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Evaluation of reclaimer sludge disposal from post-combustion CO_2 capture

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Abstract

An important environmental issue for amine-based post-combustion CO_2 capture is the generation of reclaimer sludge containing degradation products and impurities that must be disposed. This paper evaluated the environmental fate of reclaimer wastes generated from three amine-based solvents (monoethanolamine, piperazine, and a methyldiethanolamine/piperazine blend) used for CO_2 capture at a pulverized coal and a natural-gas combined cycle power plant (900 and 810 MW_e, respectively) with typical flue gas compositions. The solvent loss and impurities and degradation accumulation in the CO_2 capture units were modeled. A techno-economic analysis of different reclaiming technologies was conducted. The reclaimer sludge was classified based on US and EU regulations for hazardous waste, and alternative options for reclaimer sludge disposal were evaluated.

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Keywords: CO_2 capture; monoethanolamine; piperazine; methyldiethanolamine; solvent reclaiming; reclaimer sludge disposal; degradation

1. Introduction

Post-combustion capture using aqueous, amine-based solvents is considered to be the most widely used technology in large scale carbon capture and sequestration (CCS) demonstration plants. An important environmental issue with respect to post-combustion capture is the generation of considerable amounts of degraded amine waste

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that has to be mitigated or disposed of in an environmentally suitable manner. Capture solvents can degrade due to the presence of other gaseous species present in the flue gas such as CO_2, SO_x, NO_x, O_2, halogenated compounds and other impurities. Some species react directly with the amine, while others (such as oxygen) are involved in a series of reactions to form a set of fragmented degradation products; in addition, at high temperature, the capture solvent can degrade to form high-molecular weight degradation products. Degradation products formed by amine based solvents can include heat stable salts (HSS), non-volatile organic compounds and suspended solids. Typically, these degradation products and heat stable salts exhibit corrosive properties and reduce solvent CO_2 absorption rates. Therefore, reclaiming is required to prohibit accumulation of these degradation products in high concentration in the capture solvent.

Typically, a slip stream of amine is sent to a reclaiming system, where part of the solvent is reclaimed and returned to the capture system. The most commonly implemented reclaiming system involves thermal reclaiming (Figure 1). (Other reclaiming systems involve vacuum distillation, ion exchange, and electrodialysis.) In this process, amine vapors recovered from distillation are sent back to the CO_2 capture unit. The waste sludge remaining in the reclaimer bottoms is periodically discharged to prevent any accumulation of these impurities in the reclaimer. Literature values [1] for generated reclaimer sludge using monoethanolamine (MEA) varies from 1.2 kg/MWh_{net} to 3.3 kg/MWh_{net} for natural gas combined cycle (NGCC) and pulverized coal (PC) CO_2 capture cases, respectively. This can result in a sizeable amount of reclaimer sludge and, therefore, it is important to identify a sustainable method for disposal of these wastes.

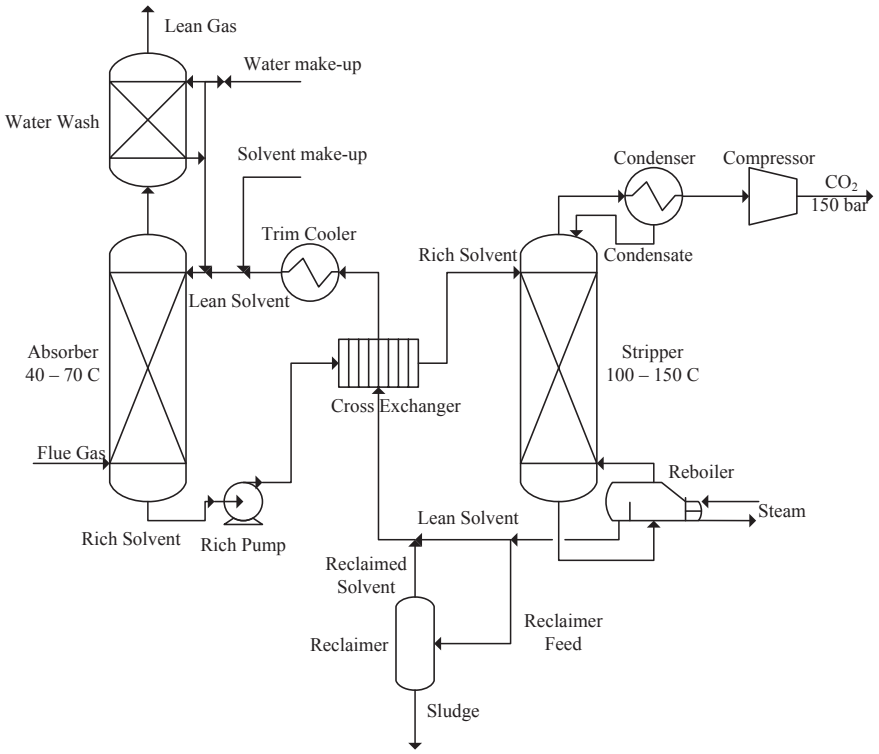

Fig. 1. Example amine scrubbing process flow diagram with thermal reclaiming.

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