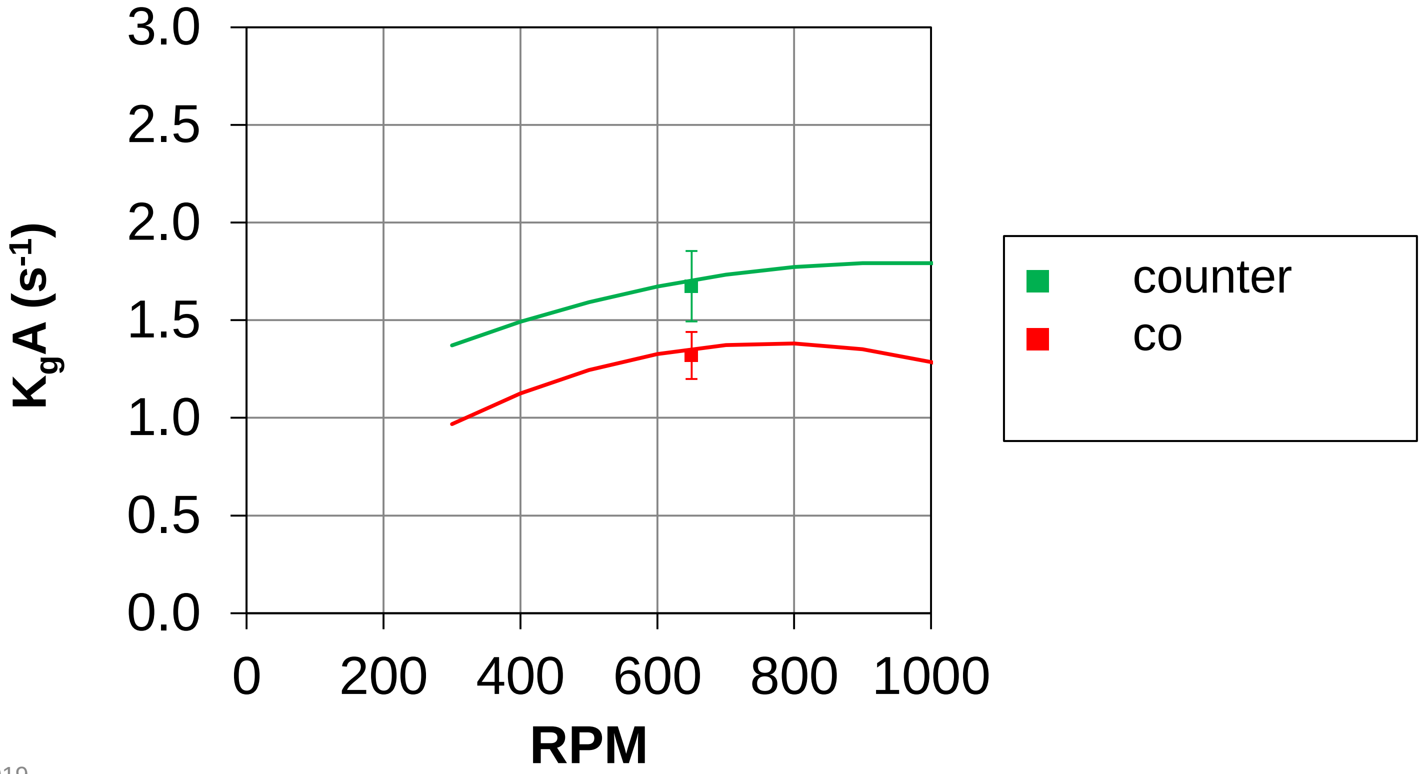
Comparison of Expamet and Montz

30 wt% MEA, $(L/G)_{mass}$ = 4 ratio, counter-current flow



