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Pilot Scale Amine-Based Carbon Capture Using Rotating Packed Beds



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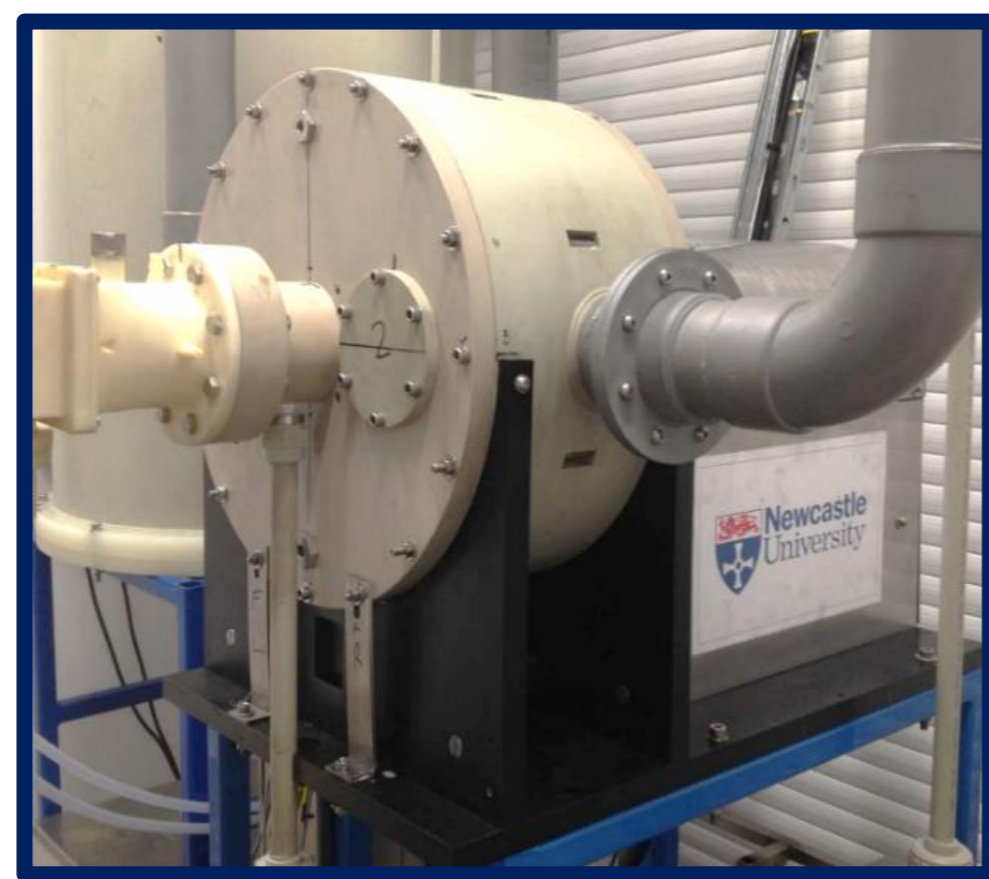


