Continuous Two-Stage Thermal Reclaiming of Monoethanolamine

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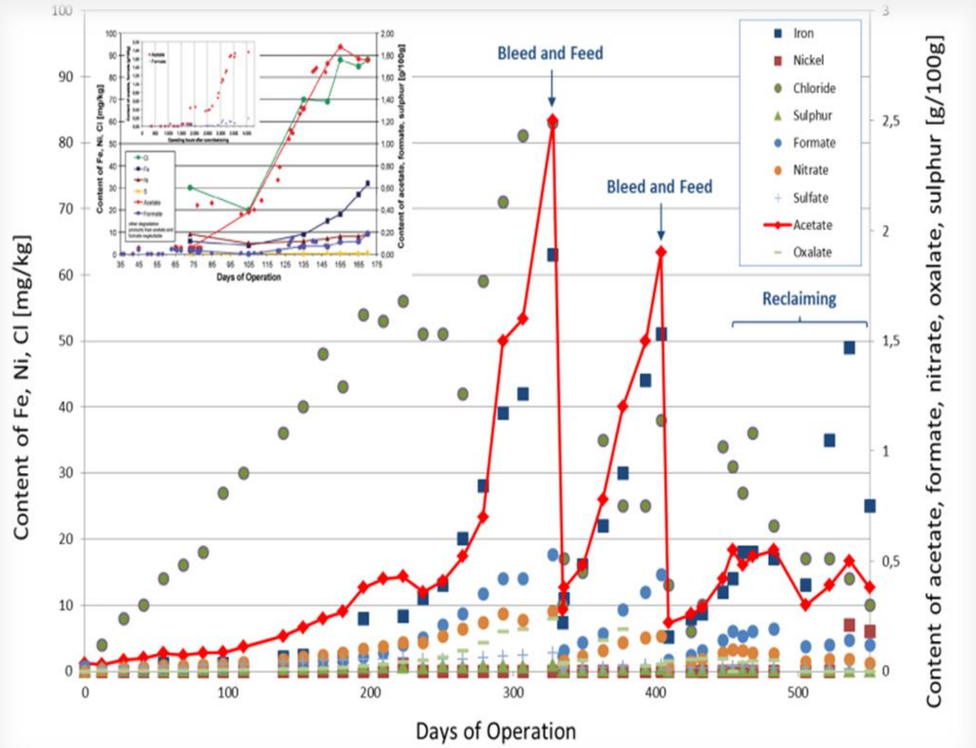
Monoethanolamine Needs Reclaiming

- MEA degradation is not linear
  - Accelerates when high amounts of impurities are present.
- Can encounter runaway degradation problems
  - Mass degradation rates
- Adequate reclaiming is a necessity
  - Need to remove most if not all impurities to stop accumulation



[Results of the 18-month test with MEA at the post-combustion capture pilot plant at Niederaussem https://doi.org/10.1016/j.ijggc.2019.102945](https://doi.org/10.1016/j.ijggc.2019.102945)

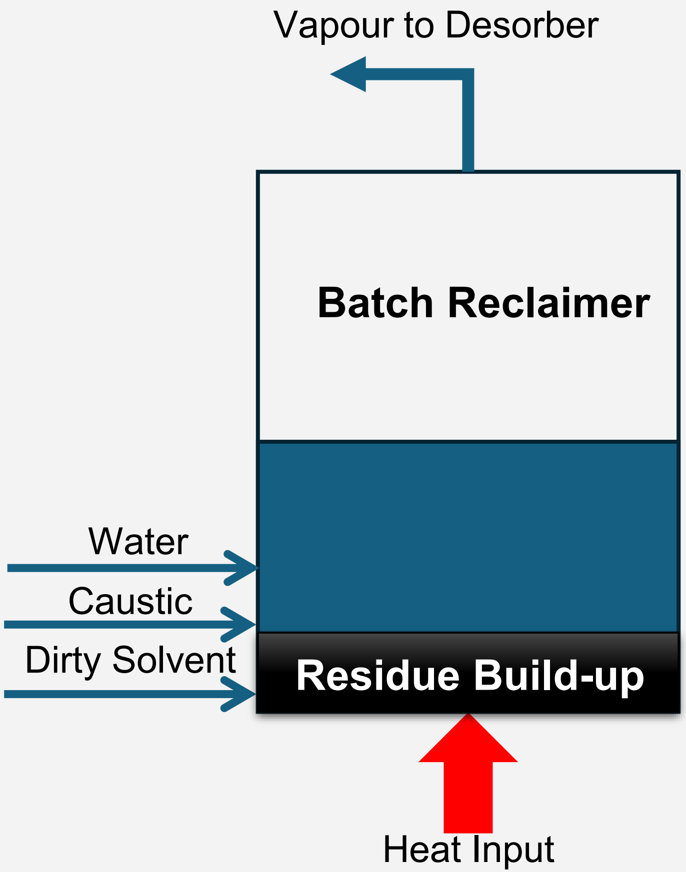
Selectivity For Monoethanolamine Reclaiming

		Degradation products	Metals	HSSs
MEA reclaiming, total number of inventory volumes reclaimed	3*			
Expected impurity reduction for ideal selectivity, s=1	96.02%			
Oct-15 reclaiming run after 1843 hrs operation – reduction from reclaiming		~95%	>95%	>95%
Apparent selectivity for removal (for 95%)		0.9986	0.9986	0.9986
CESAR1 reclaiming, total number of inventory volumes reclaimed	4.5			
Expected impurity reduction for ideal selectivity, s=1	98.98%			
Apr-20 reclaiming run after ~1600 hrs operation – reduction from reclaiming		84%	95%	89%
Apparent selectivity for removal		0.4072	0.6657	0.4905
Unremovable fraction, x		15.1%	3.9%	10.0%
Oct-20 reclaiming run after ~2200 hrs operation		82%	93%	89%
Apparent selectivity for removal		0.3811	0.5909	0.4905
Unremovable fraction, x		17.1%	6.0%	10.0%

