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COMPARISON OF THE AIR-JET SIEVE METHOD FOR DETERMINING THE FINENESS OF CEMENT WITH SOME ASTM STANDARD METHODS

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V.M. Malhotra* and N.G. Zoldners**

SUMMARY

This investigation is concerned with the fineness determination of cement comparing the air-jet sieve method with ASTM standard test methods such as hand-sieving on the No. 200 sieve, wet-sieving on the No. 325 sieve and the determination of the specific surface by the Blaine air-permeability method.

The test results indicate that:

(1) The air-jet sieve method for fineness by the No. 200 sieve gives more reproducible results than the hand-sieving method, coefficients of variation for the test results of the two test methods being 2.57 and 7.93 per cent, respectively.

(2) The air-jet sieve method for fineness using the No. 325 sieve gives results of poorer reproducibility than those obtained by the wet-sieving method. Coefficients of variation for the test results of the two methods were 8.46 and 4.17 per cent, respectively. It is suspected that the poorer reproducibility of results by air-jet sieving is due to balling of fine dry cement. There was more clogging in the wet-sieving operation even though its results were more reproducible.

(3) The method of fineness determination in terms of specific surface is superior to the air-jet sieving method using the No. 200 sieve, the coefficients of variation being 0.58 and 1.98 per cent, respectively. But these methods cannot be related directly because they do not measure the same parameters.

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INTRODUCTION

The ASTM test methods for fineness determination of cement include both the sieving and specific surface methods. The determination of fineness by the manual sieving methods is unsatisfactory and has a number of inherent drawbacks. The specific surface methods are no doubt superior to sieving methods. Neither method gives any idea of particle size distribution.

A new method, using the Alpine Air-Jet Sieve has been investigated at the Mines Branch and described by Malhotra and Wallace in Mines Branch Investigation Report IR 63-119 (1). Copies of that report were distributed to the members of the Subcommittee on Fineness of the ASTM Committee C-1 on Cement, in December, 1966. A thorough investigation of this method has been made by the research laboratory of Canada Cement Company, Limited, Montreal, leading to its adoption as their standard method for all dry sieving of cement on the Nos. 200 and 325 sieves (2).

At the meeting of the Subcommittee held on June 28, 1967, in Boston, its chairman Mr. K.J. Schatzlein suggested that more work should be done on the application of the Alpine air-jet sifter and the report submitted for inclusion in the Fineness Symposium scheduled for the ASTM Annual Meeting, June, 1968.

This report describes investigation work carried out at the Mines Branch comparing the air-jet sieving technique for determining the fineness of cement with ASTM standard test methods such as hand-sieving on the No. 200 sieve, wet-sieving on the No. 325 sieve and the determination of the specific surface by the air-permeability method (3, 4, 5).

SCOPE OF INVESTIGATION

This investigation consisted of three series of tests in which the air-jet sieving technique for determining the fineness of cement was compared with three ASTM standard test methods as follows:

Series 1 - The percentage of a 50-gram cement sample retained on the No. 200 sieve using the air-jet sieve method was compared with the percentage retained when using the hand-sieving method, ASTM Standard C 184-66 (3).

Note: The No. 200 and No. 325 sieves refers to 200-mesh and 325-mesh sieves of Tyler Standard Series.

Series 2 - The percentage of a 10-gram cement sample retained on the the No. 325 sieve using the air-jet sieve method was compared with the percentage of a 1-gram sample retained when using the wet-sieving method, ASTM Standard C 430-60T (4).

Series 3 - In this series two methods for measuring the fineness of cement were evaluated - the one determined the percentage retained on a No. 200 sieve by the air-jet sieving, the other determined the specific surface value of the companion sample by the use of the Blaine air-permeability apparatus, ASTM Standard C 204-55 (5).

Normal portland cement (ASTM Type 1) was used in each of the three test series. A lot of about 20 lb was taken from one cement bag and divided by a sample splitter into test samples of about 50 grams each.

