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**RECOVERY AND RECYCLING OF LIMESTONE IN LEC
FLUE GAS DESULFURIZATION**

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Third Year Final Report

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EXECUTIVE SUMMARY

A potentially attractive flue gas desulfurization method called Limestone Emission Control (LEC) is currently being investigated by Prudich at Ohio University. In this process, beds of 1/8 inch limestone gravel particles absorb sulfur dioxide from flue gas. This forms sulfite and sulfate salts which coat the limestone, blinding the surface and limiting utilization to 20%. Favorable economics can be generated when the unreacted portion of the limestone is recovered by mechanical grinding.

This project is a wet method for grinding and recovering the spent limestone from the LEC process, utilizing an impeller fluidizer, a new type of slurry processor. It consists of a cylindrical vessel with an impeller at one end. The impeller, driven at high rpm, concentrates the gravel size limestone in a rotating torus at the top of the cylinder, where the coating is abraded off by particle-particle impaction. The impeller generates sufficient pressure head to serve as a slurry pump. It combines the operation of wet grinding, washing, and transporting the spent and recovered limestone as an aqueous slurry.

The objectives of the first two years were to operate fluidizer in a batch mode to carry out grinding experiments, and to determine the removal of the sulfur coatings from the limestone when operating the fluidizer in a continuous mode.

The main thrusts of the third year were to complete the grinding data and coordinate the data with reactivity determinations of the recovered limestone. Direct measurement of power requirements, operation of single impeller fluidizer, grinding of surface deposits, and other methods of removing surface deposits have also been investigated along with sorption characteristics of recovered limestone, microscopic examination of the limestone surface, and limestone attrition.

The maximum horsepower required was 0.9 hp at 900 rpm, a feed rate of 2 Kg/minute, and a solids loading of 14% limestone. This works out to be in the order of \$0.25/ton of treated limestone for power purchased at \$0.05/kW-hr which is not excessive. Increased residence times do not significantly improve the residual Ca/S ratios, but do show increased loss of good limestone. Scanning electron microscope (SEM) and energy dispersive spectroscopy (EDS) analysis were applied to define how much coatings were removed. Sorption characteristics of recovered limestone, which included the design, construction, and operation of our own bench scale reactor for the needed reactivity studies, has been investigated.

Since Ohio University has shut down the LEC pilot plant operation, we don't have enough supply of coated limestone for the impeller fluidizer operation. Our own

sorption bed has only small capacity (300 gram of maximum loading at one time), which makes impossible to get enough limestone sample for the study of recovery and recycling of limestone in LEC flue gas desulfurization. We would like to coordinate with Prudich's work if the pilot plant at Ohio University is reactivated in the future, however, until then, further work on our part makes little sense, and we have not applied for fourth year funding.

1. INTRODUCTION

Prudich et. al. have proposed an attractive technology called Limestone Emission Control (LEC) for removing sulfur dioxide from flue gases. Beds of gravel size wet limestone particles absorb the sulfur dioxide from the gases on contact. Sulfite and sulfate salts deposit on the surface of the particles; however, the gas never reaches the interior, limiting the limestone utilization to approximately 20% or less. The unreacted portion of the limestone can be recovered by mechanical grinding and recycling, enabling high overall sorbent utilization. Favorable economics are derived from small equipment, simplicity, and low sorbent costs.

This project is a wet method for grinding and recovering the spent limestone from the LEC process, utilizing an impeller fluidizer, a new type of slurry processor. It consists of a cylindrical vessel with an impeller at one end. Since the impeller is driven at high rpm, the fluidizer is able to trap the stones within a revolving toroidal bed, as concentrated gravel size limestone and aqueous slurry mixture, where gentle grinding and particle-particle impaction remove the sulfite and sulfate deposits. The fines then circulate throughout the unit, while larger limestone particles remain in the toroidal bed. The impeller generates sufficient pressure head to serve as a slurry pump. It combines the operation of wet grinding, washing, and transporting the spent and recovered limestone as an aqueous slurry form back to the sorption bed. The impeller environment is free of all limestone particles large enough to remain in the toroidal bed, which minimizes equipment erosion. This method of grinding has proven to remove only the softer sulfite and sulfate salts from the particles. Actual limestone attrition is minimal, which maximizes sorbent utilization. The fluidizer is able to pump the limestone in slurry form, avoiding such complications as mechanical screws and lifts. Energy consumption of the fluidizer is low according to the calculations. The fluidizer may be advantageous over dry grinding in the aspects of sharpness of separation, transport convenience, equipment erosion, and sorption bed cementation.