Table 1. Reported TCM thermal reclaiming data and estimated selectivities for removal (see (Gibbins, 2024) for calculation details)

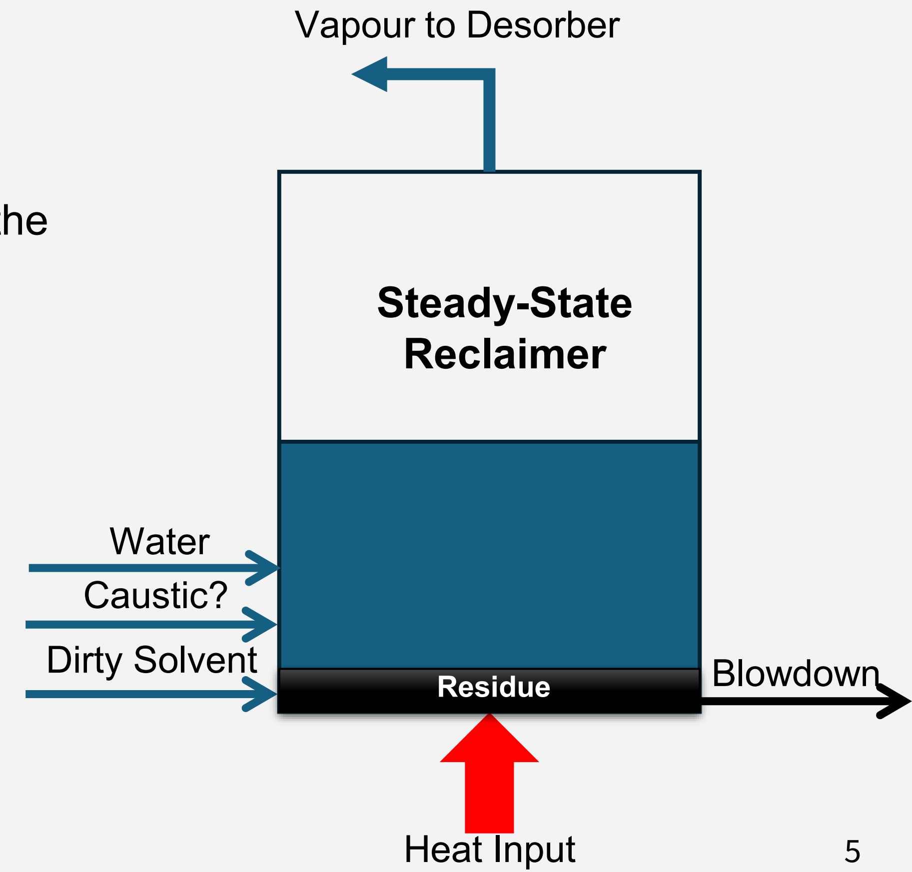
'Traditional' batch reclaiming

- Dirty solvent feed into the reclaimer
- Impurities are rejected and accumulate at the reclaimer bottoms
- The temperature as that occurs gradually increases.
- Operated in 2 to 3 steps
    - Solvent Feed- To a max Temperature
    - Water Feed- To a max recovery (water consumption)
    - Residue Concentration – Reduction of waste



Steady-state reclaiming 1

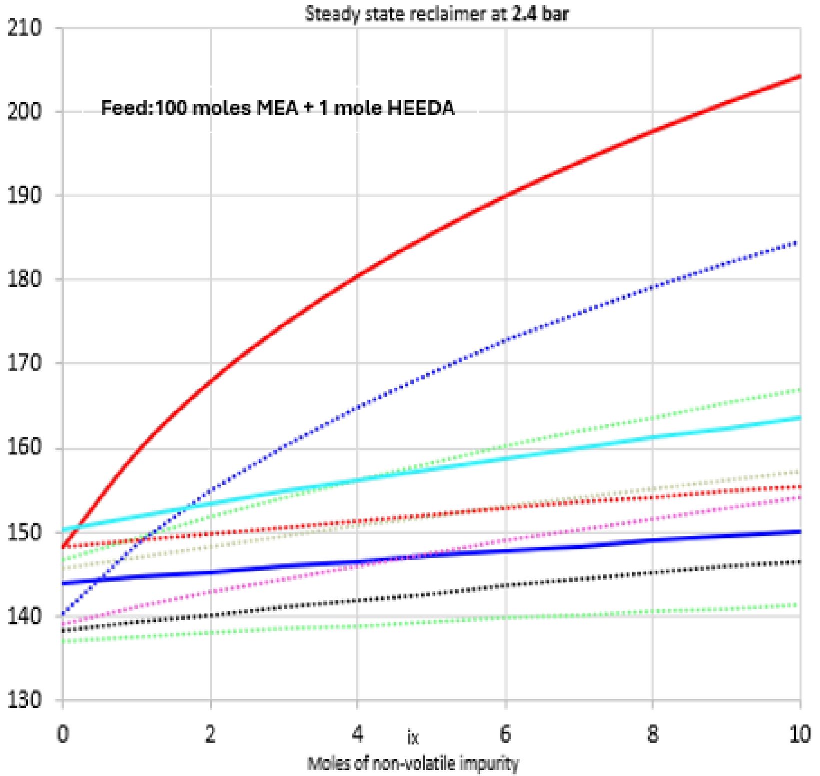
- Dirty solvent feed into the reclaimer
- Impurities are rejected and are extracted form the reclaimer bottoms
- The temperature can be set at a maximum allowed temperature
    - least energy and water consumption