ALPINE AIR-JET SIEVE

Principle

The principle of air-jet sieving lies in the use of an air current to disperse the material on the sieve and to carry the finer fractions through it. The machine works without any mechanical movement of the sieve or other part in contact with the material.

Description

The Alpine Air-Jet Sieve* is shown in Figure 1. A diagrammatic section through the working part is shown in Figure 2. It shows the housing which forms the dish, the sieve drum with cover, and the slit nozzle which extends across a complete radius of the sieve and rotates around a vertical axis.

The material to be sieved is placed on the sieve surface. The slit nozzle moves slowly in a clockwise direction below the sieve surface. A vacuum created by a suitable exhaust fan induces an air current to pass up through the sieve, clearing the mesh. The particles are suspended in air and are separated. On its downward path the air carries the fine

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*Manufactured by Alpine Luckens Corp, Augsburg, Germany.

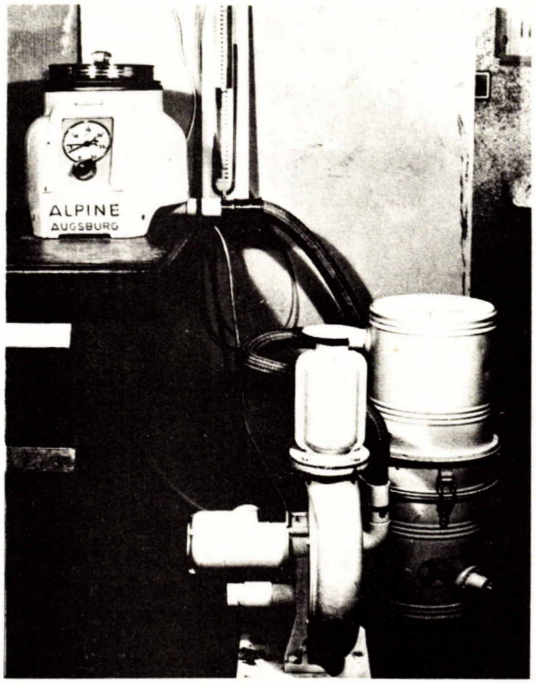

Figure 1. The Alpine air-jet sieve.

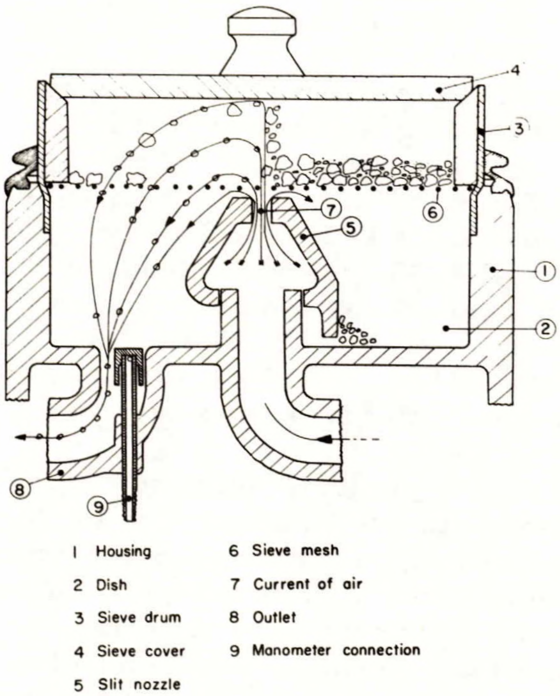

Figure 2. Diagrammatic section through the working part of the Alpine air-jet sieve.

material down through the sieve into the dish and through the outlet. The coarse material remains on the sieve surface; the fine material is collected in a filter (not shown in the section) and cannot be recovered quantitatively.

The nozzle is connected through a hollow shaft with the outside so that air can flow in. The vacuum in the dish is adjusted by dampers and indicated by a manometer which is attached to the apparatus.

Sieving Procedure

The detailed sieving procedure is given in the manual supplied by the manufacturer, and its application to cement samples is summarized below.