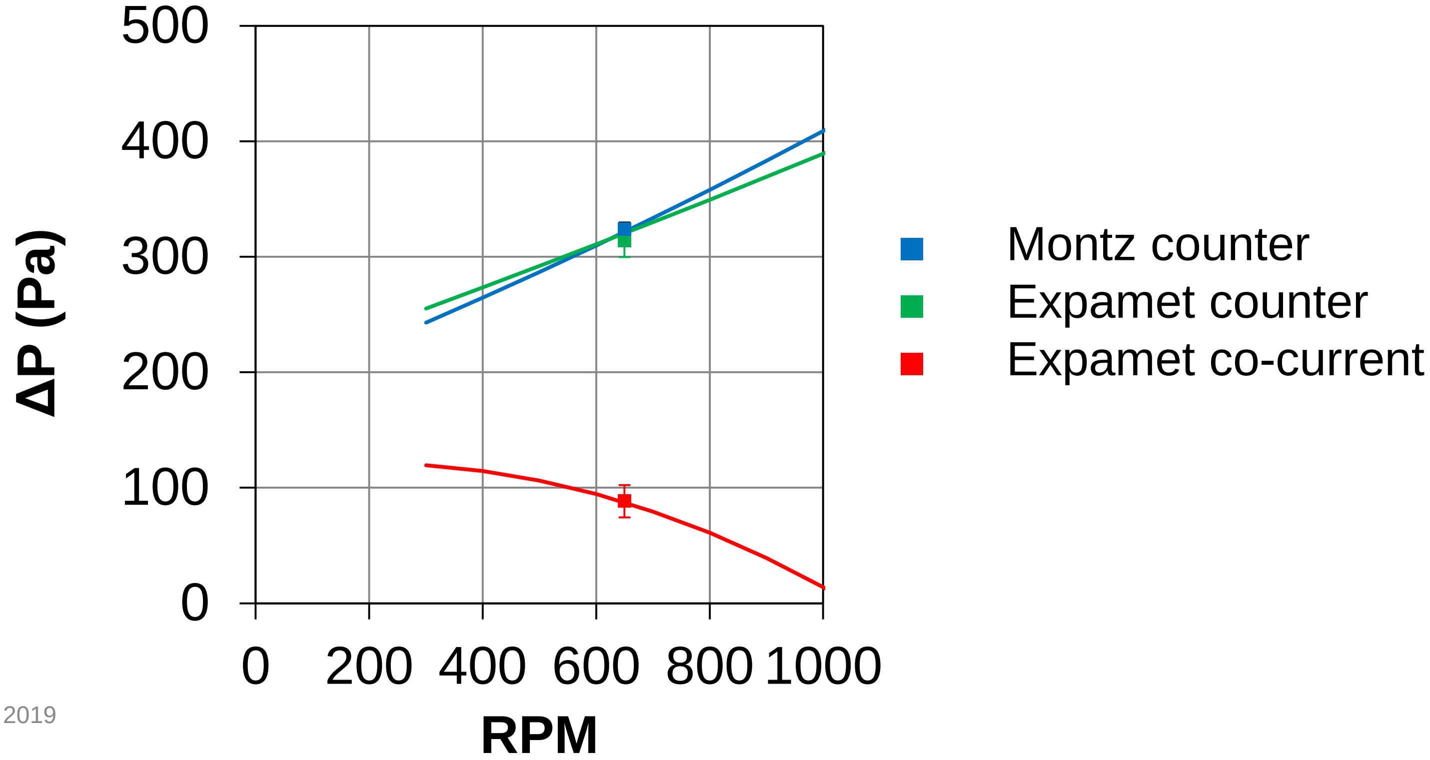
Comparison of Counter and Co Flow

30 wt% MEA, $(L/G)_{mass}$ = 4,Expamet Packing

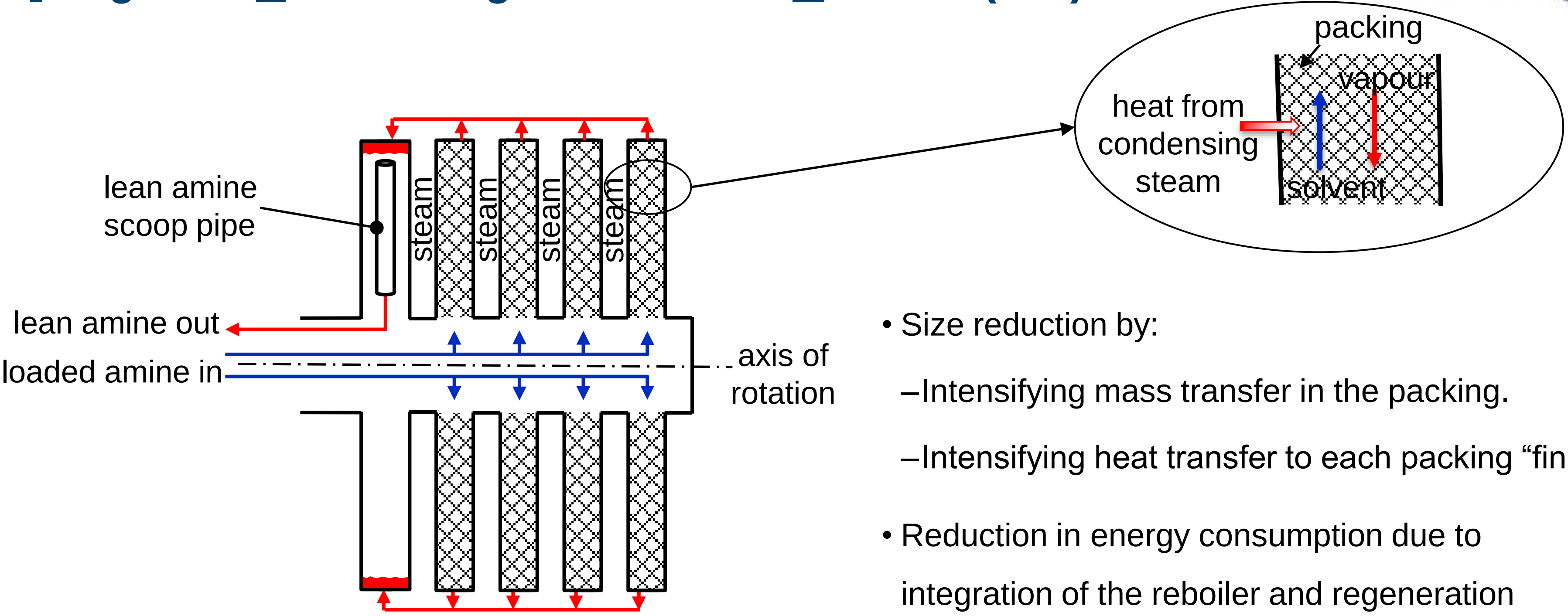