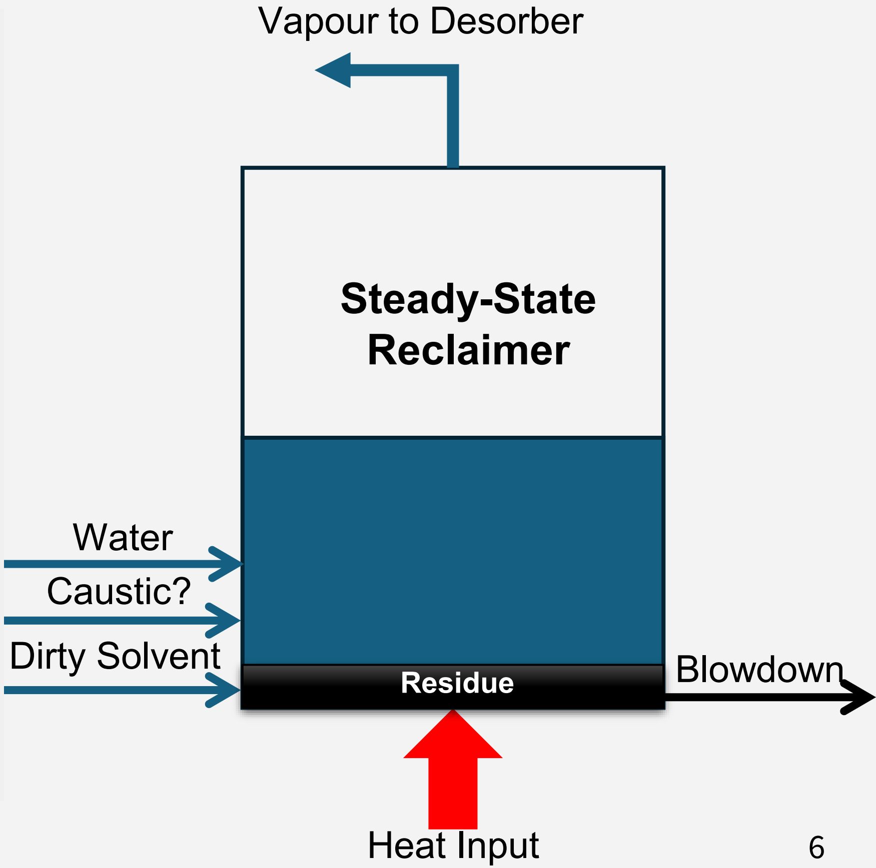


Steady-state reclaiming 2

Temperature °C

MEA in BD	H_2O feed
1	1000
5	1000
10	1000
20	1000
1	2000
5	2000
10	2000
50	2000
10	700
20	700





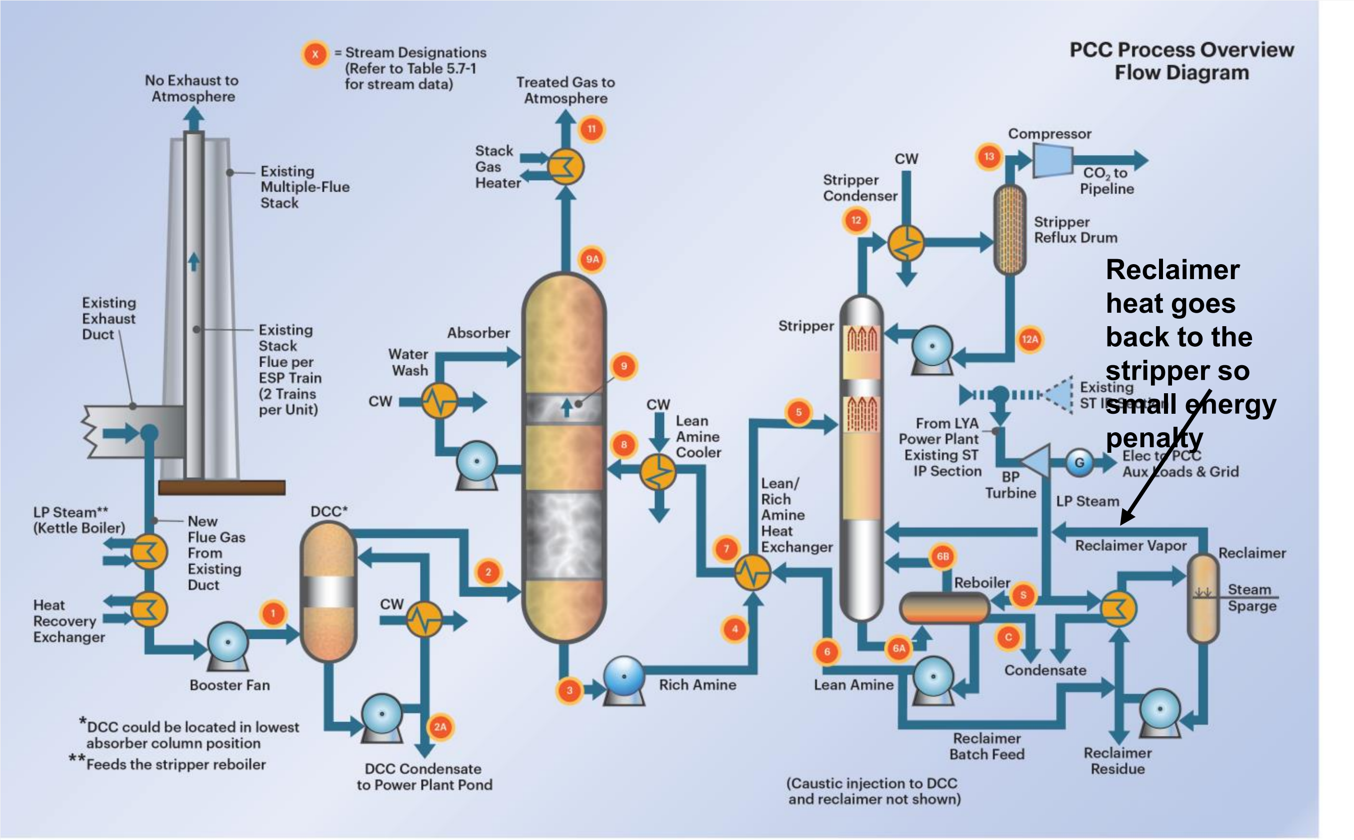
To keep the temperature low, you need to add more water or increase blowdown as your solvent becomes more impure