In the first year of research, batch operation of the grinding action of the fluidizer was investigated. A laboratory scale fluidizer, 3 inches (7.62 cm.) in diameter and 9 inches (22.86 cm.) tall, was constructed, and its grinding and pumping abilities were determined for batch mode.

Broadly, in the second year, a new larger fluidizer was constructed to allow continuous operation by adding inlet and outlet ports. The coarse slurry discharges from an outlet into a storage vessel where the gravel like solids could settle out. The liquid flow from the storage vessel could be varied from zero to the pumping capacity of the

impeller. The operating characteristics of the impeller fluidizer were determined, particularly solids flow rates; and, the percent of the sulfur salt coating ground off, all as a function of residence time, rpm, and product flow rates.

In the third year of research, direct measurement of power requirements, operation of single impeller fluidizer, grinding of surface deposits, and other methods of removing surface deposits have been investigated along with sorption characteristics of recovered limestone, microscopic examination of the limestone surface, and limestone attrition.

Sulfite/sulfate coated limestone from the operation of the pilot plant at Ohio University enabled us to study reactivity and recycling of limestone in LEC flue gas desulfurization. However, due to the shutting down of their pilot plant, we don't have a reasonable way of recycling the recovered limestone to determine the loss of limestone and its reactivity with time. Our sorption bed, which has a maximum limestone capacity of 300 gram, was originally designed for just the limestone reactivity study. This sorption bed can not produce enough re-coated limestone samples for operation of the impeller fluidizer. Unless we have access to a pilot plant such as the LEC facility, further study is not feasible, and we have not applied for a fourth year of funding.

The statement of work for the third year is appended. The project was on schedule and on budget, and all tasks were completed within the limitations of sample supply.

2. EQUIPMENT

A new impeller fluidizer, shown in Figure 1, was designed and constructed as a result of experimental difficulties in operating the small impeller fluidizer that was designed for the first batch studies. The new fluidizer is 8.5 inches in diameter, 25 inches tall, and has a volume 23 times that of the first unit. The top inlet is 2 inches in diameter. There are two outlets of the same diameter located 2.5 and 7 inches from the top, in order to be able to change residence time without changing the inlet solids flow rate. In the operating ranges we use, the solids loading contained between the top of the fluidizer and the first outlet is in the order of 1 Kg, and for the second outlet, about 2.5 Kg. The unit has operated at solid flow rates up to 2 Kg/min (264 lbs/hr). No attempt is made to control solid flow rate out of this unit, the outlet ports are sized sufficiently large that the process rate limiting factor is the inlet solids feed rate. All coarse solids that show up at the outlet are removed as fast as they appear. All previous operating problems of the small unit have been solved with this larger unit.

3. POWER MEASUREMENTS

A torque transducer was added to the drive shaft of the large impeller fluidizer so that power requirements could be measured directly. A three phase, five horsepower, variable speed motor was used to drive the impeller. The transducer was calibrated by applying a known force to a 2.5 foot rod mounted to the motor shaft. The torque is proportional to the transducer output. Rotational speed was measured optically. Calibration is shown in Figure 2. Power is then determined by equation (1).

$$\text{Power [hp]} = \text{Torque [ft. * lbf]} * (2 \pi \text{ rpm} / 60) / 550 \text{ [ft. * lbf / hp]} \quad (1)$$

3.1. Agitation with water only

The fluidizer was filled with water and the impeller speed was varied from 0 to 1400 RPM. Figure 3 shows the horsepower required as a function of rpm. Empirical correlations of the horsepower requirements for unbaffled mixers have been developed. The power consumption is calculated using the Nagata power number correlation:

$$N_p \equiv \frac{Pg_c}{\rho N^3 d^5} \quad (2)$$

where

N_p = power number

P = power

ρ = fluid density

N = impeller speed

d = impeller diameter

g_c = conversion factor

N_p is a function of impeller Reynolds number (Re), impeller dimensions and configuration, and location of impeller. For a specific system, N_p is a function of impeller Re and is constant in the turbulent regime ($Re > 10,000$).

