Capture of Industrial Carbon Dioxide Emission by Wet Scrubbing

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ABSTRACT

Analysis has shown that carbon dioxide forms between 13 to 15% of the combustion exhaust gases that are released directly into the atmosphere. The release of this gas into the atmosphere is chiey responsible for increased warming that is in turn causing changes in global climatic patterns. In order to minimize the impact this gas have on the environment, it is necessary that a capturing mechanism be developed. The main objective of this research therefore was to develop a method that would assist in reduction of carbon dioxide emissions generated from fossil fuel based combustion plants.

The technique involved post combustion capture method, in which solvent and gas contacted in a counterow con_guration within an absorber. A corrugated packing pro_le facilitated this contact by providing an optimal mass transfer surface for both gas and liquid phases. The di_erence between the molar ow rate of carbon dioxide owing across the absorber was measured to determine the rate of absorption based on equation of state of a perfect gas. Provision was made to allow measurement of ow conditions such as inlet gas ow rate, solvent ow rate, gas temperature and solvent concentration. These parameters were tracked to determine the impact of their variation on the absorption of carbon dioxide gas.

Baseline tests utilizing water as the solvent indicated that an absorption of more than 19% of carbon dioxide passing through the absorber occurred at a given liquid ow rate. This was attributed to solvent spreading within the absorber. When inlet gas ow rate was doubled, more than 19% of carbon dioxide passing through the rig was absorbed. This was as a result of gas and liquid phases mixing within the absorber facilitated by the packed bed surface. Heating of the carbon dioxide gas caused an increase in absorption of more than 10% for varying liquid ow rate

and by 14% for varying gas ow rate. This was attributed to an increase in heat energy for reaction of carbon dioxide and water.

A low concentration of between 0 to 0.015 mol/liter was also chosen for comparison of performance of two types of solvents namely; sodium hydroxide and calcium hydroxide. Sodium hydroxide solution was found to absorb more than 14% of carbon dioxide compared to plain water. Calcium hydroxide solution had an absorption capacity of 35% more than plain water. Calcium hydroxide therefore, had a superior absorption behaviour compared to sodium hydroxide which was attributed to its unique ionization capacity.

Carbon dioxide was also heated and made to pass through the rig having each of the two hydroxides atomized in turn. A reduction in absorption capacity by more than 8% occurred for the case of sodium hydroxide while a 30% reduction was observed for the case of calcium hydroxide. This was attributed to the exothermic nature of reaction between carbon dioxide and the hydroxides. This made the formation of carbonic acid to dominate formation of carbonates. Higher concentrations in the range between 0.05 and 0.15 mol/liter were also tested. For these concentrations, carbon dioxide absorption was found to be 4 times greater than the case of

dilute sodium hydroxide. Calcium hydroxide having a similar concentration range had an absorption capacity that was 30% more than the dilute case. This implied that for higher concentrations, calcium hydroxide absorption capacity was inferior to that of sodium hydroxide. Water and sodium hydroxide were also recycled and performance tests conducted. Though there was reduced absorption with each subsequent run, it was evident that recycled solvent retained an absorption capacity of more than 13%.

The study therefore established that a wet scrubber made an e_cient carbon capture system for application in fossil fuel combustion plants. Tests indicated that its capacity was positively inuenced by high liquid ow rates that promote spreading and high gas ow rates that enhanced mixing within the absorber.

Arrange of solvents and their performance di_ered based on operating conditions. For example, heating promoted absorption of carbon dioxide in water while it inhibited hydroxides performance. The latter behaviour was attributed to the fact that high temperature caused an increase in vapor pressure of carbon dioxide that made it to resist absorption. For dilute solutions, calcium hydroxide made a better solvent due to greater ionization capacity compared to sodium hydroxide. Recycling of solution would be bene_cial as it led to overall conservation of water.

The emission reducing mechanism _nds application in a range of industrial systems that utilize fossil fuel such as coal and petroleum for combustion. These include electricity generating power plants as well as boilers for production of steam used for heating in industrial processes. Foundry furnaces for processing of metal as well as cement producing plants all utilize fossil fuels and they generate carbon dioxide, hence requiring such an emission reducing mechanism.