Desorber-connected continuous reclaimer for MEA

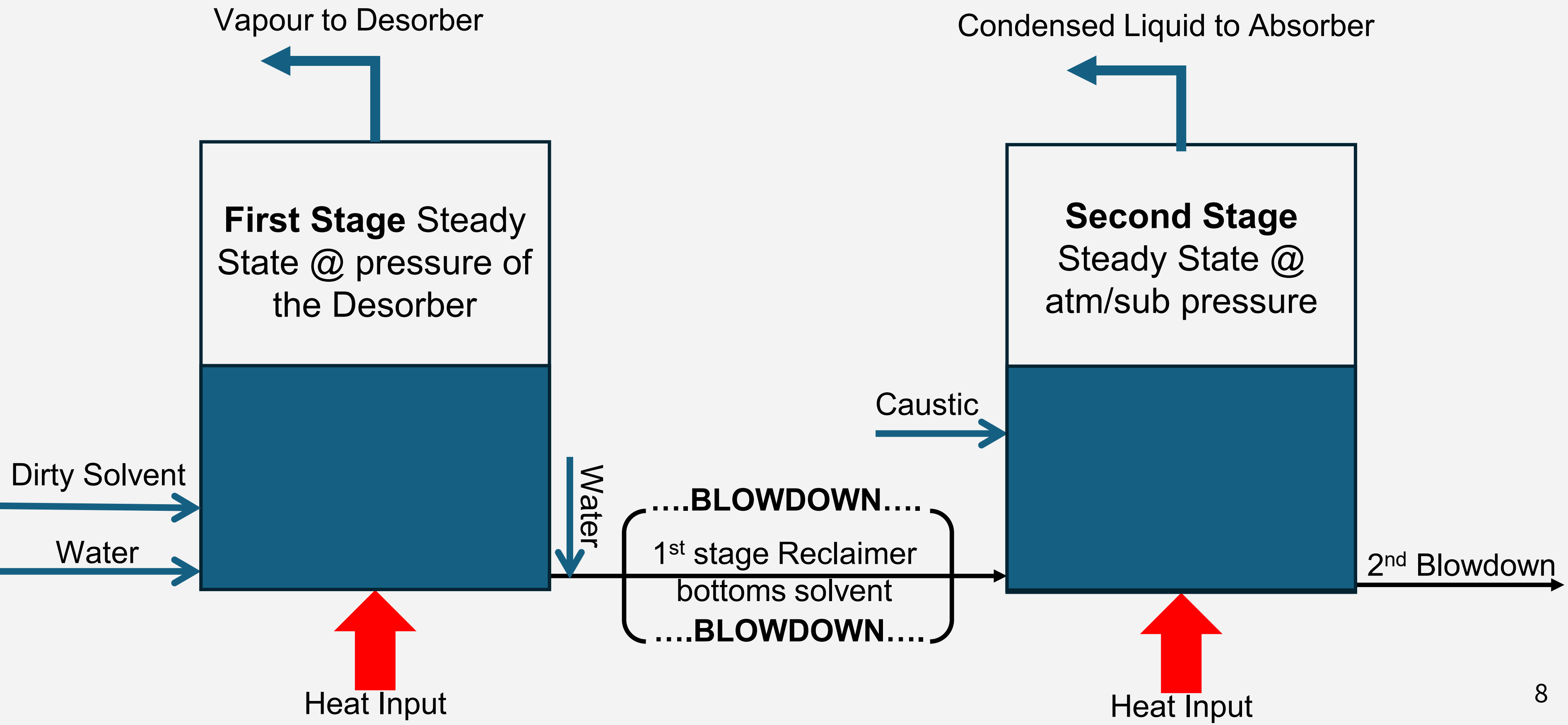
- Retrofit study for a brown coal power plant in Australia

Bechtel (2018) for CO2CRC, Retrofitting an Australian Brown Coal Power Station with Post-Combustion Capture, http://www.co2crc.com.au/publication-category/reports

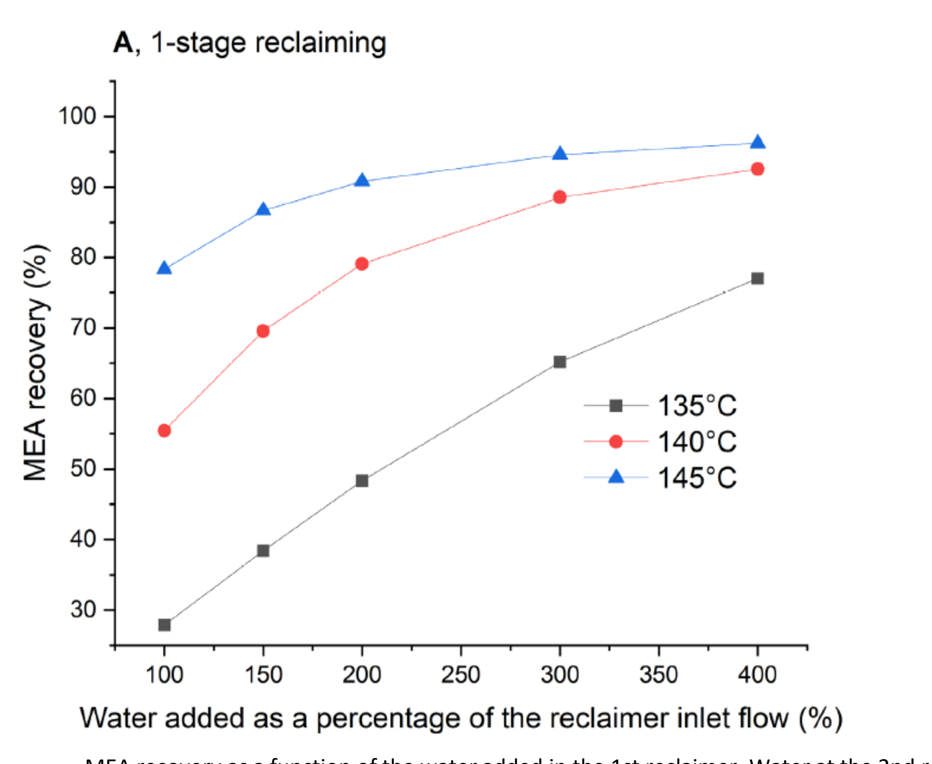
- Continuous reclaimer venting into stripper to recover thermal energy
- Typically, can reclaim one inventory volume in one week to one month
- Can reject >99% of impurities in simple reclaimer with heat recovery – not possible with blends
- Reclaimer waste may be usable for SCR