The power number correlation describing the unbaffled, bottom-entry impeller fluidizer is:

$$N_p = \frac{A}{Re} + B \left[\frac{1000 + 1.2 Re^{0.66}}{1000 + 3.2 Re^{0.66}} \right]^P \quad (3)$$

where

Re = impeller Reynolds number, $\rho N d^2 / \mu$, μ is the fluid viscosity

$$A = 14 + \left(\frac{b}{D} \right) \left[670 \left(\frac{d}{D} - 0.6 \right)^2 + 185 \right] \quad (4)$$

$$B = 10^n, n = 1.3 - 4\left(\frac{b}{D} - 0.5\right)^2 - 1.14\left(\frac{b}{D}\right) \quad (5)$$

$$p = 1.1 + 4\left(\frac{b}{D}\right) - 2.5\left(\frac{d}{D} - 0.5\right)^2 - 7\left(\frac{b}{D}\right)^4 \quad (6)$$

b = impeller width

D = impeller fluidizer diameter

The calculated horsepower from these correlations is shown by the solid line in Figure 3. The calculated values are close to the measured values, overestimating the power requirements by about 16% in our operating range.

3.2. Agitation with water-limestone mixtures.

The impeller fluidizer was batch-operated with water-limestone mixtures at rotating speeds from 700 to 900 rpm. Figure 4 shows the horsepower required as a function of weight percent limestone loading. Up to loadings of 13 weight percent, the additional power (that in excess of water only operation) required varies nearly linearly with increasing limestone loadings.

3.3. Agitation and pumping with water-limestone mixtures.

The limestone storage tank was connected to the impeller fluidizer. The exiting solids (limestone) accumulated in this storage tank and the water was recycled to the inlet. The recycling water flow rate was monitored by using an orifice meter, see Figure 1. We have a choice of one of two outlets, located 2.5 and 7 inches from the top of the fluidizer, in order to be able to change residence time of limestone without changing the inlet solids flow rate.

Figure 5 shows the horsepower as a function of outlet choice, rpm, and feed rate. The rpm's used were 800 and 900, and the solid feeding rates were varied from 1 Kg/min to 2 Kg/min. The maximum horsepower required was 0.95 at 900 rpm, 2nd outlet, and 2 Kg/minute feed rate. This works out to be about \$0.25/ton of treated limestone based on the power purchased at \$0.05/kW-hr. The energy requirements of the impeller fluidizer do not seem excessive at this point.

4. LIMESTONE GRINDING

We can operate the impeller fluidizer in a relatively limited rpm range, for above 950 rpm the limestone slugs sufficiently to shake the equipment. Below 700 rpm the limestone bed does not concentrate at the top. Within those operating limitations, grinding experiments were carried out with the larger fluidizer to determine the removal of the sulfate coating, and these are summarized in Table 1. Runs #2 to #6 show that the sulfur content of the recovered stones is nearly independent of residence time and rpm. Although we do not have enough data points to develop a statistical analysis of these results, the most complete sulfate removal was observed in run #2, which had the shortest residence time. The batch runs, #9 & #10, showed incomplete sulfur removal, even with residence times of 20 minutes.

From these results, it is apparent that when the fluidizer is operated in a continuous mode, most of the grinding action and removal of the sulfur coating happens as the feed limestone hits the rotating limestone bed. We do not see much visual evidence of vertical rotation cells in the torus. The impaction and change of direction of the flowing bed at the outlet may also be a contributor.

Samples 12 and 13 are runs where limestone was placed on a screen (15 mesh), washed by water spray (flow rate of 62.5 ml/sec), and simultaneously shaken for 2 and 20 minutes, respectively. Very little of the sulfate coating was removed by this action.

Fines that have been simply shaken from dry coated limestone have been analyzed. That analysis is shown in Table 2. These fines were produced from the gentlest of abrasions and still have (Ca+Mg)/S mole ratios of 6.6 to 1, indicating the loss of "good" limestone in these particles. In addition, sulfur is present almost entirely in the form of sulfate species, not for sulfite, on the samples we received. These samples have been exposed to the weather for periods of weeks to months, and oxidation of the sulfite to sulfate has taken place. At this point, it is not known what effect this has on the mechanical properties of coating.

5. MICROSCOPIC EXAMINATION OF THE LIMESTONE SURFACE

The surfaces of selected samples of limestone were examined by a scanning electron microscope (SEM) that has microprobe or energy dispersive spectroscopy (EDS) capabilities. The intent was to attempt to locate the sulfur deposits in the limestone sample, determine if there were any obvious effects of grinding on sulfur removal, and compare EDS semi-quantitative analysis with prior determinations of Ca/S mole ratios.

