Escuela Superior Politécnica del Litoral

PARES y NONES
Un break científico

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A Techno-Economic Evaluation of Post-Combustion Carbon Capture Using Renewable Ammonia

SCAN ME

PROBLEM

Post-combustion carbon capture (PCC) using conventional amine-based solvents like MEA involves high regeneration energy, solvent degradation, and environmental concerns. Aqueous ammonia offers a low-cost, renewable alternative, however, its implementation faces technical challenges such as ammonia slip and solid precipitation (ammonium bicarbonate), which can lead to equipment blockages and increased operational complexity.

GENERAL OBJECTIVE

To evaluate the technical and economic performance of aqueous ammonia-based PCC systems with different process configurations: Base case, Rich Solvent Flashing (RSF), Lean Vapor Compression (LVC), and a novel Crystallizer-based (CRY) setup treating flue gas from a gas-fired power plant.

PROPOSAL

The study employed Aspen Plus® simulations for modeling four PCC configurations as shown in Figures 1 to 4: a base case, RSF, LVC, and CRY. Each setup treated 350 t/h of flue gas using a 5 wt% aqueous NH_3 solution. Process parameters such as CO_2 capture rate, ammonium bicarbonate formation, reboiler duty, regeneration energy, and economic costs (CAPEX/OPEX) were analyzed. The CRY configuration also evaluated the production of AmBic as a valuable by-product.

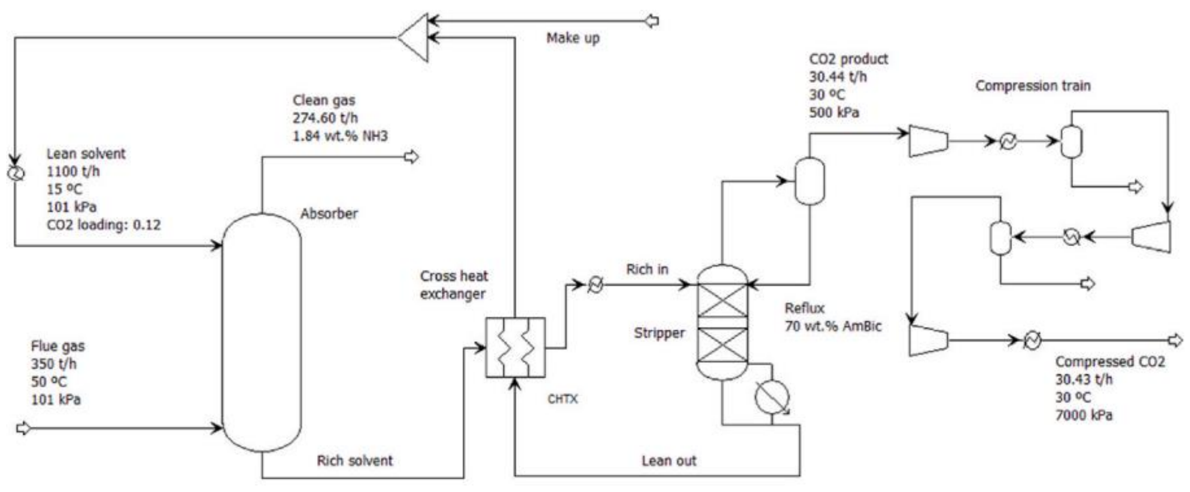

Fig. 1. Base case PCC plant layout.

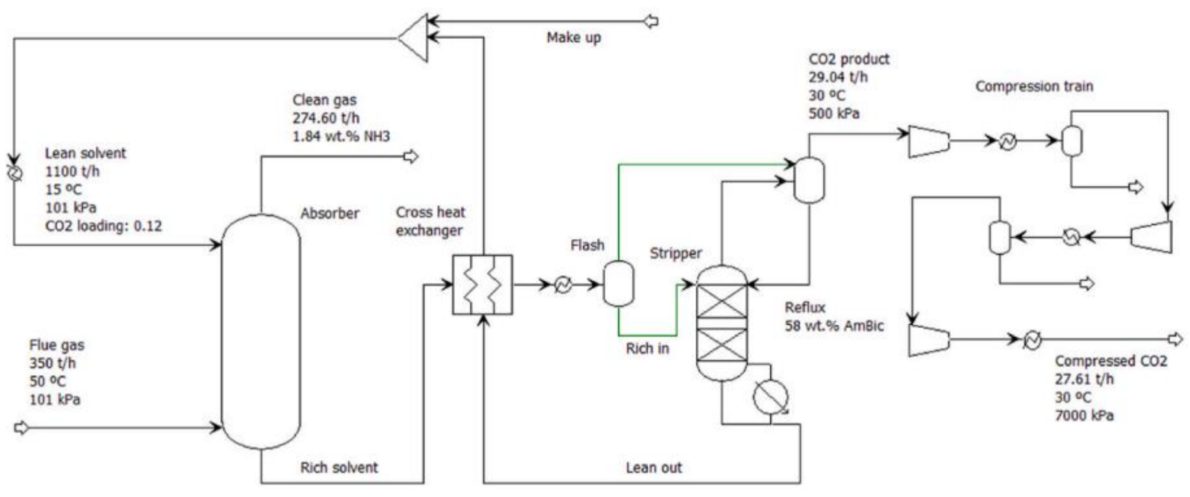

Fig. 2. Rich solvent flashing PCC plant layout.