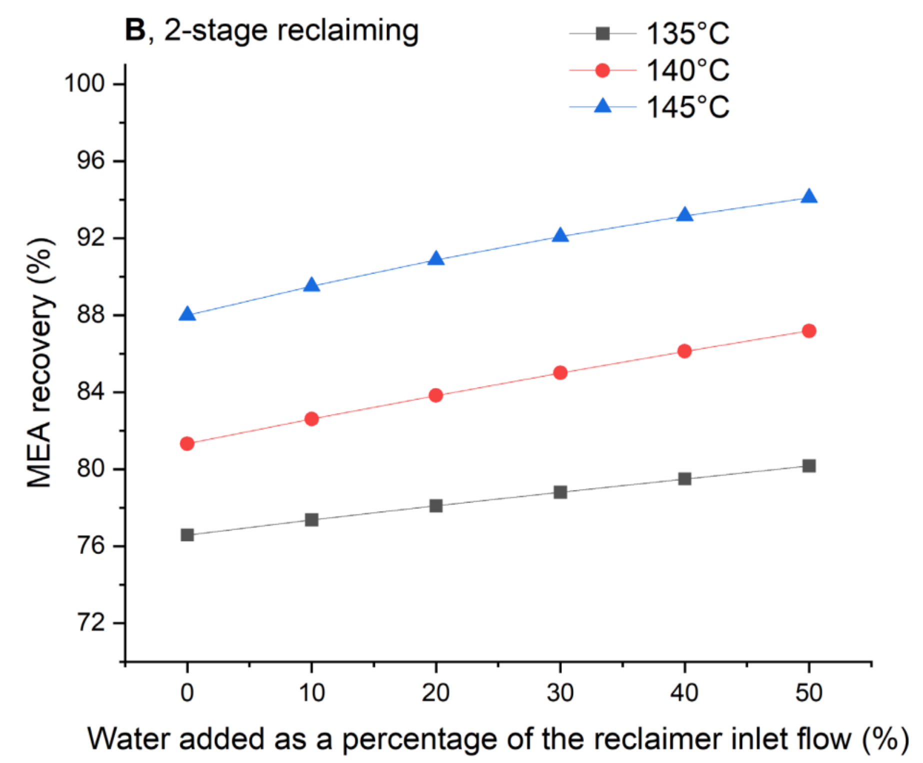


Two-stages at steady state



Two-stage vs single stage at steady state





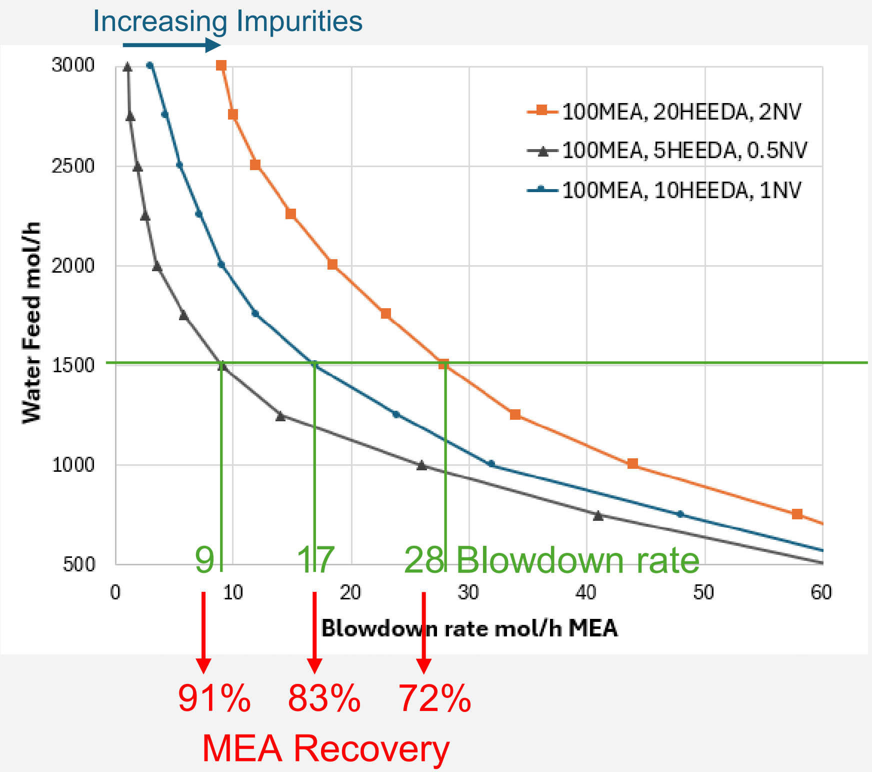
MEA recovery as a function of the water added in the 1st reclaimer. Water at the 2nd reclaimer is fixed at 30% of the inlet flow. Both stages operate at the same temperature.

