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ENERGY CONSERVATION POTENTIAL
OF PORTLAND CEMENT
PARTICLE SIZE DISTRIBUTION CONTROL
PHASE III --
IMPROVED CONTROL OF THE FINISH GRINDING PROCESS
IN CEMENT MANUFACTURE

CTL Contract CR7913-4330

QUARTERLY REPORT
FOR THE PERIOD

April 1, 1985 - June 30, 1985

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Technical Progress Report
1 April 1985 - 30 June 1985

Phase III
Energy Savings by Improved Control of the Finish Grinding
Process in Cement Manufacture

I. OBJECTIVE AND SCOPE

The main objective of Phase III is to develop practical economic methods of controlling the particle size distribution of portland cements using existing or modified mill circuits with the principal aim of reducing electrical energy requirements for cement manufacturing.

The work of Phase III, because of its scope, will be carried out in 10 main tasks, some of which will be handled simultaneously.

Task 1 will acquire suitable clinker and gypsum, characterize both materials, and deliver 40-50 tons clinker and 2-3 tons gypsum to each of two subcontractors, Allis-Chalmers (A-C) Corporation at Oak Creek, WI and Kennedy Van Saun (KVS) at Danville, PA. Half of the clinker and gypsum delivered to Allis-Chalmers will be crushed to -10 mesh and delivered to Construction Technology Laboratories (CTL) at Skokie, IL for use in subsequent tasks.

Task 2 will utilize the crushed clinker and gypsum in the CTL closed circuit pilot ball mill to establish baseline conditions. This task will provide matrix and test plans for the subsequent tasks involving grinding operations at CTL, A-C, and KVS. Instruments and feeders will be calibrated and checked.

Task 3 will utilize the CTL pilot ball mill to determine if changes in mill operating parameters can affect particle size distribution so as to produce a controlled cement that will save grinding energy and also provide good performance.

Task 4 will study the performance of a high efficiency air classifier relative to production of the kind of controlled particle size distribution cement that was developed in Phases I and II of this project. This task includes purchase and erection of specified classifier equipment.

Task 5 will study the effects of gypsum on the performance of the grinding operation and particularly its effects on air classification.

Task 6 will study use of semi-air swept grinding technology to arrive at some optimum set of operating parameters that will produce a controlled particle size distribution cement.

Task 7 will handle data developed by prior tasks and will integrate the information into a mathematical model designed to establish operating parameters which will lead to particle size distribution control and energy savings.

Task 8 involves the A-C pilot roller mill which will develop data leading to optimum operating conditions required to produce controlled particle size distribution cements.

Task 9 will select cement samples from the most promising operations and perform standard cement and mortar tests.

Task 10 manages the project and provides required reports and technology transfer.

II. SUMMARY OF PROGRESS

Task 1

Task 1 is considered essentially complete as described in the previous quarterly report (Jan. 1, 1985 to March 31, 1985). The grindability of the clinker used for the test program was determined.

Task 2

Several grinding runs were conducted with the CTL closed circuit ball mill. Both clinker and clinker/gypsum mixtures were ground under various operating conditions in order to produce products required under this task as well as to characterize the mill system. This task is ongoing.

Task 3

Equipment required for modification of the CTL mechanical separator was ordered.

Task 6

Test grinds were conducted by a subcontractor to estimate parameters required for simulation of the CTL mill system. Grinding tests were also conducted for determining the effect of air sweep.

III. DETAILED PROGRESS

April 1, 1985 to June 30, 1985

Task 1: Acquisition, Characterization, and Distribution of Materials

Subtask 1(b): A grindability test on the cement clinker procured for this program was conducted by Allis Chalmers. The work index was found to be 17.5 kWh/ton.

Task 2: Ball Mill Baseline Tests

Subtask 2(b): An extensive series of test runs was conducted by use of the closed circuit mill system with a fixed ball charge and mill speed. The tests were run in order to characterize the mill's performance with the feed materials obtained for this project. Various separator adjustments and feed rates were used. This task will be continued until cement products are produced with four significantly different Blaine specific surface areas under operating conditions which allow about 80-100% powder loading. The 100% loading factor is defined as the amount of material being ground that will occupy 100% of the interstices of the ball charge.

Initial test runs were conducted by use of cement clinker as mill feed. The feed material was precrushed to

-16 mesh prior to grinding. The separator was run initially with only two main fan blades. As shown in Table 1, the circulating load was high for this mill system, resulting in very fine products. Increasing the number of main fan blades to four and then to eight blades increased the air flow rates enough to permit lower circulating loads and coarser products. Under the existing auxiliary fan arrangement, production of a coarse product was difficult. At all fan speeds and with two, four, or eight blades, fines removal was generally inadequate, causing a gradual increase in mill loading. The concomitant high circulating loads enabled production of clinker as fine as $410 \text{ m}^2/\text{kg}$.

Test runs were continued with clinker/gypsum mixtures. The raw materials were proportioned to produce cements containing about 3.5% SO_3 overall. Initial cement runs presented operational difficulties, apparently due to the increased amount of fines produced. This resulted in increased dust emission as well as accumulations of powder in some system locations.