To determine the fineness of cement, a sieve is placed on the sieve housing and the predetermined amount of cement is added, the sieve is covered and the switch clock is turned on. To prevent cement sticking to the cover, the knob of the sieve cover is tapped every ten seconds with a plastic hammer. At the end of sieving the apparatus is switched off. The sieve is removed, the residue retained is weighed and its percentage is calculated.

TEST PROCEDURE AND RESULTS

In the first series of tests, thirty companion pairs of cement samples were prepared from the same cement lot by riffling. One 50-gram sample from each pair was used for fineness determination by hand-sieving on the No. 200 sieve in accordance with section 7.2 of CSA Standard A5-1961. This test procedure is identical in all essential respects to the method outlined in the ASTM Standard C184-44 and differs from the latter only in minor details. The companion 50-gram sample was used to determine the percentage retained on the No. 200 sieve using the air-jet sieve for a fixed time of 6 minutes. This time was considered to be the minimum for efficient sieving (1). The same sieve was used in each test.

In the second series of tests, thirty companion pairs of cement samples were prepared using the same cement lot as before. A 1-gram sample from each pair was used for fineness determination by wet-sieving on the 2-in.-diameter No. 325 sieve (ASTM Standard C430-60T). Approximately 10 gram of cement from the companion 50-gram sample was used to determine the percentage retained on the No. 325 sieve using the 8-in.-diameter air-jet sieve. After each sieving operation, the sieve was properly cleaned by soaking it in a sonic bath, and then blowing air through it.

In the third series of tests, thirty companion pairs of cement samples were prepared using the same cement lot as before. One 50-gram sample from each pair was used for determining the percentage retained on the No. 200 sieve using the air-jet sieve. Approximately 3 gram of the companion sample was used to determine the specific surface by the Blaine air-permeability method (5).

In order to limit variables, all fineness determinations were carried out by the same technician under reasonably controlled laboratory conditions. During this investigation, which lasted only several weeks, temperature in the laboratory varied between 70 and 75°F and relative humidity ranged from 40 to 60 per cent.

A summary of the test results and statistical analyses is given in Table 1. Detailed test results are given in Tables A to F in the Appendix.

DISCUSSION OF RESULTS

Comparison of Air-Jet Sieve and Hand-Sieving Methods

The coefficient of variation for the percentage retained on a No. 200 sieve was 2.67 per cent for the air-jet sieve method and 7.93 for the hand-sieving method. This indicates superior reproducibility of test results for the former method. The mechanically more consistent operation of the Alpine air-jet sieve combined with the fixed sieving time seems mainly responsible for the low coefficient of variation.

Comparison of Air-Jet Sieve and Wet-Sieving Methods

The coefficient of variation for the percentage retained on a No. 325 sieve was 8.46 for the air-jet sieve method and 4.17 per cent for the wet-sieving method. It is suspected that poorer reproducibility of results by air-jet sieving is due to balling of fine dry cement (2). There was more clogging of sieve in the wet-sieving operation. Though in this investigation the wet-sieving produced results of better reproducibility than air-jet sieving on No. 325 sieve it would be incorrect to impute that wet-sieving is a better means of separation than air-jet sieving.

TABLE 1

Summary of Test Results and Statistical Analyses

	Series 1		Series 2		Series 3	
	Air-Jet Sieve Method (No. 200 sieve)	Hand-Sieving Method (No. 200 sieve)	Air-Jet Sieve Method (No. 325 sieve)	Wet-Sieving Method (No. 325 sieve)	Air-Jet Sieve Method (No. 200 sieve)	Blaine Air-Permeability Method
No. of Test Results	30	30	30	30	30	30
Maximum Percentage Retained	3.02	4.37	9.99	12.68	1.46	3049*
Minimum Percentage Retained	2.71	3.24	7.62	10.69	1.33	2987*
Average Percentage Retained	2.88	3.65	8.86	11.66	2.77	3019*
Standard Deviation of Percentage Retained, per cent	0.077	0.29	0.75	0.486	0.055	17.6*
Coefficient of Variation, per cent	2.67	7.93	8.46	4.17	1.98	0.58

*For the Blaine air-permeability method, the values refer to maximum, minumum and average specific surface areas expressed in cm^2 per gram of original cement that has not been sieved.