Comparison of Pressure Drop

30 wt% MEA, $(L/G)_{mass} = 4$

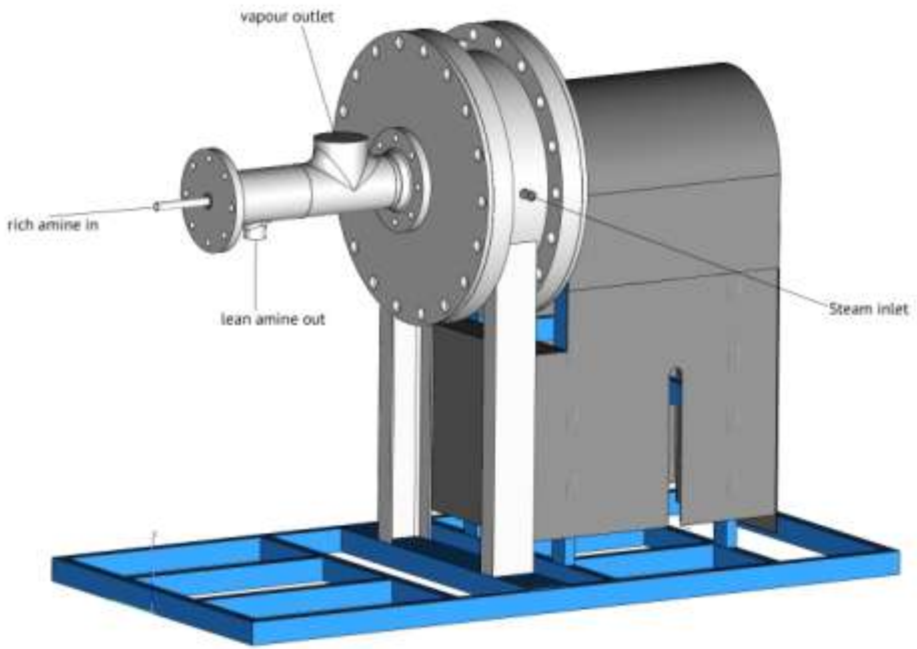


Integrated Solvent Regenerator and Reboiler (ISR)

