Simulation and multivariable optimization of post-combustion capture using piperazine - DTU Orbit (08/11/2017)

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Piperazine presents a great potential to develop an energy efficient solvent based CO_2 post-combustion capture process. Recently 8 molal piperazine (PZ) has shown promising results, however it faces operational challenges due to limited solid solubility. The operating range can be extended by decreasing the concentration of PZ and/or increasing the lean loading. However, optimal process conditions must be determined accounting for heating and cooling demands plus solvent re-circulation. In this paper, we identify and generalize trends of performance for a broad range of operating conditions: 1.8-9 m PZ/kg water (molal) and 0.2-0.6 lean loading for absorption and desorption in both, open and closed-loop simulation. We pinpoint scenarios where intercooling significantly improves the performance of the post-combustion process. The energy penalty is minimized as part of the closed-loop multivariable optimization. The results are created in Aspen Plus using the hybrid CAPCO2 rate-based user model. This model includes precipitation when estimating the heat and mass transfer rates. The results show how the capture process needs to be operated up to 14% above the minimum achievable heat duty, to avoid clogging from solid formation. 5 m PZ is the most promising trade-off between energy efficiency and solid-free operation with a specific reboiler duty of 3.22 GJ/t CO2 at 0.34 lean loading. The performance of the process can be further improved by assuming a minimum temperature of 30 °C which gives an optimal specific reboiler duty of 3.09 GJ/t CO2 (8 m PZ, 0.334 lean loading) for conditions without advanced heat integration.

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