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 45oC 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