Introduction

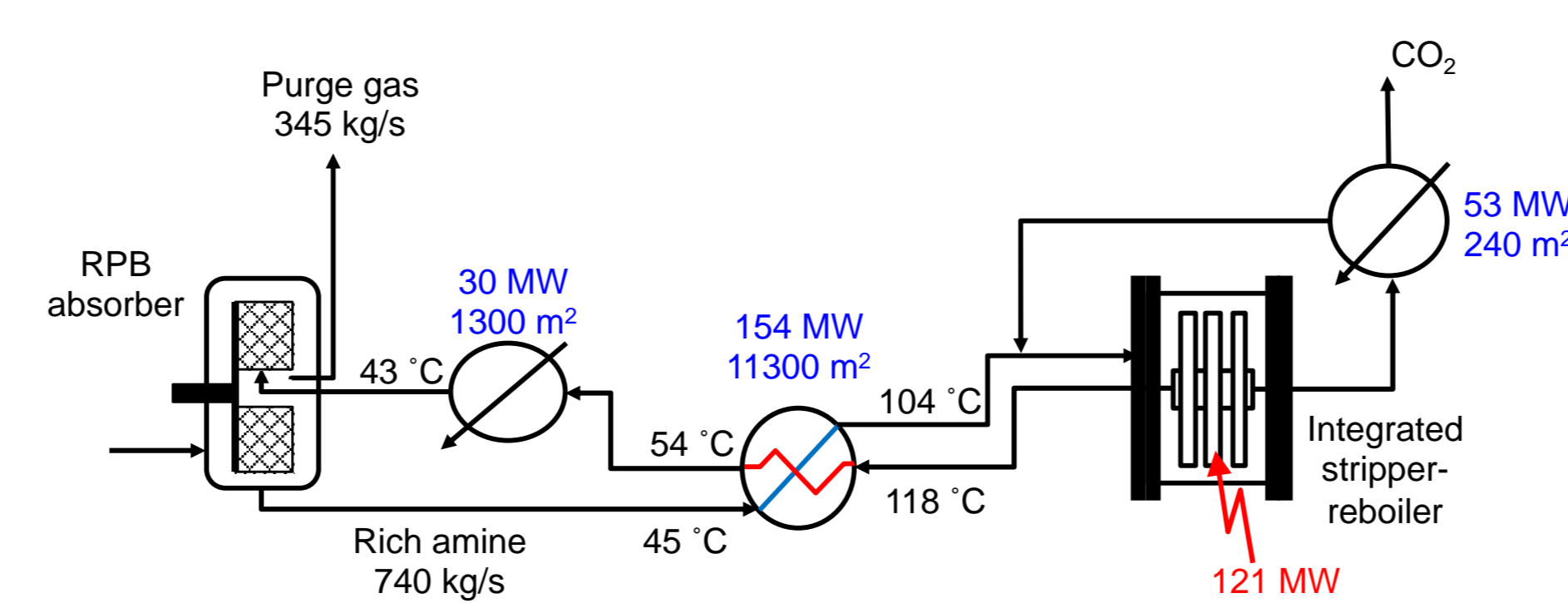
At Newcastle University, we test amine-based carbon capture processes in pilot-scale demonstration units. Both absorption and regeneration steps use rotating packed beds (RPBs) to intensify the carbon capture process. RPBs exploit centrifugal fields to improve mass-transfer. This substantially reduces the size of the equipment. RPBs could be used to capture CO₂ from power production and industrial processes, at a reduced capital cost. Additional benefits include a reduced response time, which could be a benefit to load-following power plants, and lower solvent inventory. We have experience partnering with company-contracted research involving RPBs and this is something we are keen to continue in the future. This poster covers the current progress in pilot-plant demonstration of rotating packed bed carbon-capture at Newcastle University.

Pilot Plant Facility at Newcastle

Absorber

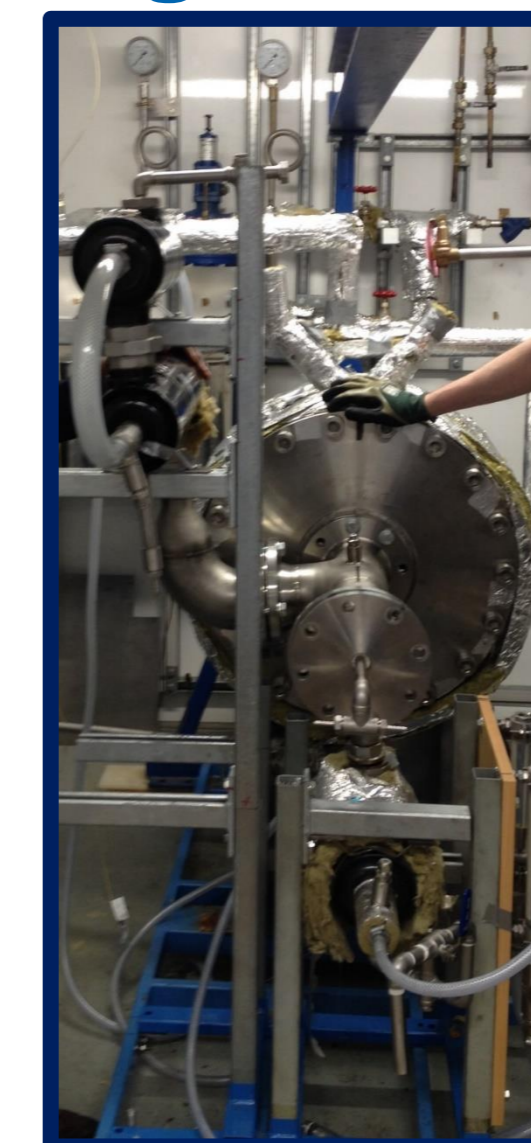


- Flexible RPB absorber designed to be run in three gas flow configurations: counter-current, co-current and cross-flow.
- Rotational speeds of up to 1500 rpm to intensify mass transfer.
- Flue gas humidification and practical liquid-gas ratios provide realistic conditions.