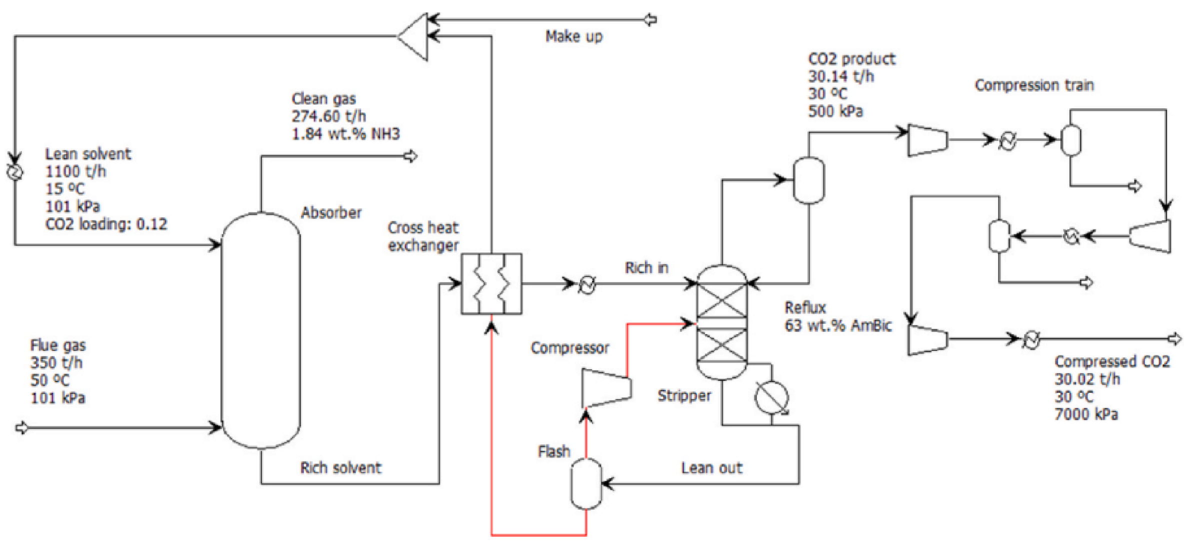

Fig. 3. Lean vapor compression PCC plant layout.

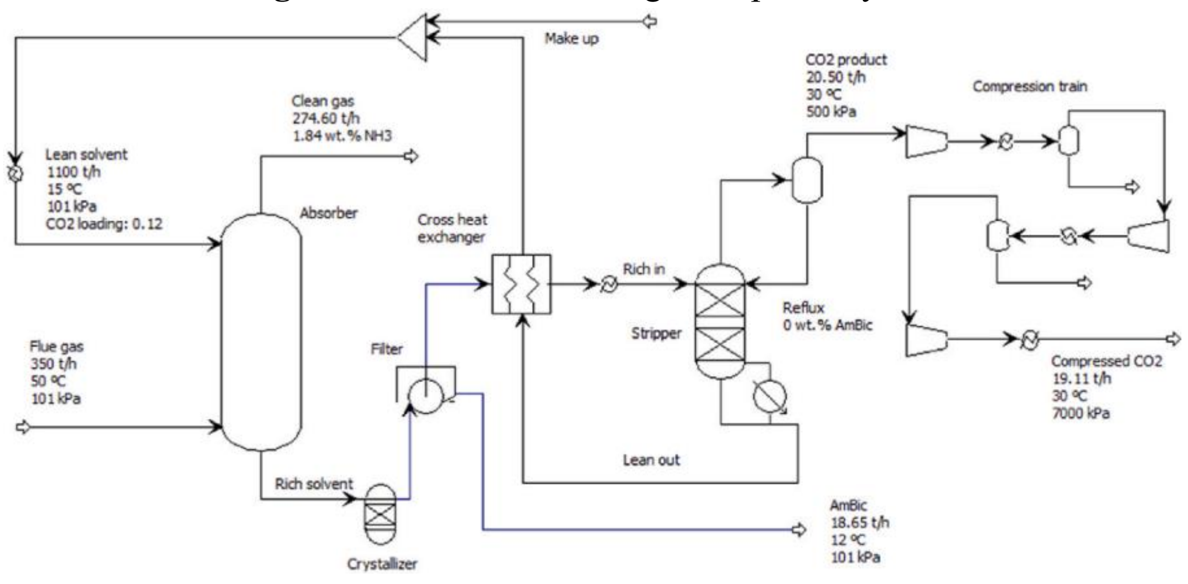

Fig. 4. CRY PCC plant layout.