Since the auxiliary fans are mounted on the same drive shaft as the main fan on the separator used for these tests, the effective range of useful fan speeds was reduced. At or above a certain fan speed, the auxiliary fan had a greater effect in opposing powder recovery than the main fan could overcome with increased air flows. In our experience,

the minimum circulating load was consistently found to be at a fan speed lower than the maximum. It was felt that increased fines recovery by the separator would increase the production capacity of the mill system. To that end, the auxiliary fans were modified.

Initially, one complete auxiliary fan assembly was removed. The resulting performance produced higher product rates, but the product was too coarse to be of value. The next separator modification entailed moving the auxiliary fan blades inward (towards the shaft), effectively reducing the auxiliary fan diameters. This allowed production of fairly coarse products ($230 \text{ m}^2/\text{kg}$ to $270 \text{ m}^2/\text{kg}$) at feed rates nearly twice as great as before. The results of the initial cement grinding runs are given in Table 2.

Lack of a mass flow measuring device on the mill outlet stream resulted in excessive run times. In each of the grinding runs discussed above, the test procedure entailed starting of the mill system at specified settings (feed rates, fan speeds, etc.) and then waiting for the system to stabilize before collecting finished product. Considerable time and raw materials were spent while waiting for a steady state of operation. The procedure required starting the mill in an underloaded condition (i.e., less than 100% of the voids filled with powder) and then monitoring the circula-

tion rate until it remained unchanged for at least one hour. Many of the runs described in the tables did not provide useful products or data. Considerable time and raw materials could be saved by use of an online mass flow meter. This would enable us to monitor the system's approach to steady-state and prevent the perturbations in the system caused by sampling. The number and scope of future grinding runs may now have to be reconsidered so that the remaining raw materials are not depleted before the end of the test program.

Task 4: Performance of High Efficiency Classifier

Subtask 4(a): The equipment required for modification of the C-E Raymond Separator in use at CTL has been ordered from the manufacturer. The time required for delivery of equipment is approximately 30 days. Installation time has been estimated at four days by C-E Raymond.

Task 6: Semi-Air Swept Milling

Several of the test grinds described in the appendix to the previous quarterly report (January 1, 1985 to March 31, 1985) have been conducted at KVS. In addition, two of the test grinds planned for at Pennsylvania State University have also been conducted. Both test programs, under the direction of Dr. L. G. Auston of Pennsylvania State University are continuing.

Subtask 6(a): At Pennsylvania State, PS Test sets 1 and 2 have been completed. PS Test 1 is used to determine breakage rates (S) and primary progeny fractions (B) for different starting feed sizes. PS Test 2 determines the S and B values for four different powder loadings and one feed size.

Subtask 6(b): At KVS, a two-foot diameter mill has been run at five levels of hold-up, in order to determine the effect of powder loading on sound level with a specified ball charge (KVS Test 1). KVS Test 2 determined the result of both grinds in the same mill with a fixed powder loading and six different grinding times. KVS Tests 3, 4, and 5 were run by operating the two-foot mill in open circuit with one powder loading and three levels of production as controlled by air flow rates. KVS Tests 6 to 14 are still pending.

In both the KVS and Pennsylvania State University test programs, particle size measurements are in varying states of completion. There have been no unanticipated delays in progress thus far.

Task 8: Roller Mill Investigation

Subtask 8(b): The pilot roller mill at Allis-Chalmers has been improved by addition of a new classifier and improved load controls on the rollers. Gypsum was preground to -24 mesh for the roller mill tests. Clinker and gypsum were

blended to produce about 3.5 percent SO_3 (by weight) in the finished cement product. The percent SO_3 of the mixture was determined at CTL by XRF analysis and found to be acceptable for the roller mill tests.

Task 10: Administration and Report

Changes in milestone dates were authorized by the Department of Energy through Dennis McMurtrey of EO&G. These changes required recalculating monthly expenditure schedules shown on Form EIA-459E. The total expenditures to-date indicate that 80% of the allotted monies have been spent and that a new action to provide further allotment is required to keep the project going.

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IV. PLAN FOR FUTURE WORK

Task 2(b) is continuing, and is expected to be completed by mid-July. There are no major anticipated changes contemplated in the work program. An effort to curtail the number of runs is being considered due to the long production runs needed to assure steady-state conditions.

Table 1. Results of Clinker Grinding Runs

Date	Feed Rate, lb/hr	Far Speed, RPM (# of blades)	Circulating Load, %*	Product Finesness (m ² /kg)	Tailings, % +200 mesh	Fines + Tails % +200 mesh	Damper (Coarse/Fine)
4/30	100	1400 (2)	1860	320	36	39	Fine
5/1	100	"	990	300	29	30	"
5/2	111	"	1270	300	33	33	"
5/8	100	"	1050	300	28	28	"
5/9	84	750 (2)	3430	410	28	24	"
5/10	84	1000 (4)	1570	300	24	27	"
5/14	84	"	2430	300	30	28	"
5/14	128	"	1690	290	49	48	"
5/16	85	850 (4)	1450	310	24	23	"
5/17	60	"	400	350	19	13	"
5/20	90	"	1530	330	--	--	"
5/21	84	"	1040	290	28	23	Coarse
5/22	84	1100 (4)	1250	290	33	27	"
5/22	84	1100 (8)	1040	280	33	30	"
5/23	84	1400 (8)	1110	280	35	35	"