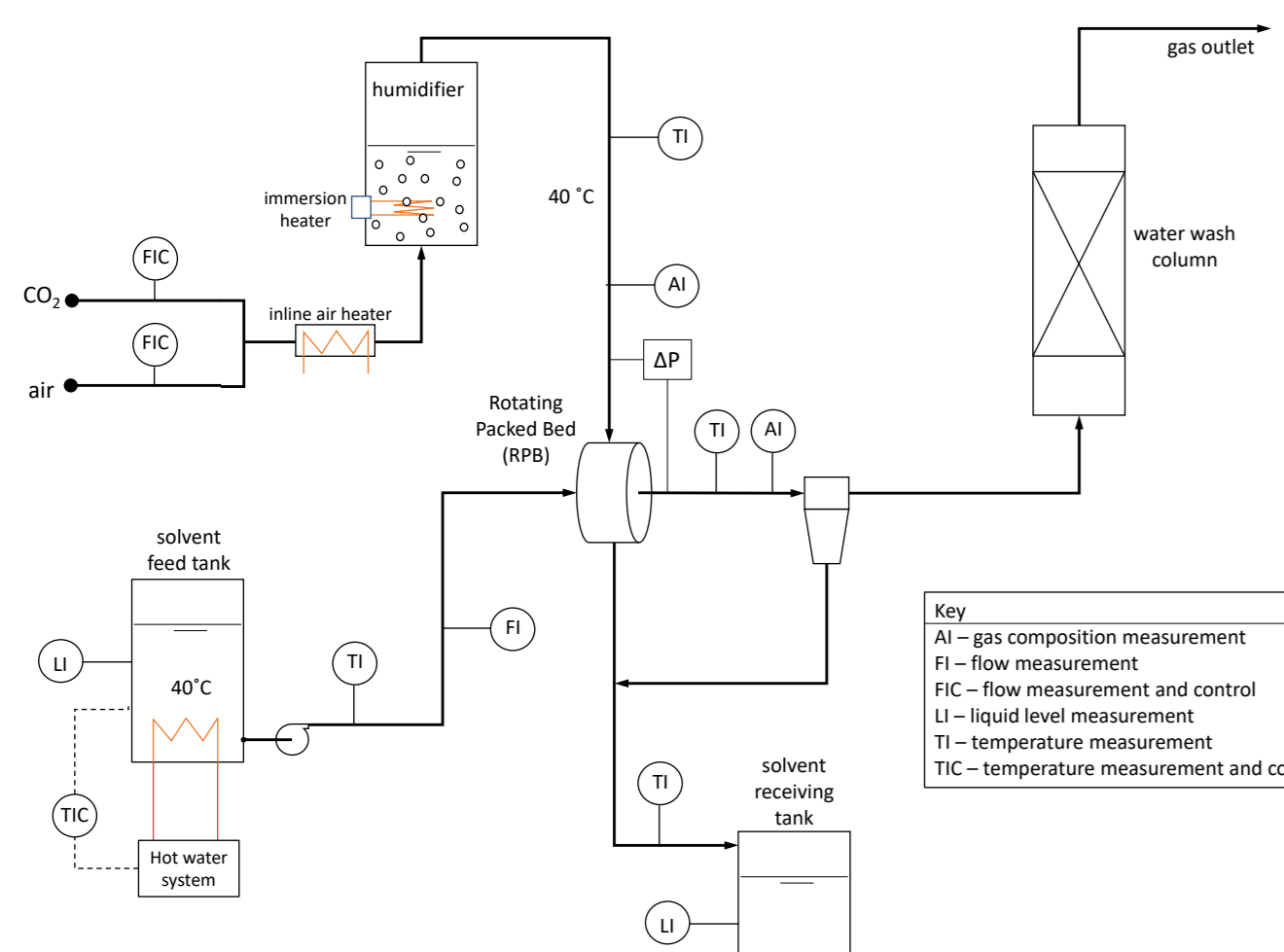
Solvent based carbon capture system for 250 MWe gas power station. Values are for 30 mass% mono ethanol amine solution.