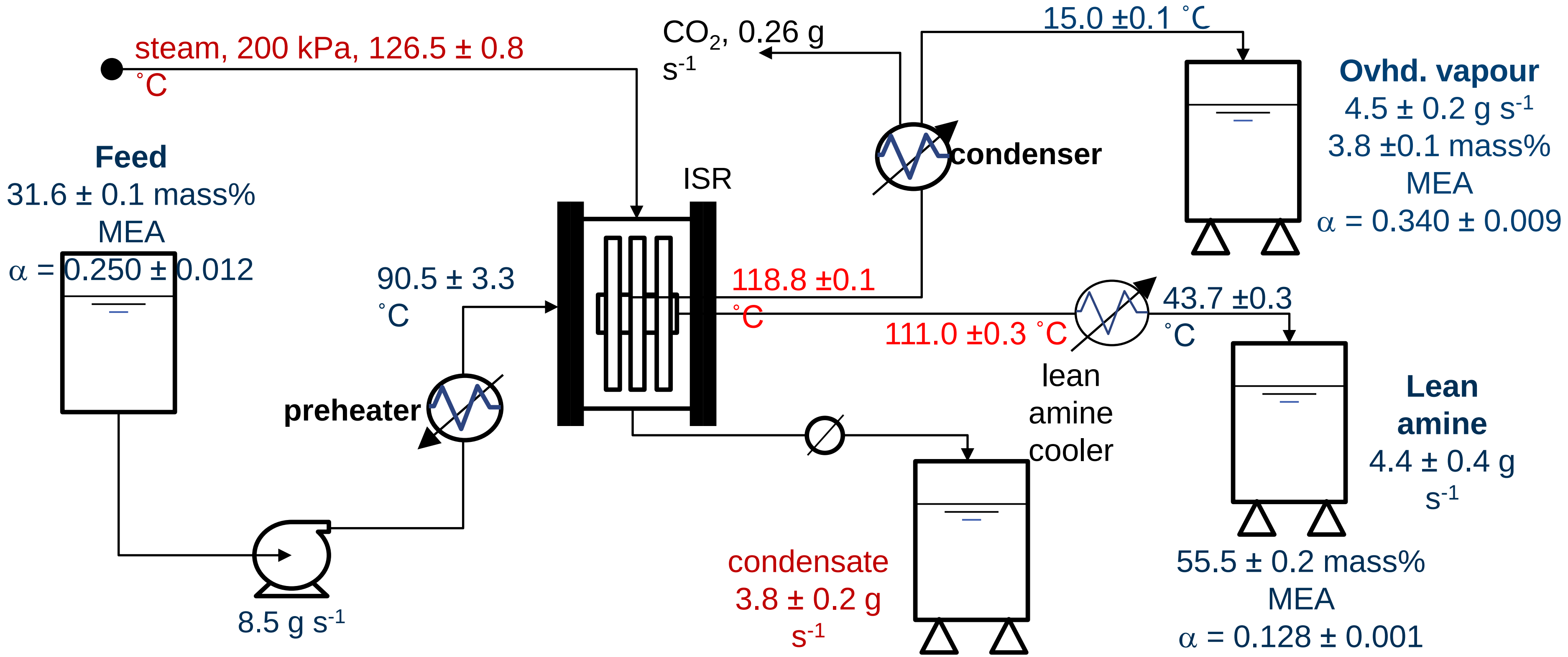


- Size reduction by:
  - –Intensifying mass transfer in the packing.
  - –Intensifying heat transfer to each packing “fin”.
- Reduction in energy consumption due to integration of the reboiler and regeneration column.

