

ANNUAL PROJECT REPORT
AS OF DECEMBER 2001

1. **PROJECT SPONSOR:**
Civil & Env. Engr. Dept.
Mail Location 71
Univ. of Cincinnati
Cincinnati OH 45221-0071
2. **PROJECT MANAGER:**
Dr. Tim C. Keener, PE
Professor
Civil & Env. Engrg.
TELEPHONE: (513) 556-3676
EMAIL: tkeener@uceng.uc.edu
3. OCDO GRANT NO. C2.9
4. PROJECT UPDATE XXX OR
FINAL REPORT _____
4. PROJECT TITLE: CO₂ Separation and Sequestration Utilizing FGD
Scrubber By-Products
6. **PROJECT TERM: FROM:** September 1, 2001 **TO:** September 30, 2002
7. **PROJECT** NAME COST-SHARE
CO-SPONSORS: OCDO \$ 79,231
Univ. of Cincinnati \$ 27,117
- TOTAL PROJECT COSTS** \$ 106,348

I. ABSTRACT

8. OBJECTIVES:

This project is investigating a reliable and inexpensive method of separating CO₂ from flue gas by means of using magnesium hydroxide (Mg(OH)₂). In this process Mg(OH)₂ is easily and cheaply reclaimed from power plants using a magnesium enhanced flue gas desulfurization system (ME-FGD). Using a slurry of magnesium hydroxide separation of CO₂ from simulated flue gas in an absorber has been demonstrated. It is proposed to use the magnesium hydroxide either as a method of chemically fixing CO₂ in a stable form (as magnesium carbonate, MgCO₃) for sequestration purposes, or as a "chemical wheel", whereby it is used to absorb CO₂ in an absorber and is then subsequently regenerated and recycled. Sufficient quantities of magnesium hydroxide can be produced from lime used for ME-FGD purposes, and this technology has already been demonstrated.

9. WORK DONE AND CONCLUSIONS:

Design of CO₂ absorption system and results.

In order to determine the absorption characteristics of CO₂ into slurries of Mg(OH)₂, a bubble column bench-scale experimental device is used. This type of system allows for a high degree of control for the experimental conditions.

Simulated flue gas is used as the source of CO₂ in these experiments. The simulated flue gas is comprised of mixtures of certified compressed gases in order to obtain various concentrations of CO₂ ranging from 10%-15% (balance N₂ and O₂) by volume which have been used throughout this study.

The bubble column is fitted with a glass frit through which the simulated flue gas is passed producing small bubbles, which travel upwards through the solution. The gas volumetric flow rate is varied from 0.5 to 2 standard liters per minute and the slurry volume is maintained at either 250 mL or 500 mL. The slurry concentration is varied according to the experimental objectives.

Two types of Mg(OH)₂ have been used in this study: A commercial grade purchased from a chemical supplier, and Mg(OH)₂ samples recovered as FGD by-products from the Zimmer Power Plant in Moscow, Ohio.

The reclaimed magnesium hydroxide slurry was found to have a mean particle size of 10 μm using a Spectrex SPC-510 laser particle analyzer.

Experiments have been performed using these samples of Mg(OH)₂ in a 500 ml slurry containing from 1 to 5 g Mg(OH)₂. Data for experiments run at 25°C, 45°C and 65°C with inlet CO₂ concentration of 10% has been analyzed. Result showed that particle size of the commercial slurry did not have a consistent effect. The slurries containing different particle sizes absorbed almost the same amounts of CO₂. Therefore, the particle size of magnesium hydroxide did not seem to be an important factor.

Increasing the temperature of the reaction does seem to have a significant effect. For 20% CO₂, the amount of CO₂ absorbed decreased 15% at 45 °C and 40% at 65 °C.

The initial concentration of CO₂ in the gas stream was varied from 5%_v to 20%_v and the concentration of reclaimed Mg(OH)₂ was fixed at 5g/500 ml. Compared to the 5%_v and 10%_v CO₂ gas stream, the molar flux of 20%_v CO₂ decreases more in the first ten minutes. In addition, most of the reaction for the 20%_v was completed within half of the time

compared to 10%_v CO₂. This shows that the CO₂ concentration affects the initial absorption rate.

Design of combined CO₂ absorption and regeneration system (Continuous) & results

A combined absorption and regeneration system was constructed for continuous reaction. The initial absorption temperature was between 52-55 °C and the regeneration temperature was 65°C. For the absorption of CO₂ gas, a new bubble column was used with circulating solution at the inlet and outlet. The pH was measured in both reactors during the experiment at the same time. Also temperatures of each reactor were measured to monitor the isothermal condition of each system. Before the bubbling column, CO₂ was completely saturated and reheated through the tubing line. All measurements were logged by the data acquisition system individually and were recorded during the experiment. Additional experiments were conducted with temperatures from 40 to 80 °C. For these tests, regeneration temperatures were maintained greater than absorption temperatures. A total 0.1 mol of Mg(OH)₂ was used for each experiment. The results showed that increasing regeneration temperature resulted in more decarbonization from solution. These results have important implications for any regeneration system to be designed.

10. **PLANS FOR COMING YEAR:**

During coming year, a reactor designed to give substantially greater mass transfer rates will be used to determine the mass transfer coefficients necessary for scale up to a greater size. Designing and constructing a gas-liquid-solid fluidized bed reactor, which will operate on a continuous flow basis, will accomplish this. This will also allow for an integrated regeneration system to be designed into the system so that continuous flow absorption-desorption tests can be conducted for long periods.

II. HIGHLIGHTS/ACCOMPLISHMENTS

11.

The 1st year results have indicated that CO₂ is readily absorbed into solutions containing reclaimed Mg(OH)₂. The experiment conducted in a bubble reactor with simulated flue gas containing 15%_v CO₂ in contact with a 20 %_w solution of Mg(OH)₂ have proven that up to 70% of CO₂ separation may be achieved. In addition, proof-of- concept temperature swing regeneration tests have been conducted with solutions containing either calcium hydroxide, sodium hydroxide or magnesium hydroxide. As a result, magnesium hydroxide showed that over 200% utilization of solids was achieved for only a 13°C temperature change during regeneration.

III. ARTICLES/PRESENTATIONS

12.

" Feasibility of CO₂ Separation from Power Plant Flu Gases with Reclaimed Mg(OH)₂" Kyung Sook Jung, Tim. C. Keener, and Soon-Jai Khang, to be presented at the **95th Annual AWMA 2002 conference & Exhibition, Baltimore, Maryland, June 23-27, 2002.**