Regenerator



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

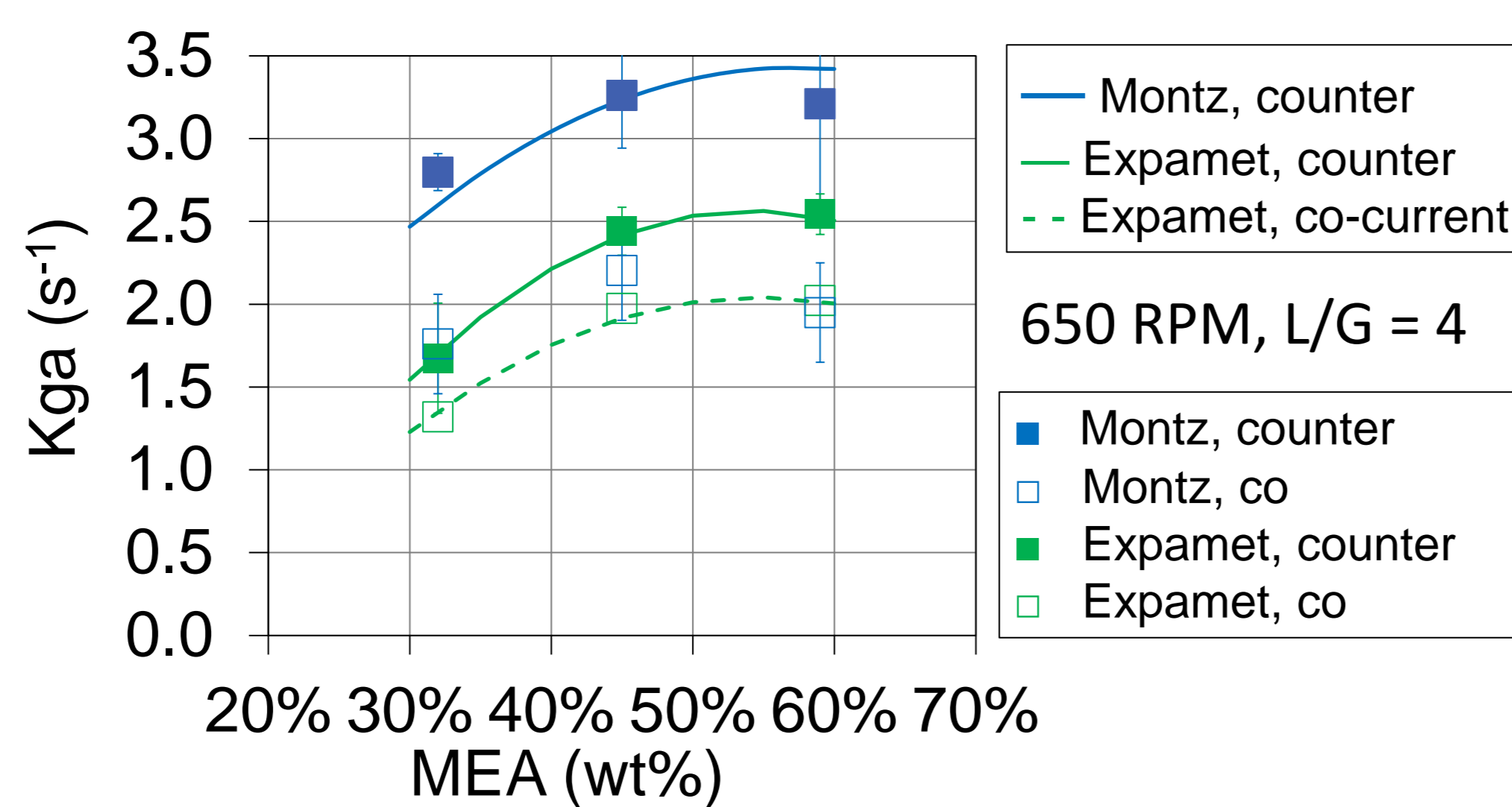
CO₂ Absorption Experiments



PFD of absorption experiment

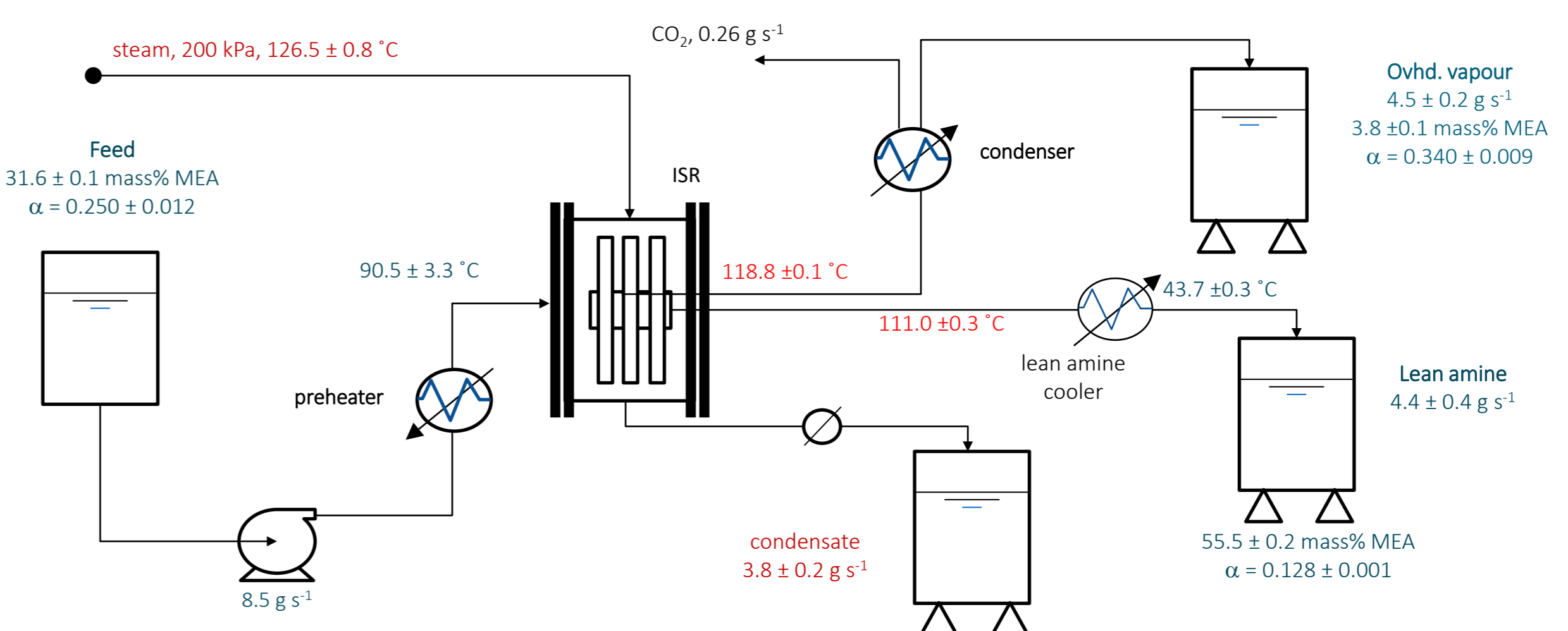
- Synthetic flue gas is generated by mixing air and CO₂, preheated to 40°C and humidified.
- MEA is preheated to 40°C and $\alpha = 0.2 \frac{\text{mol}_{\text{CO}_2}}{\text{mol}_{\text{MEA}}}$ preloading.
- The inlet flow is monitored using a Coriolis flow meter.
- Gas analysers used to monitor inlet and outlet CO₂ molar concentration
- High degree of flexibility for packing types and configurations.

- Experiments characterise mass transfer in the RPB under realistic conditions.
- Improved mass transfer results using propriety packing developed with Julius Montz GmbH.