Four different samples were chosen for the examination. Sample A refers to limestone, coated to capacity with sulfur in the form of sulfate, from the pilot plant at Ohio University. In sample B, the sulfate coating was partially abraded off by placing the gravel sample on a screen (15 mesh), washing with water, and simultaneously shaken for 2 minutes. Samples C and D were treated in the large impeller fluidizer for two minutes by batch operation, and for a residence time of two minutes by continuous operation, both with 900 rpm, respectively.

Samples were set on double sided tape on aluminum fixtures and coated with a platinum film for conductivity. Micrographs of the sample surfaces were taken at different magnifications, ranging from x50, to x10000. Semi-quantitative analyses of the surfaces for Ca/S ratios were attempted using EDS at 15 KeV.

The micrographics show nothing remarkable. We could not see any distinguishing characteristics between samples that were treated and samples that were not. The EDS results are more interesting. Semi-quantitative analysis using EDS shows the weight percent of the elements on the limestone surface. The mole ratios of Ca/S by both EDS and bulk wet chemical analyses are given in Table 3.

Where a comparison could be made, the EDS surface analyses were in agreement, within experimental error, of the compositions of the abraded coating material, or fines, recovered from the grinding operation. As shown in Table 3, EDS analysis of limestone samples A and C yields almost same Ca/S mole ratio at the surface of the stones as was found by wet chemical analysis of the fines. When the removal of sulfate material from the surface was nearly complete, as in sample D, EDS and wet chemical analysis of the recovered stones give nearly the same result.

EDS also made possible for mapping of sulfur element location on the surface or inside the limestone samples. The sample of limestone was cut to open inside. The dot matrix mapping results of sulfur element location show even distribution of sulfur element inside the limestone. The surface which was cut to open might be contaminated

by the fines which were coated on the limestone surface during cutting process and/or coating process, or that the interior is blocked by sulfate products.

6. REACTIVITY STUDIES OF THE RECOVERED LIMESTONE

The grinding experiments with the impeller fluidizer have to be coordinated with reactivity studies of the recovered limestone, otherwise we just don't know where we are in adjusting those operating parameters that determine the severity of the grinding action. Arrangements had been made to have the reactivity studies of recovered limestone carried out at Professor Prudich's laboratory at Ohio University; unfortunately, that has not worked out. Their analytical instrumentation for sulfur analysis has not been reliable, and the inability of the manufacturer to repair that instrument has resulted in serious delays in their own work, making it unlikely that they will be able to provide service studies on our samples in a timely fashion.

We discussed this problem with Dr. Richard Chu and Dr. Robert Statnik during their site visit in mid January, 1993. At that time it was agreed to modify the Statement of Work for the third year, deleting Task VIII, Counter-Current Operation of Multiple Fluidizers, which is probably not necessary in view of the performance of the new fluidizer, and modifying and enlarging Task V Sorption Characteristics of Recovered Limestone to include the design, construct, and operation of our own bench scale reactor for the needed reactivity studies to coordinate the impeller fluidizer grinding experiments with the reactivity studies of the recovered limestone. The design and construction of the bench scale reactor has been completed, debugged and is operational.

6.1. Equipment & Procedures.

A schematic design of the equipment for the reactivity studies is shown in Figure 6. The design follows that of Professor Prudich's bench scale reactor[1], simplifying where necessary because of budget and time constraints. A feed stream of 1000 ppm sulfur dioxide gas in 80 cubic feet per hour of compressed air was passed through heat exchanger, heated to 200°F, and saturated steam was also injected so as to control the relative humidity of the air/SO₂/vapor mixtures. This gas/vapor mixture was sent to a 2" diameter limestone fixed bed reactor. The reactor has a capacity of a 300 gram limestone.

Sulfur dioxide concentrations was determined by a HORIBA SO₂ Infrared Gas Analyzer. It is a dual range instrument, 0 to 1000 ppm and 0 to 3000 ppm, and sufficed for this study. This analyzer has a 1 volt signal output which was connected to PC data acquisition equipment. Break through curves of concentration for SO₂ were determined to find the reactivity or sorption capacity of the treated limestone.

Several batches of limestone taken from the reactor were treated in the impeller fluidizer again for the recovery of the unused portion of the limestone. The impeller speed was 900 rpm, limestone feed rate was 0.5 Kg/minute, and residence time was 2 minutes. The recovered limestone was dried for the sample analysis.

6.2. Results.

We did not achieved satisfactory operation of the bench scale reactor for the initial runs. A typical SO_2 sorption curve for these early runs is shown in Figure 7. From all the early runs, SO_2 concentration in the outlet streams would rise to the inlet SO_2 in less than 10 minutes of operation. This could have been the result of (a) channeling of the feed gas through the bed, or (b) improper operation of the bed with respect to relative humidity or temperature, or (c) the capacity of recovered limestone is very much reduced compared to fresh limestone.

