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Experimental Investigation of Absorbent Regeneration Techniques to Lower the Cost of Combined CO_2 and SO_2 Capture Process

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Abstract : The presence of SO_2 in power plant flue gases makes flue gas desulfurization (FGD) an essential requirement prior to post combustion CO_2 (PCC) removal facilities. Although most of the power plants worldwide deploy FGD in order to comply with environmental regulations, generally the achieved SO_2 levels are not sufficiently low for the flue gases to enter the PCC unit. The SO_2 level in the flue gases needs to be less than 10 ppm to effectively operate the PCC installation. The existing FGD units alone cannot bring down the SO_2 levels to or below 10 ppm as required for CO_2 capture. It might require an additional scrubber along with the existing FGD unit to bring the SO_2 to the desired levels. The absence of FGD units in Australian power plants brings an additional challenge. SO_2 concentrations in Australian power station flue gas emissions are in the range of 100-600 ppm. This imposes a serious barrier on the implementation of standard PCC technologies in Australia. CSIRO's developed CS-Cap process is a unique solution to capture SO_2 and CO_2 in a single column with single absorbent which can potentially bring cost-effectiveness to the commercial deployment of carbon capture in Australia, by removing the need for FGD. Estimated savings of removing SO_2 through a similar process as CS-Cap is around 200 MMUSD for a 500 MW Australian power plant. Pilot plant trials conducted to generate the proof of concept resulted in 100% removal of SO_2 from flue gas without utilising standard limestone-based FGD. In this work, removal of absorbed sulfur from aqueous amine absorbents generated in the pilot plant trials has been investigated by reactive crystallisation and thermal reclamation. More than 95% of the aqueous amines can be reclaimed back from the sulfur loaded absorbent via reactive crystallisation. However, the recovery of amines through thermal reclamation is limited and depends on the sulfur loading on the spent absorbent. The initial experimental work revealed that reactive crystallisation is a better fit for CS-Cap's sulfur-rich absorbent especially when it is also capable of generating K_2SO_4 crystals of highly saleable quality ~ 99%. Initial cost estimation carried on both the technologies resulted in almost similar capital expenditure; however, the operating cost is considerably higher in thermal reclaimer than that in crystalliser. The experimental data generated in the laboratory from both the regeneration techniques have been used to generate the simulation model in Aspen Plus. The simulation model illustrates the economic benefits which could be gained by removing flue gas desulfurization prior to standard PCC unit and replacing it with a CS-Cap absorber column co-capturing CO_2 and SO_2, and it's absorbent regeneration system which would be either reactive crystallisation or thermal reclamation.

Keywords : combined capture, cost analysis, crystallisation, CS-Cap, flue gas desulfurisation, regeneration, sulfur, thermal reclamation
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