Air-Jet Sieve and Blaine Air-Permeability Methods

The coefficient of variation for the air-jet sieve method using a No. 200 sieve was 1.98 per cent; the corresponding value for the Blaine air-permeability method was 0.58 per cent. Notwithstanding the superior reproducibility of the results of the latter method, it is emphasized that the two methods are not directly related. The air-jet sieve method gives a percentage of particles remaining on a No. 200 sieve, while air-permeability method measures the surface area of particles in square centimeters per gram of material.

Bias Between the Values of Air-Jet Sieve and Other Sieving Methods

A consistent bias was found in the percentage retained on a No. 200 sieve using the air-jet sieve and hand-sieving methods; the average percentage retained was 0.77 per cent higher for the latter method. No investigations were undertaken to explain the above difference. However, Wahl and Larouche (6) who are using the air-jet sieve for in-plant quality-control studies in an aluminum plant in Canada attribute such differences to the characteristic grain diameter* of the particles passing the sieves at the end of the screening period. They claim that accurate size distribution can be obtained from either screening method by use of the characteristic grain diameter instead of aperture size.

Although in the ASTM Standard Specification for Portland Cement (C 150-67) the fineness of cement is specified only by the minimum specific surface requirement, the Canadian standard A5-1961 specifies the maximum amount retained on No. 200 sieve.

It must also be noted that the research laboratory of the Canada Cement Company, Limited, has adopted the air-jet sieving as their standard method for all dry sieving of cement on Nos. 200 and 325 sieves (2).

CONCLUDING REMARKS

1. The Alpine air-jet sieve method of determining the percentage of cement retained on the No. 200 sieve gives more reproducible results than the hand-sieving procedure.

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*Characteristic Grain Diameter = $\sqrt[3]{\frac{\text{weight in gram}}{\text{specific gravity}} \times \frac{6}{\text{number of particles}}}$

2. When Alpine air-jet sieve was used some clogging of the No. 325 sieve was observed. More clogging of the sieve may be expected when finer cements are used, because these have a tendency to ball.

3. The Blaine air-permeability method of determining the specific surface of cement gives test results of superior reproducibility, however, this method cannot be related directly to the Alpine air-jet sieve method because the two methods do not measure the same parameters.

REFERENCES

1. V.M. Malhotra and G.G. Wallace, "A New Method for Determining the Fineness of Cement", Canada Mines Branch Investigation Report IR 63-119, Department of Energy, Mines and Resources, Ottawa, Canada, December 1963, 13 pp.

2. Circular Letter from W.S. Weaver to ASTM Committee C-1 membership, October 17, 1966.

3. Standard Method of Test for Fineness of Hydraulic Cement by the No. 100 and No. 200 Sieves (C 184-66), 1967 Book of ASTM Standards, part 9, p. 177.

4. Standard Method of Test for Fineness of Hydraulic Cement by the No. 325 Sieve (C 430-60T), 1967 Book of ASTM Standards, Part 9, p. 372.

5. Standard Method of Test for Fineness of Hydraulic Cement by Air-Permeability Apparatus (C 204-55) 1967 Book of ASTM Standards, Part 9, p. 206.

6. B.J. Wahl and P. Larouche, "Accuracy and Precision in Industrial Screen Analysis" American Society Bulletin, May 1964, Vol. 43, No. 5, pp. 377-379.

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APPENDIX

Tables A and B (Series 1)
C and D (Series 2)
E and F (Series 3)

(detailed test results)