RESULTS

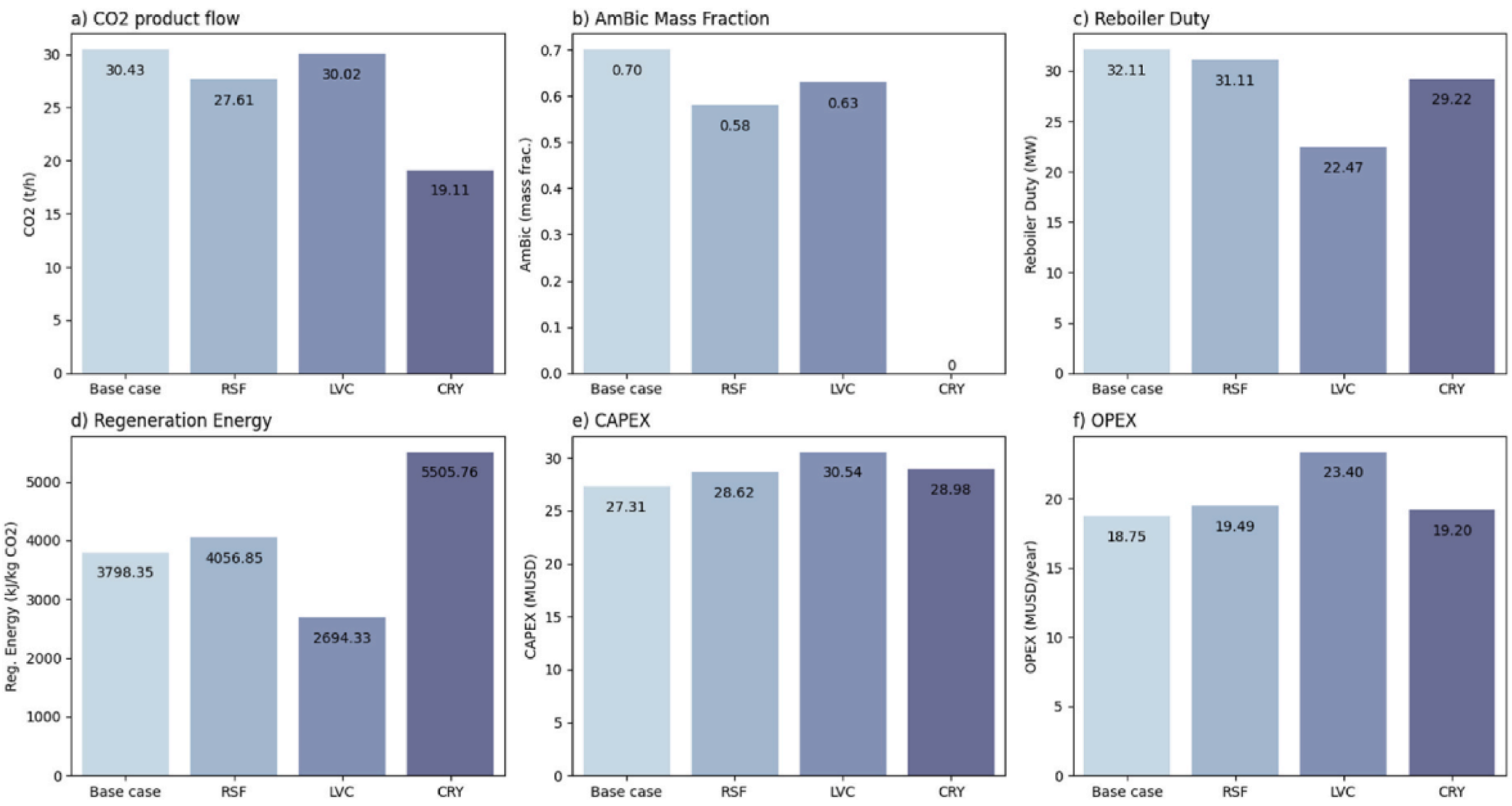

Fig. 5. Bar charts for the different key performance indicator. (5a-CO2 flow rate comparison, 5b-AmBic mass fraction comparison, 5c-Reboiler duty comparison, 5dRegeneration energy comparison, 5e-CAPEX comparison, and 5f-OPEX comparison).

CONCLUSIONS

- RSF offered modest improvement in AmBic reduction (−17.37%) and a slight decrease in reboiler duty (−3.10%), but also led to reduced CO_2 product flow while increasing CAPEX and OPEX
- LVC achieved significant energy savings, with a 30% reduction in reboiler duty and 29% lower regeneration energy. However, these gains came with the highest OPEX due to the additional compressor.
- CRY showed the lowest AmBic content (0%), eliminating precipitation risks in the reflux section. It reduced reboiler duty by 9%, though this was offset by a 37% drop in CO_2 flow and a 45% rise in regeneration energy due to CO_2 redirection for AmBic formation. However, AmBic recovery adds economic value, positioning CRY as a dual-benefit configuration.