*Due to dust losses from tailings, this number is reported as

$$CL (\%) = 100 (\text{Fines} + \text{Tails}) / (\text{Feed})$$

Table 2. Results of Cement Grinding Runs Prior to
Aux. Fan Modifications

Date	Feed Rate	Fan Speed	Circulating Load, %	Product m ² /kg	Damper (Coarse/Fine)
5/29	85	1400	1090	3000	Coarse
6/3	74	850	1660	2800	Coarse
6/4	72	850	1040	3200	Fine
6/5	60	750	1100	-- ¹	Fine
6/10	59	1370	240	3600	Fine
6/11	58	1400	220	3700	Fine
6/12	38	1400	210	3700	Fine
6/13	98	1400	480	3400 ²	Coarse
6/17	194	1400	770	3000 ³	Coarse

Notes: (1)Excessive fines resulted in run abort.

(2)Mill Powder Loading measured at 49%.

(3)Mill Powder Loading measured at 126%.

U.S. DEPARTMENT OF ENERGY
FEDERAL ASSISTANCE PROGRAM/PROJECT STATUS REPORT

FORM EIA-459F
(10/80)

FORM APPROVED
OMB No. 1900-0127

1. Program/Project Identification No. DE-FC07-81CS40419.A005	2. Program/Project Title Finish Grinding in Cement Manufacture, Phase III of Energy Conservation	3. Reporting Period 1/4/85 through 6/30/85
4. Name and Address Potential of Portland Cement Particle Size Construction Technology Distribution Control Laboratories, A Division of the Portland Cement Association 5420 Old Orchard Road, Skokie, IL 60077		5. Program/Project Start Date A004: 1/3/85
		6. Completion Date A005: 12/31/86 planned

7. Approach Changes

☒ None

8. Performance Variances, Accomplishments, or Problems

- Task 2: The lack of a mass flow device for circulating load has increased time to determine optimum operating parameters of mill system at various product specifications. This has caused a slippage of about 2 months.
- Task 8: New classifier parts for Allis-Chalmers pilot roller mill had to come from Germany. Delay of about 2 months on delivery caused a delay in start-up of this task.

☐ None

9. Open Items

The authorization to purchase the C-E Raymond air classifier was received 6/5/85. CTL advised DOE on 6/1/85 that it was not possible to include the mass flow device in the proposed A005 modification since the delivery time was 3 months, taking us beyond the time of need.

☐ None

10. Status Assessment and Forecast

Completion date of Task 2 (B) has been authorized to move to July 30, 1985.
Completion date of Task 8 (C) has been authorized to move to August 30, 1985.
Completion date of Task 3 (D) has been authorized to move to October 1, 1985.
Completion date of Task 4 (E) has been authorized to move to November 15, 1985.
No change in forecasts of other tasks is contemplated.

☐ No Deviation from Plan is Expected

11. Description of Attachments Technical progress report #2 for period 1/4/85 - 6/30/85; Milestone log; Milestone Plan (EIA-459B); FAMS report (EIA-459E); invoice for April, May, June 1985;
☐ None Statement of cumulative costs for this project (A005) only.

12. Signature of Recipient and Date

S. W. Tresouthick
July 25, 1985

13. Signature of DOE Reviewing Representative and Date

FEDERAL ASSISTANCE MILESTONE PLAN

1. Program/Project Identification No. DE-FC07-81CS40419.A004

2. Program/Project Title Energy Conservation Potential of Portland Cement Particle Size Control - Phase III: Finish Grinding in Cement Manufacture

4. Program/Project Start Date A005 6/5/85

5. Program/Project Completion Date Dec. 31, 1986 planned

3. Performer (Name, Address)
Construction Technology Laboratories, A Division of the Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077

6. Identification Number

7. Planning Category (Work Breakdown Structure Task)

8. Program/Project Duration (months)

9. Comments (Notes, Name of Performer)

6. Identification Number	7. Planning Category (Work Breakdown Structure Task)	8. Program/Project Duration (months)												FY 85 > <												Name of Performer
		Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12	Jan 13	Feb 14	Mar 15	Apr 16	May 17	Jun 18	Jul 19	Aug 20	Sep 21	Oct 22	Nov 23	Dec 24	
A	Contract award 1/3/85	EA																								
B	Complete pilot mill baseline tests (2)	A																								
C	Complete ball mill tests at A-C (8)	A																								
D	Assess ball charge loading and mill speed effects on pilot scale ball mill efficiency (3)	A																								
E	Complete improved separator performance tests (4)	A																								
F	Complete tests involving energy efficiency of separate grinding and mixing of gypsum (5)	A F																								
G	Complete semi-air swept cement milling tests (6)	A G																								
H	Optimize ball mill circuits by math modeling (7)	A H																								
I	Submit draft final report and quarterlies (10)	A I																								

- END -

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