TABLE A

Percentage Retained on No. 200 Sieve Using Hand-Sieving

Sample No.	Sample Weight, g	Weight Retained on No. 200 Sieve, g	Percentage Retained on No. 200 Sieve, g
1	50.0030	1.6193	3.238
2	49.9996	1.8135	3.627
3	50.0003	1.6870	3.374
4	50.0014	1.8316	3.663
5	50.0000	1.8299	3.660
6	50.0009	1.7441	3.488
7	49.9992	1.7958	3.592
8	50.0004	1.9349	3.870
9	50.0010	1.7538	3.508
10	50.0003	1.7838	3.568
11	50.0004	1.6772	3.354
12	50.0001	1.7296	3.459
13	50.0001	1.8148	3.630
14	50.0003	1.7225	3.445
15	50.0010	1.6859	3.372
16	50.0000	1.6888	3.378
17	50.0003	1.8737	3.747
18	50.0004	2.1428	4.286
19	50.0000	2.0377	4.075
20	50.0002	1.9096	3.819
21	50.0002	2.1873	4.375
22	50.0003	1.9845	3.969
23	50.0003	1.6954	3.390
24	50.0003	1.7130	3.426
25	50.0004	1.7230	3.446
26	50.0003	1.7434	3.487
27	50.0005	1.8341	3.668
28	49.9994	2.1002	4.200
29	50.0002	1.8821	3.764
30	50.0000	1.7876	3.575

TABLE B

Percentage Retained on No. 200 Sieve Using Air-Jet Sieve

Sample No.	Sample Weight, g	Weight Retained on No. 200 Sieve, g	Percentage Retained on No. 200 Sieve, g
1	50.0550	1.3587	2.714
2	50.0080	1.3712	2.742
3	50.0078	1.4065	2.812
4	50.0107	1.3659	2.731
5	50.0047	1.4140	2.827
6	50.0008	1.4114	2.823
7	50.0076	1.4109	2.821
8	50.0022	1.4270	2.854
9	50.0144	1.4435	2.886
10	50.0015	1.4142	2.828
11	50.0039	1.4461	2.892
12	50.0168	1.4332	2.865
13	50.0022	1.4024	2.805
14	50.0088	1.4566	2.913
15	49.9925	1.4529	2.906
16	50.0084	1.5106	3.021
17	50.0043	1.4535	2.907
18	50.0036	1.4785	2.957
19	50.0021	1.4325	2.865
20	50.0021	1.4327	2.865
21	50.0035	1.4750	2.950
22	50.0036	1.4319	2.863
23	50.0141	1.4539	2.907
24	50.0031	1.4754	2.951
25	50.0024	1.4397	2.879
26	50.0024	1.4631	2.926
27	50.0040	1.4351	2.870
28	50.0057	1.5077	3.015
29	50.0032	1.5008	3.001
30	50.0077	1.4755	2.950

TABLE C

Percentage Retained on No. 325 Sieve Using Wet-Sieving

Sample No.	Sample Weight, g	Weight Retained on No. 325 Sieve, g	Percentage Retained on No. 325 Sieve, g
1	1.0003	0.1101	11.01
2	0.9997	0.1132	11.32
3	1.0001	0.1241	12.41
4	1.0002	0.1200	12.00
5	1.0005	0.1138	11.37
6	1.0005	0.1211	12.10
7	1.0000	0.1137	11.37
8	0.9998	0.1165	11.65
9	1.0001	0.1139	11.39
10	1.0004	0.1208	12.07
11	1.0001	0.1145	11.45
12	1.0000	0.1114	11.14
13	1.0005	0.1129	11.28
14	1.0004	0.1139	11.38
15	1.0000	0.1145	11.45
16	0.9998	0.1159	11.59
17	1.0000	0.1167	11.67
18	1.0015	0.1219	12.17
19	1.0003	0.1144	11.44
20	1.0006	0.1203	12.02
21	1.0006	0.1098	10.97
22	1.0003	0.1069	10.69
23	1.0002	0.1144	11.44
24	1.0001	0.1265	12.65
25	1.0009	0.1269	12.68
26	1.0000	0.1146	11.46
27	1.0006	0.1217	12.16
28	1.0001	0.1168	11.68
29	1.0007	0.1213	12.12
30	1.0001	0.1159	11.59