An orifice meter was designed and constructed for measurement of steam flow rate, and therefore control of the relative humidity. However, even with the relative humidity at 100 %, we found that we had to spray water onto the bed entrance to enable reaction between SO_2 and limestone. The SO_2 concentration was reduced 15% by the addition of the water. The temperature of the reactor was maintained at 148°F. A typical break through curve is shown in Figure 9, where outlet concentration reached inlet concentrations only after an hour or more. The samples from the successful runs were collected, analyzed by both wet chemical analysis and EDS (Energy Dispersed Spectroscopy), and recovered by treatment in the impeller fluidizer. The results are shown in Table 4.

The wet chemical analysis of the SO_2 treated samples in the reactor (Sample C) has about the same Ca/S ratio as the original coated limestone samples (Sample A). The EDS surface analysis of the same samples show that the surface of the newly coated limestone has a Ca/S ratio of 0.85, and a (Ca+Mg)/S mole ratio of 1.09, which probably means a Ca/S ratio of 1, the difference being the result of experiment error. The original coated limestone samples provided by Prof. Prudich had Ca/S ratios at the surface in the order of 5 to 1, which at this point is not understood.

Five different sample types were tested for the SO_2 sorption characteristics. Sample AA was as received from the LEC pilot plant at Ohio University. Its sorption characteristics are shown in Figure 8. Sample BB was a coated limestone from the LEC process that had been treated at a feed flow rate of 1 Kg/minute at 900 RPM, 1st outlet, 2.5 minutes of approximate residence time in the impeller fluidizer. Its sorption characteristics are shown in Figure 9. Sample CC was obtained from sample BB after

treatment of BB in the impeller fluidizer for the same conditions as sample BB above. Its sorption characteristics are shown in Figure 10. Sample DD was retreated CC subject to one more recovery cycle. Its sorption characteristics are shown in Figure 11. Sample EE is raw limestone. Its sorption characteristic is shown in Figure 12.

These results indicate that, within the experimental error, the sorption characteristics of the limestone samples recovered from repeated exposure, abrasion cycles do not significantly show a reduction in sorption capacity.

7. CONCLUSIONS

The reactivity studies of the treated limestone samples from the various experiments have been completed. Limestone samples, whose active surface were recovered after sulfite/sulfate coating removal in the impeller fluidizer, were placed in our sorption bed. The analysis showed the limestone samples were as active as new limestone which had never been exposed to the SO_2 flue gas. The unreacted portion of the limestone was successfully recovered by mechanical grinding, and the reactivity of the recovered limestone does not seem to be significantly reduced.

The mechanical energy requirements for grinding and pumping of the limestone is not at all excessive. The maximum horsepower required for the bench scale impeller fluidizer was 0.9 hp at 900 rpm, a feed rate of 2 Kg/minute, and a solids loading of 14% limestone. This works out to be in the order of \$0.25/ton of treated limestone for power purchased at \$0.05/kW-hr.

Since Ohio University has suspended its pilot plant operation, we don't have enough supply of coated limestone for the impeller fluidizer operation. Our own sorption bed has only small capacity (300 gram of maximum loading at one time), which makes very difficult to get enough limestone samples for the study of recovery and recycling of limestone in LEC flue gas desulfurization. We would like to coordinate with Prudich's work if the LEC facility is reactivated in the future, however, until then, further continuation of this study makes little sense, and we have elected not to request funding for a fourth year.

8. REFERENCES

1. Prudich, Michael E. et al, "Low Temperature Dry Scrubbing Reaction Kinetics and Mechanisms" Final Report for the Period September 1, 1990 to August 31, 1991
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3. Gilchrist, J.D., Extraction Metallurgy, 2nd Edition, Pergamon Press, Oxford, 1980.
4. Gardner, N.C. et. al., Recovery and Recycling of Limestone in LEC Flue Gas Desulfurization, First Year Final Report, Case Western Reserve University, August, 1991.

Figure 1

Figure 2

Figure 3

Figure 4

POWER vs Wt.% of LIMESTONE

Figure 5

Figure 6

Figure 7.