Can be found @ DOI: 10.1021/acs.iecr.4c04530

Tradeoff between MEA recovery, Water addition and Degradation product recovery

Limits with steady states 1

- Operating a reclaimer at 145 deg.C.
- A large trade off between blowdown rates or water addition.
- 3 scenarios with varying amount of impurities.
- At a set water feed rate you must have different blowdown rates to keep temperature constant.
- Second steady state suffers the same limits
  - Can achieve x 100% recovery but that is extremely water costly.
  - Potential to have a 3rd batch stage to limit water consumption and maximise MEA recovery (vacuum)
- This is just modelling which needs validation.
  - Use built lab steady state and batch reclaimer.



Limits with steady states 2

- Operating a reclaimer at 145 deg.C.
- A large trade off between blowdown rates or water addition.
- 3 scenarios with varying amount of impurities.
- At a set water feed rate you must have different blowdown rates to keep temperature constant.
- Second steady state suffers the same limits
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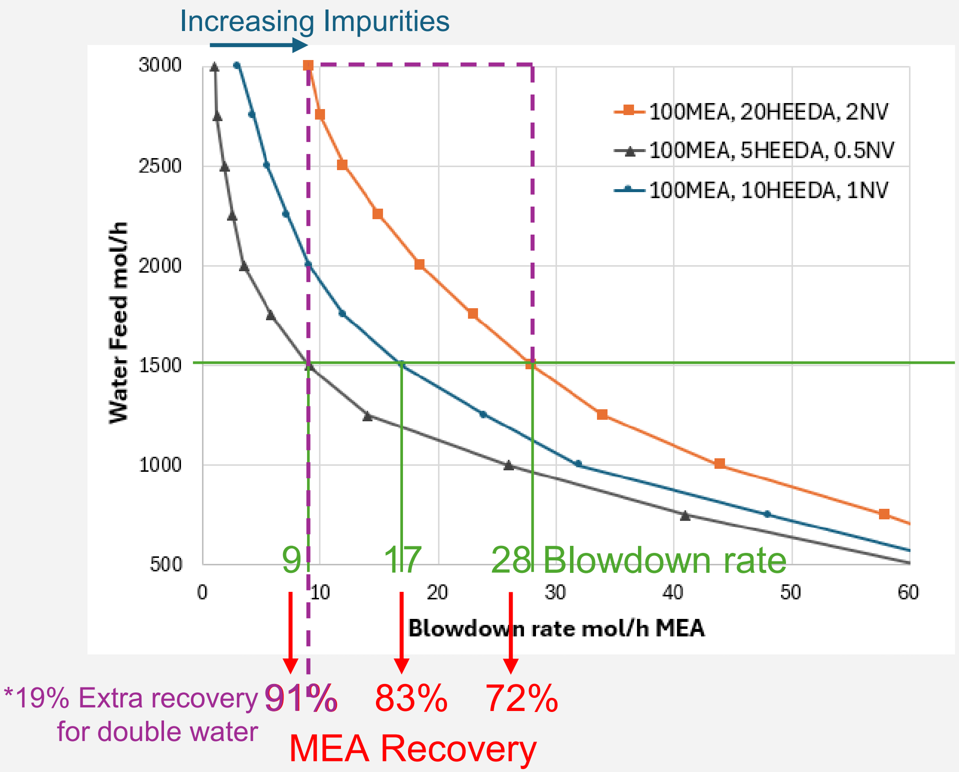
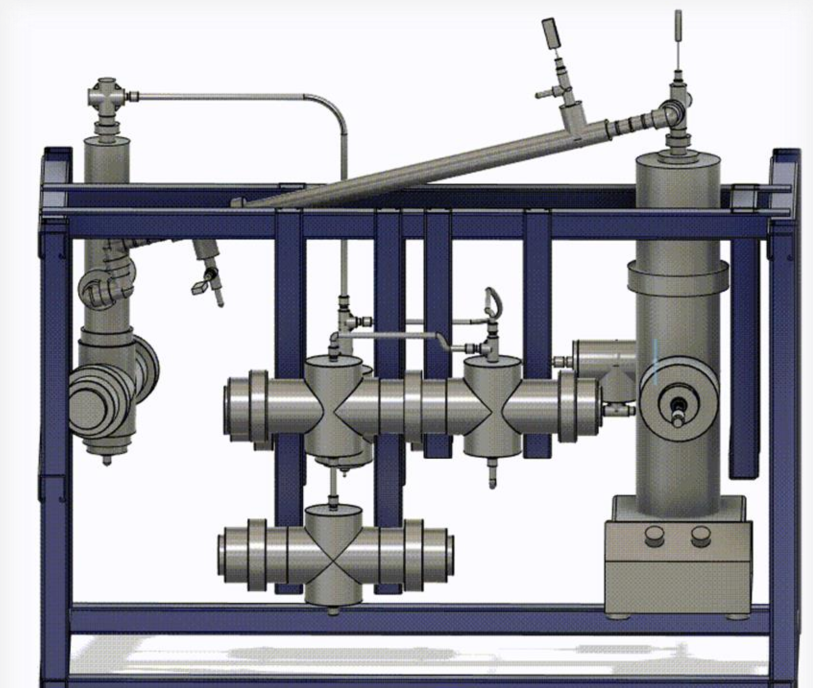


