

Novel Low Grade Waste Heat Recovery System with Simultaneous Electricity Generation, Carbon Sequestration and Urea Production

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Over 60% of energy generated during electricity production is discarded as low-grade waste heat. Concurrently, modern power plants are reluctant to capture and sequester flue-gas CO₂, due to high cost and significant efficiency reductions. The novel system invented in this research converts untapped low grade waste heat into valuable byproducts including electricity, captured CO₂, and Urea. The system generates electricity by engineering a concentration gradient using CO₂ emissions and recycled NH₃(aq) in an Osmotic Heat Engine. An NH₄HCO₃ solution then selectively decomposes into pure CO₂ and NH₃ gas streams for carbon capture and Urea production. The performance of each component was separately evaluated, and integrated to determine viability of the complete process. In electricity generation, a high concentration solution was created through NH₃(g) (recycled) and CO₂(g) absorption with pH 8.6 and NH₃:CO₂ 1.3:1, parameters exceeding draw solution requirements. 14.4Wh electricity was produced per kg CO₂ scrubbed, translating to 180 MWh per day from a 500 MW power plant. The Pressurization-Depressurization CO₂(g) capture at 45°C produced 98% NH₃(g), 1.02atm; 99% CO₂(g), 2.1atm and was 85.5% more efficient than current carbon-capture systems. Ammonium Carbamate/Urea production achieved conversion efficiencies of up to 99% and was carbon negative, net sequestering 770 kg CO₂/ton Urea. Based on the CO₂ emissions of 500MW coal power plant, the system will produce 335 metric tons of Urea/hour respectively. The proposed integrated system dramatically lowers the cost of carbon capture/sequestration and converts otherwise waste products into valuable Urea, while simultaneously improving the efficiency of power plants and industrial facilities.

Awards Won:

First Award of \$5,000