SO₂ CONCENTRATION vs TIME

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

TABLE 1
Grinding Experiments

Sample	RPM	Feed Rate (Kg/min.)	Outlet #	Approximate Residence Time (minutes)	Mole Ratio Ca/S
1 Coated Limestone					86
2 Stones	900	.5	1	2	216
3 Stones	910	1.0	1	1	264
4 Stones	800	0.5	1	2	261
5 Stones	800	0.5	1	2	222
6 Stones	900	1.0	2	2.5	248
7 Raw Fines					5
8 Batch Run Fines	900			2.0	39
9 Batch Run Fines	900			20	72
10 Batch Run Stones	800			20	153
11 Batch Run Stones	800			2	129
12 Washing and Agitating Stones or Screens				2	92
13 Washing and Agitating Stones or Screens				20	111

TABLE 2
Analysis of the Dry Raw Fines

Elements	Wt. %	Mole %
Calcium	18.24	.456
Magnesium	3.16	.13
Sulfate	7.89	.082
Sulfite	< 0.01	< 1.25 x 10 ⁻⁴
Total Sulfur	2.83	.088

TABLE 3
EDS and Wet Chemical Analysis of Limestone Samples
Mole Ratio Ca/S

Sample	EDS Analysis	Wet Chemical Analysis
A. Coated Limestone	5.3	86
Raw Fines	-----	5
B. Washing and Agitating		
Stones on Screens		
Stones	9.9	92
Fines	-----	-----
C. Batch Run		
900 rpm, 2 minutes		
Stones	66.3	129
Fines	-----	72
D. Continuous Feed		
900rpm, 2 minutes		
Stones	225	264
Fines	-----	-----

TABLE 4.

Sample	Ratio Ca/S EDS Analysis	Ratio Ca/S Wet Chemical Analysis
(A) Coated limestones as received from Prof. Prudich	5.3	86
(B) Sample A after treated in the impeller fluidizer at 900 RPM, 2 min. of residence time	225	264
(C) Sample B after SO ₂ absorption in reactor	0.85	94
(D) Sample C after cleaned in impeller fluidizer at 900 RPM, 2 min. of residence time	1574	422

STATEMENT OF WORK FOR THE THIRD YEAR

OCRC PROJECT 3.2

The third year will start September 1, 1992 and end August 31, 1993. The work is organized into tasks as follows:

Task 1 Direct Measurement of Power Requirements

Torque and rpm transducers will be added to the drive shaft of the impeller so that power requirements can be measured directly. In all subsequent experiments the energy efficiency for removal of the sulfur salt coatings will be determined. Task 1 is expected to require 1 month.

Task II Operation of Single Impeller Fluidizer

Experiments will continue for operation with a single impeller fluidizer with a limestone feed. Critical operating parameters such as maximum products rates, and operability and pumpability of the fluidizer with limestone gravel will be completed. Modifications and revisions will be made as needed. Task II will require one month.

Task III Grinding of Surface Deposits

Quantitative experiments on the removal of surface sulfur salt deposits will continue. The amount of surface deposits removed, as well as the attrition of the limestone gravel, will be determined by measurement of the Ca/S mole ratio in the recovered limestone, and in the fines of the removed surface material. The variables are the residence time of the limestone in the fluidizer, the impeller rotational velocity, and the presence or absence of internal baffles in the fluidizer. Power requirements will be measured directly for all of these tests so that the energy efficiency for the grinding can be directly measured.

Task IV Other Methods of Removing Surface Deposits

A large fraction of the sulfur salt deposits might be removed by gentler methods other than the impeller fluidizer. We plan to examine three methods, 1) washing with a water jet, 2), shaking the limestone in a screen in combination with washing, and simply agitating in a stirred tank.

Task V Sorption Characteristics of Recovered Limestone

A bench scale reactor will be built to measure the sorption capacity the recovered limestone. Break through curves for SO_2 sorption will be determined, and comparisons made with the original limestone samples. The intent is to determine how deep the grinding must be to maximize energy efficiency, sorption capacity, and minimize attrition of the good limestone. This task will be integrated with tasks III and IV. Tasks III, IV, and V will require five months.

Task VI Microscopic Examination of the Limestone Surface

We plan to examine the surface of select samples of limestone in a scanning electron microscope that has microprobe capabilities. The intent is to locate the sulfur deposits in the limestone sample and see how it varies with extent of grinding. Task VI is allocated one month.

Task VII Limestone Attrition

We plan to make several runs on raw limestone particles to determine the attrition rate directly, without the complications of the sulfur salt coating removal. The attrition will be measured by direct mass balance. Task VII will require one month.

Task VIII Final Report

A final report will be prepared. Task IX is allotted one month for completion.

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