Construction of the Pilot Scale Unit

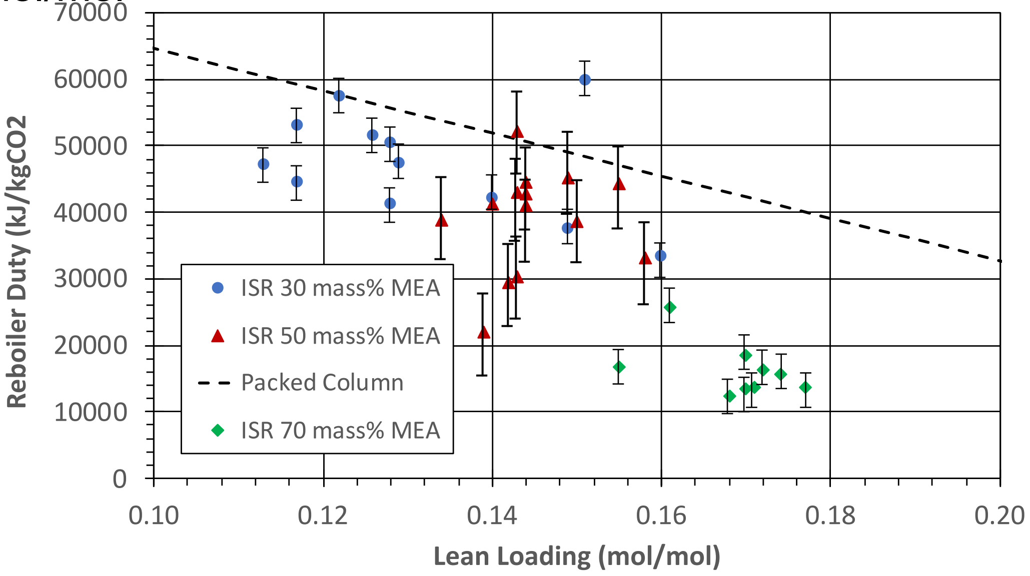


Experimental Setup



Reboiler Duty as a function of amine strength

Feed at 90˚C   Total reflux   Feed MEA loading = 0.24 mol/mol



- Compare to data of Sakwattanapong (2005)
- 30-50% reduction in loading.
- 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

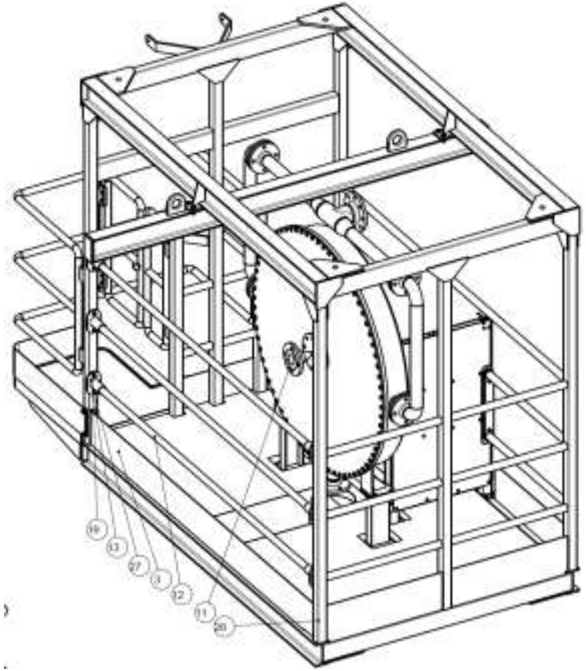
- RPB significantly increases rate of mass transfer compared to a packed column.
- The flow configuration of the absorber has a significant effect on the rate of mass transfer and the pressure drop.
- The reboiler and regenerator columns have been integrated.
- As well as reducing the size of the regenerator and reboiler, integration of the units reduces the reboiler energy use.

Future Work

Newcastle University

Project Artemis – Testing of RPB and ISR for 90% capture of CO_2

- Testing to achieve TRL 7.
- Work funded by UK government and CCSL.
- In partnership with University Sheffield.
- Test rig will be sited at CPACT near Sheffield
- RPB Absorber will be commissioned in July 2019.
- ISR will be commissioned in September 2019.



Acknowledgements

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Lab scale rotating test rigs are available for solvent testing

Questions?