TABLE D

Percentage Retained on No. 325 Sieve Using Air-Jet Sieve

Sample No.	Sample Weight, g	Weight Retained on No. 325 Sieve, g	Percentage Retained on No. 325 Sieve g
1	10.0000	0.7621	7.621
2	10.0000	0.7638	7.638
3	10.0001	0.7729	7.729
4	10.0001	0.8617	8.617
5	10.0007	0.8121	8.120
6	9.9998	0.9175	9.175
7	10.0004	0.9598	9.598
8	10.0003	0.8807	8.807
9	10.0006	0.9859	9.857
10	10.0006	0.8721	8.720
11	10.0006	0.8487	8.486
12	10.0008	0.9442	9.440
13	10.0005	0.8895	8.893
14	10.0013	0.9964	9.960
15	10.0003	0.8649	8.648
16	9.9999	0.8675	8.675
17	10.0000	0.7965	7.965
18	10.0000	0.9782	9.782
19	10.0000	0.8314	8.314
20	10.0001	0.9645	9.645
21	10.0004	0.8443	8.442
22	10.0000	0.9639	9.639
23	10.0006	0.8304	8.302
24	10.0001	0.9258	9.258
25	10.0007	0.8104	8.101
26	10.0006	0.9597	9.595
27	10.0003	0.8345	8.344
28	10.0000	0.9993	9.993
29	10.0007	0.8367	8.364
30	10.0006	0.9960	9.958

TABLE E

Specific Surface by Blaine Air Permeability Method

Sample No.	Sample Weight, g	Average Time, Sec	Specific Surface*, cm²/g
1	2.9056	66.93	3018
2	2.9051	67.13	3023
3	2.9051	67.26	3026
4	2.9054	67.33	3027
5	2.9050	65.67	2990
6	2.9051	67.60	3033
7	2.9051	66.40	3006
8	2.9053	66.70	3013
9	2.9050	66.85	3017
10	2.9050	67.57	3033
11	2.9053	67.73	3036
12	2.9050	68.28	3049
13	2.9052	67.37	3028
14	2.9054	68.16	3046
15	2.9051	67.87	3039
16	2.9052	67.80	3038
17	2.9052	66.93	3018
18	2.9054	68.00	3042
19	2.9051	65.54	2987
20	2.9051	67.10	3022
21	2.9052	67.20	3024
22	2.9052	66.20	3002
23	2.9050	67.00	3020
24	2.9052	67.60	3033
25	2.9050	66.20	3002
26	2.9051	65.73	2991
27	2.9052	66.53	3009
28	2.9050	66.55	3010
29	2.9062	66.05	2998
30	2.9053	65.70	2990

*Specific Surface = $\frac{1643.6}{\rho(1-e)} \times \sqrt{(1-e)^3 T}$ where $e = 0.5$ (porosity)
$\rho = 3.15$ (specif.gravity)
T = air flow time, sec.

TABLE F

Percentage Retained on No. 200 Sieve Using Air-Jet Sieve

Sample No.	Sample Weight, g	Weight Retained on No. 200 Sieve, g	Percentage Retained on No. 200 Sieve, g
1	50.0000	1.3828	2.766
2	50.0000	1.3555	2.711
3	50.0002	1.3823	2.764
4	50.0002	1.3766	2.753
5	49.9998	1.3690	2.738
6	50.0004	1.4032	2.806
7	50.0003	1.3789	2.758
8	49.9999	1.3698	2.740
9	50.0000	1.3732	2.746
10	50.0000	1.3790	2.758
11	50.0000	1.3814	2.763
12	50.0001	1.3996	2.799
13	50.0004	1.3805	2.761
14	50.0000	1.3889	2.778
15	50.0006	1.3769	2.754
16	49.9996	1.3654	2.731
17	50.0008	1.3539	2.708
18	49.9999	1.3696	2.739
19	50.0003	1.3313	2.662
20	50.0007	1.3668	2.733
21	50.0007	1.3545	2.709
22	49.9997	1.3879	2.776
23	50.0004	1.4608	2.921
24	50.0000	1.3787	2.757
25	50.0002	1.3717	2.743
26	49.9999	1.4199	2.840
27	50.0007	1.4070	2.814
28	50.0002	1.4307	2.861
29	50.0012	1.4510	2.902
30	50.0010	1.3875	2.775