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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 No. CR7913/4330

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QUARTERLY REPORT
July 1, 1986 to September 30, 1986

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Technical Progress Report
July 1, 1986 - September 30, 1986

Energy Conservation Potential of Portland Cement
Particle Size Distribution Control
Phase III

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.

Because of its scope, the work of Phase III 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 effect 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

Tasks 1, 2, 3, 4, 5, 6, and 8

Complete.

Task 7

Data from the CTL pilot mill were incorporated in the mathematical model developed and used by the subcontractor. -

Task 10

Mortars and pastes made in Tasks 2, 3, 4, 5, and 8 were tested. Trends in mill system behavior and resulting product characteristics were developed.

III. DETAILED PROGRESS

July 1 to September 30, 1986

Task 7: Optimize Ball Mill Circuits by Mathematical Modeling

Dr. I. G. Austin, our subcontractor for Tasks 6 and 7, has

accepted a temporary teaching post at Santiago, Chile. We are setting up new channels of communications with him in order to carry out the remainder of work on Task 7.

Task 10: Physical Testing, Administration, and Final Report

Physical tests of cements from various tasks have been completed. Cements from Tasks 2, 3, 4, 5, and 8 were tested for mortar strength, time of set, and normal consistency. Mortar test results are presented in Table 1.

As Table 1 shows, mortar flows at about the same water addition (within 1.5% of each other) were normal. Times of set were moderate to long, owing in part to low levels of fines. As the bar chart of Figure 1 shows, degrees of early strength gain for the various mortars depends strongly on levels of fines, in terms of either Blaine or % finer than 3 micrometers. Strength gains at later ages (7 to 28 days) are closely related to the cement topsiize. Note, for example, the low early strength of the roller mill product (AC39) due to the small amount of material finer than 3 micrometers. Mortar AC39 recovers strength at later ages to nearly equal the 28-day strengths of the Task 5 mortars.

Cements were selected for paste performance tests in order to look for differences between cements produced under various operating conditions. Table 2 and Figure 2 present these results for cements in the 3030 to 3110 Blaine range. Table 3 and Figure 3 present cement paste test results for cements in the 3190 to 3350 Blaine range. The aforementioned paste results are reported in order of decreasing 7-day paste cube strength, which often agrees with the order of 28-day mortar cube strengths.

One observation regarding the paste tests is the apparent exaggeration of strength gains in the 7 to 28 day period as compared with mortar results. While higher later strength gains occur for mortars when the corresponding paste shows high later strength gains, unless large differences exist in the topsiizes of cements, fineness is almost as important as topsiize in predicting 28 day mortar strength.

The mortars prepared in this project met or exceeded performance characteristics of those prepared from commercial cements, even though the Blaine finenesses were much lower. This gives a good indication that lower specific power usage was attained in the experimental work.

Given the geometry of the CTL pilot ball mill, with its short residence time and high circulation rates, it was possible to simulate commercial cement PSD only with very low powder loading levels. This increased the mill residence time and the level of fines produced. The resulting Blaine finenesses, while higher than normal for usual operation of the mill, were not accompanied by product topsizes smaller than those for cements with lower Blaines but shorter mill residence times. Mill residence time, therefore, appears to be one of the major factors in controlling the bottom end of the PSD curve. The project final report will discuss these findings in detail.

IV. FUTURE WORK

Task 7: Optimize Ball Mill Circuits by Mathematical Modeling

Completion of simulation work is expected within the next quarter. A documented computer model will be provided by the subcontractor. Suggested optimization steps based on the modeling work will be developed for the pilot mill system. It is likely that Milestone H will be missed and will be completed November 30, 1986.

Task 10: Physical Testing, Administration, and Final Report

Data analysis will be completed. A final report will be issued. The final report draft is presently being written on all tasks except Task 7, which means the draft is ahead of schedule. We expect to complete the entire project on schedule.