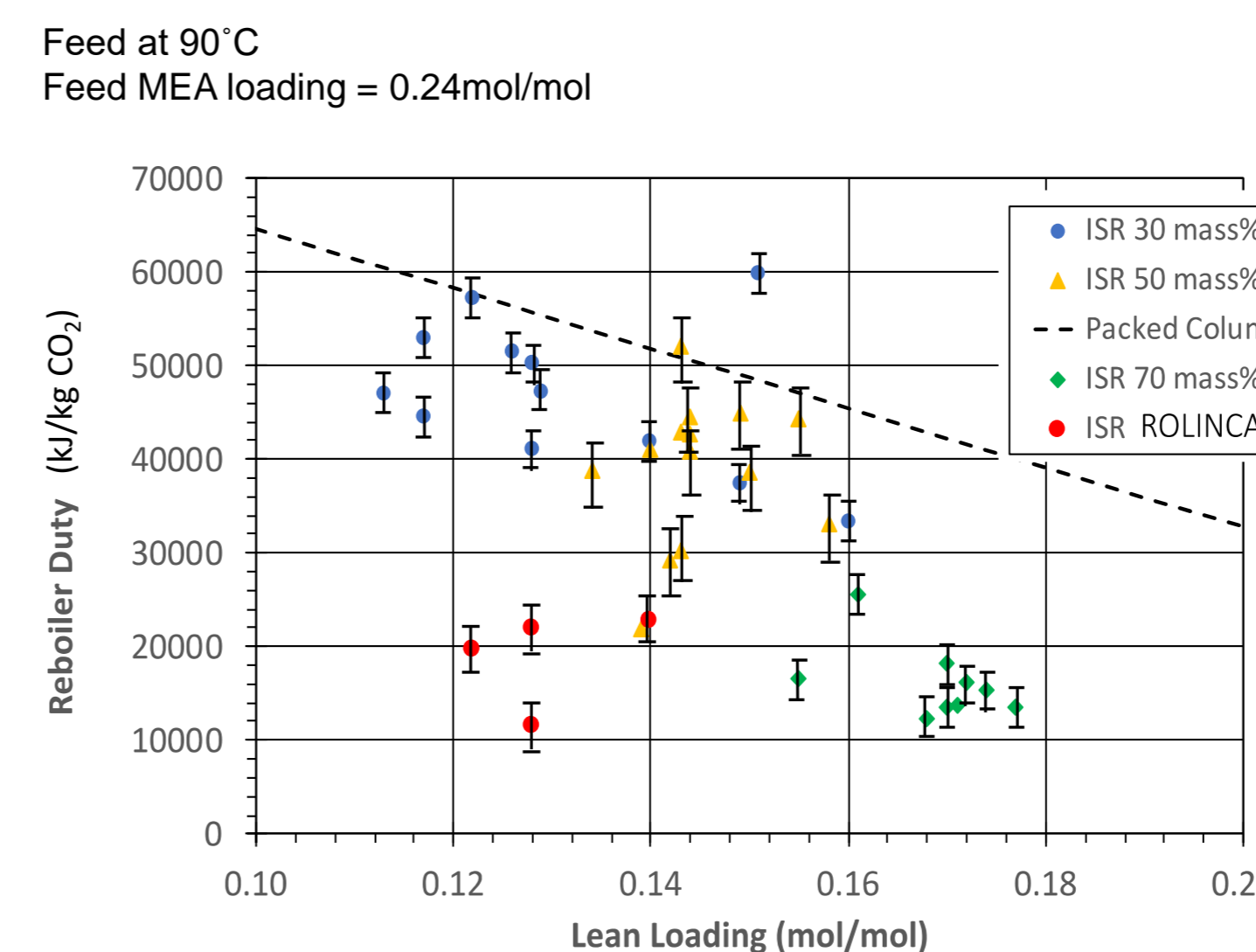
Comparing the Absorption at different MEA concentrations, for different packings and configurations.

Regeneration tests using rich MEA solutions



PFD of regeneration tests

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



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.

Artemis Project



- 1.1m rotating packed bed, aiming to achieve a 90% carbon capture target.
- To be installed at Doosan Babcock Ltd. Glasgow site.
- Testing to achieve a technology readiness level 7 (demonstration in operational environment).
- Absorption and regeneration RPB processes will be installed as a functioning intensified carbon capture pilot-plant.

Conclusions

- The pilot-plant RPB system is capable of testing carbon-capture solvents for CO₂ absorption and regeneration under realistic conditions.
- 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.
- Mass transfer during absorption improves with solvent concentration, packing optimisation and Counter-current gas flow configuration.

Acknowledgements

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