Stage 1 Continuous Thermal Reclaimer

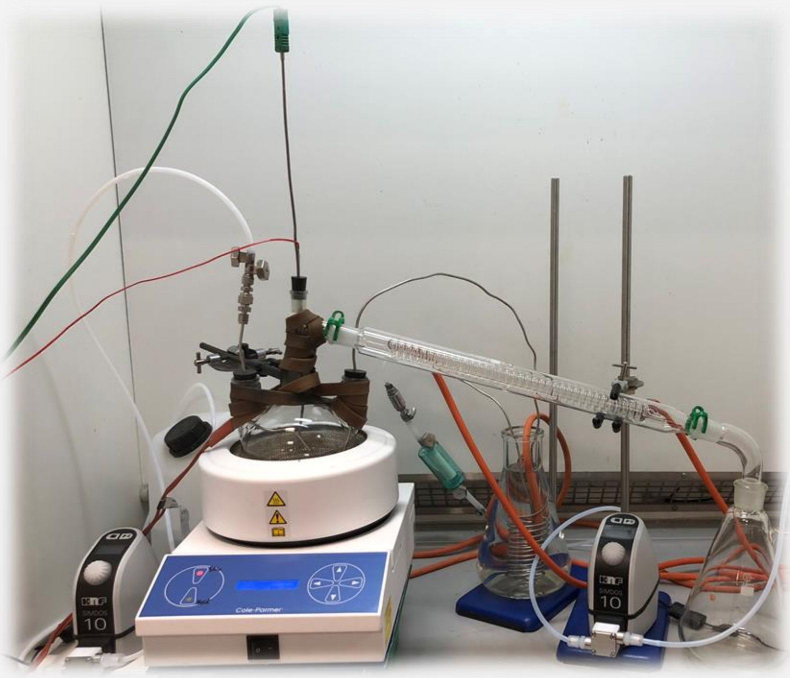


GHGT-17 [OCT 2024]

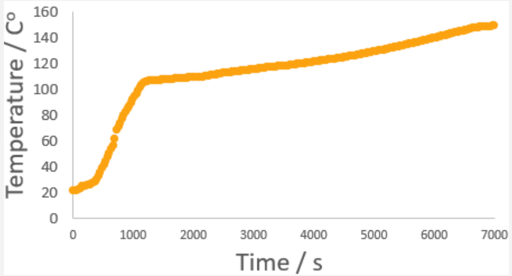
PCCC- 8 [SEP 2025]

Joel, Lucas and Pokora, Marcin and Ibrahim, Aisha and Lucquiaud, Mathieu and Michailos, Stavros and Gibbins, Jon, SMART - Solvent Management At Reduced Throughput – A Prototype Demonstration Plant (December 19, 2024). Proceedings of the 17th Greenhouse Gas Control Technologies Conference (GHGT-17) 20-24 October 2024, Available at SSRN: https://ssrn.com/abstract=5064129

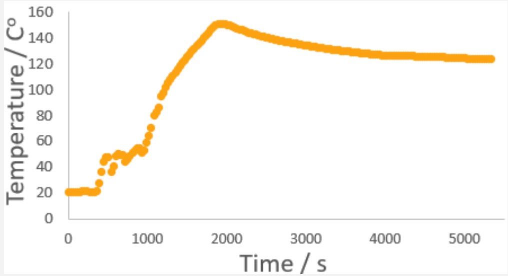
Lab Batch Thermal Reclaimer 1



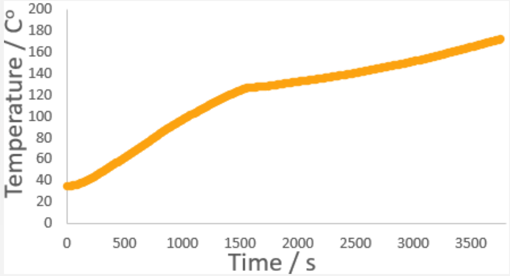
- Step 1: Solvent Feed



- Step 2: Water Feed

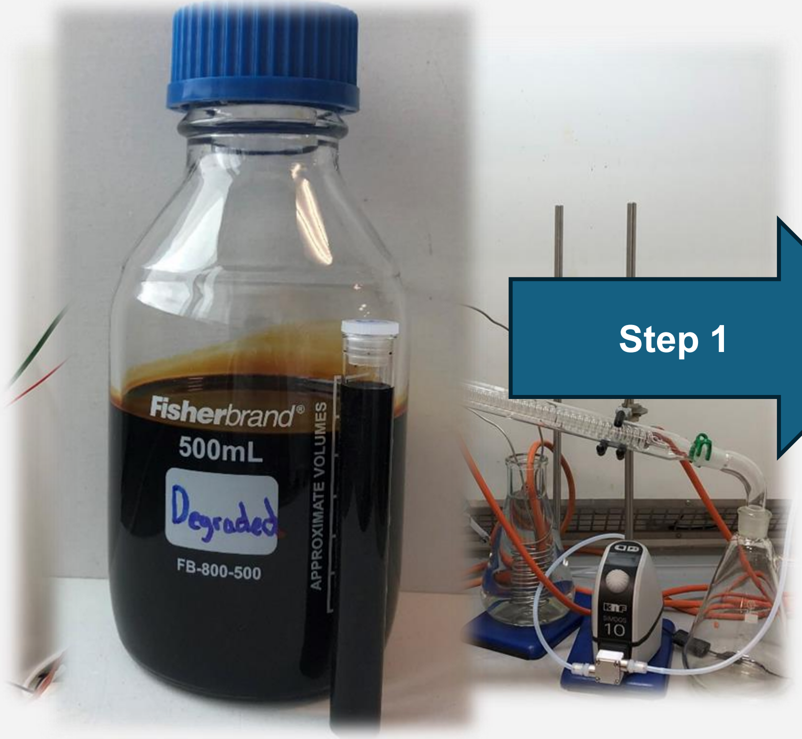


- Step 3: Residue Reduction



Temperature was used as an indicator to determine the endpoint of step 1 & 2

Lab Batch Thermal Reclaimer 2



Step 1

- Step 1: Solvent Feed

Step 2

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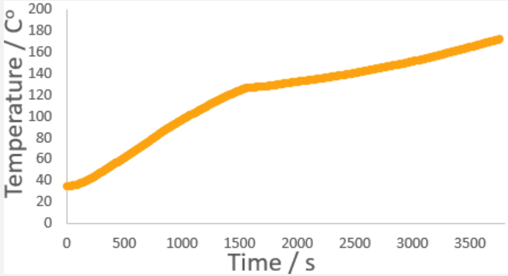