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Table 1. Mortar Performance Results

RUN #	TASK	STRENGTH AT AGE, PSI			FINAL SET, HR	FLOW, % (C109)
		3-DAYS	7-DAYS	28-DAYS		
4-1A	4 High Effic. Classifier	4550	6230	7410	5.5	107.0
3-36	3 Ball Charge Variation	3960	5370	6850	7.3	113.0
4-3	2 Normal Conditions	3380	5140	6730	8.1	110.0
2-4	5 Sep. Clinker/Gyp. Grind	4520	5430	6520	6.0	108.5
2-15	5 Sep. Clinker/Gyp. Grind	4080	5180	6280	7.6	106.5
5-3/2-6	5 Gyp. Fed to Classifier	3870	5150	6210	6.3	107.0
AC39	8 Roller Mill Product	3270	4410	6080	6.5	114.5

RUN #	TASK #	BALL SIZE	BALL LOAD, %	BLAINE SQCM/G	PCT. FINER	PCT. FINER	PCT. FINER	PCT. BETWEEN	95 PCT.
					30 um	25 um	3 um	3-30 um	SIZE MICRONS
4-1A	4	M	35	3560	91.5	84.0	11.0	80.5	34.0
3-36	3	L	25	3425	86.0	76.5	10.5	75.5	38.0
4-3	2	M	35	3250	85.0	75.0	9.5	75.5	38.5
2-4	5	M	35	3610	87.5	80.0	11.0	76.5	39.5
2-15	5	M	35	3610	88.0	79.5	11.0	77.0	36.0
5-3/2-6	5	M	35	3120	85.5	77.0	8.5	77.0	45.0
AC39	8	--	--	3180	88.5	82.5	7.5	81.0	37.5

Figure 1. Mortar Cube Strengths
at 3, 7, and 28 Days

Table 2. Cement Paste Performance, 3030-3110 Blaine Range.

RUN #	STRENGTH AT AGE, PSI			BALL SIZE	BALL LOAD, %	FEED LB/HR	CIRC. LOAD, %	BLAINE SQCM/G	PERCENT FINER	PERCENT FINER	PERCENT FINER	PERCENT BETWEEN	95 PCTILE SIZE MICRONS
	1-DAY	7-DAY	28-DAY						30 μ m	25 μ m	3 μ m	3-30 μ m	
3-4	1400	5600	9338	M	35	100	819	3050	82.0	73.5	9.0	73.0	44.0
4-2	1125	5138	8800	M	25	100	1231	3110	81.5	71.0	9.0	72.5	40.5
4-1	1188	4450	9088	M	25	100	1274	3100	80.5	69.0	10.0	70.5	40.0
4-5H	1275	4063	8125	M	35	160	900	3030	81.0	71.0	9.0	72.0	46.0
4-11H	913	3250	7225	L	35	145	1073	3050	80.0	72.0	10.0	70.0	44.0
3-39	725	2663	7438	L	35	120	1591	3030	81.5	70.0	9.0	72.5	42.0

Figure 2. Cement Paste Strength Gains

3030-3110 Blaine Range.

Table 3. Cement Paste Performance, 3190-3350 Blaine Range.

RUN #	STRENGTH AT AGE, PSI			BALL SIZE	BALL LOAD, %	FEED LB/HR	CIRC. LOAD, %	BLAINE SOCM/G	PERCENT FINER	PERCENT FINER	PERCENT FINER	PERCENT BETWEEN	95 PCTILE SIZE MICRONS
	1-DAY	7-DAY	28-DAY						30 μ m	25 μ m	3 μ m	3-30 μ m	
4-4	1388	6025	9500	M	35	115	982	3230	86.0	76.0	10.0	76.0	38.0
4-3	1113	5475	8075	M	35	115	835	3250	85.0	75.0	9.5	75.5	38.5
3-50	1288	5388	8800	S	35	115	499	3350	86.0	74.0	10.0	76.0	39.0
3-38	925	3838	8538	L	35	126	1631	3200	85.5	76.0	9.5	76.0	37.5
4-9H	700	3575	8575	S	35	145	887	3190	86.5	77.5	9.0	77.5	38.0
4-8H	1450	3513	6950	M	35	145	929	3310	85.0	74.5	10.0	75.0	39.0

Figure 3. Cement Paste Strength Gains

3180-3350 Blaine Range.

END

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