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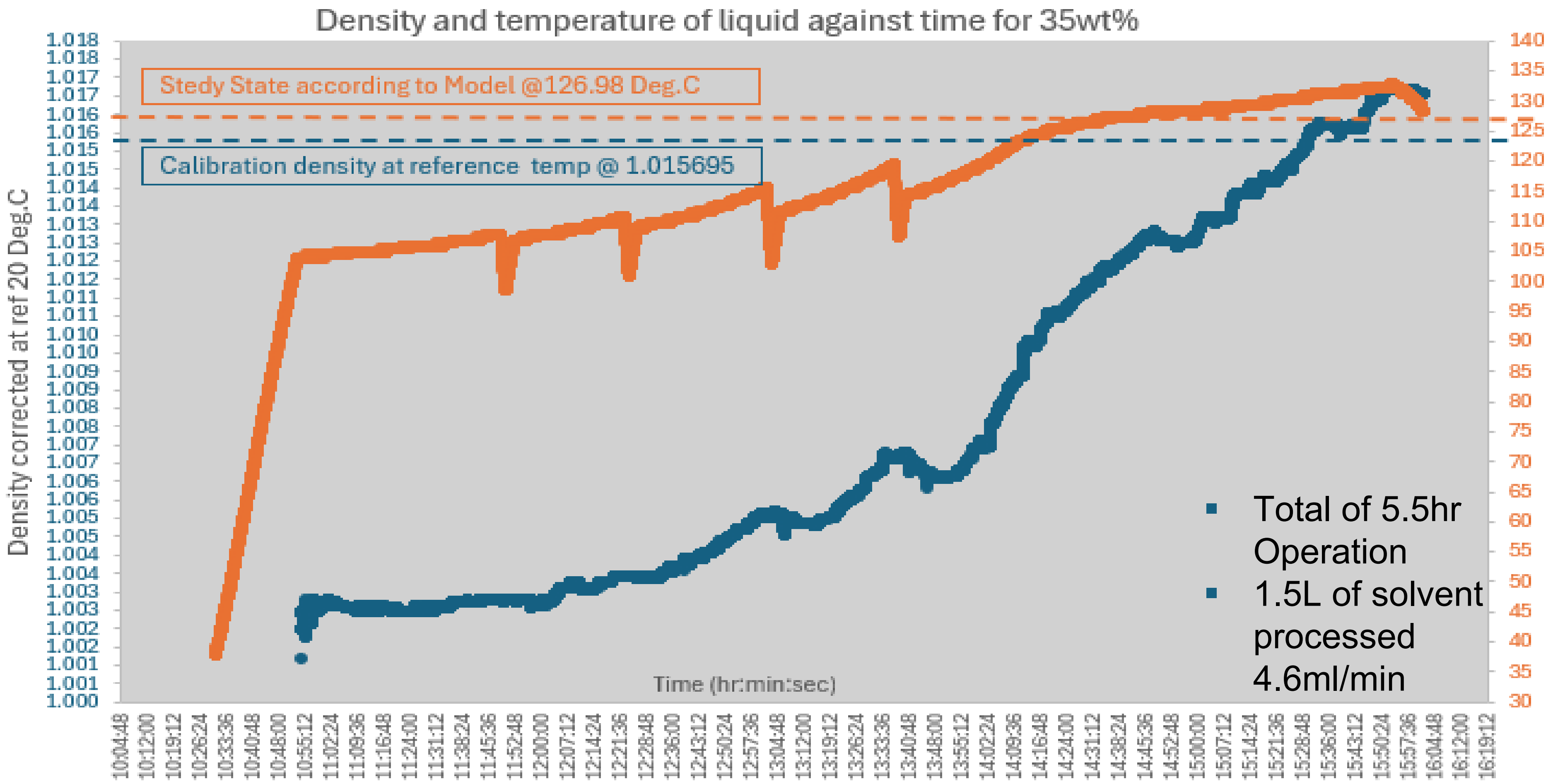
Real time Density Measuring during Reclaiming

- Modified batch apparatus

- Equipped with a Wika devil sensor for 'real' time density of distillates.

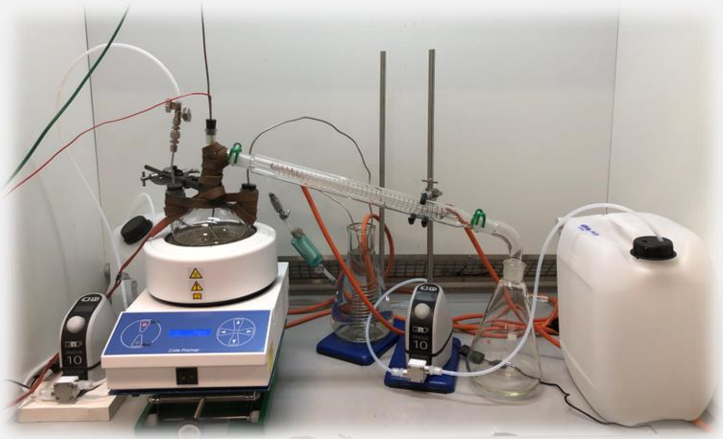
- Can see density changes through out the reclamation process.

- Can this be used to indicate at which points 2nd stage reclaiming steps should stop?



- Total of 5.5hr Operation
- 1.5L of solvent processed 4.6ml/min

Current Status & Next Steps



- Modelling can give ideas but in reality, too complex
- Steady state and batch designs built & ready for operation using added impurities of choice
- Run the 2 reclaiming stages in tandem
- Run long-term tests, quantify amine recovery, validate benefits and model
- Reclaiming should not be an afterthought, and you cannot look at it in isolation because the way you reclaim effects the whole process. Hence, the development of the SMART rig. See slides from Session 7A talk 4

Acknowledgements

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