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A NEW METHOD FOR DETERMINING FINENESS OF CEMENT

by

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MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

This investigation was carried out to evaluate a new sieving method for determining the fineness of cements. Twenty 50-g samples of a normal portland cement were used for fineness determination by the Alpine Air Jet Sieve, a new sieving apparatus; the fineness of the companion twenty 50-g samples was determined by hand sieving on a No. 200 sieve as outlined in the CSA standard A5-1961. The comparative test results show that the Air Jet Sieve gives more reproducible results than the CSA standard method, coefficients of variation for the two methods being 2.8 and 6.8 per cent respectively. Further, it is considered that the degree of reproducibility for theAir Jet Sieve test results should be of the same order as that obtained in Blaine's Air Permeability method for determining specific surface of cements.

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Direction des mines

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NOUVEAU PROCÉDÉ POUR DÉTERMINER LA FINESSE DE MONTURE DES CIMENTS

par

V. M. Malhotra* et G. G. Wallace**

RÉSUMÉ DES RÉSULTATS

Cette expertise a été faite pour déterminer la valeur d'un nouveau procédé de tamisage qui sert à déterminer la finesse de monture des ciments. Vingt échantillons de 50 g de ciment portland ont servi à déterminer la finesse à l'aide d'un nouveau tamis Alpine à jet d'air. La finesse de vingt échantillons témoins de 50 g avait été établie par tamisage à la main à l'aide d'un tamis n° 200 recommandé dans le CSA standard A5-1961. Les résultats des essais comparatifs indiquent que le tamis à jet d'air donne des résultats plus facilement reproduisibles que le procédé classique CSA, les coefficients de variation pour les deux procédés étant de 2.8 et de 6.8 p. 100 respectivement. De plus, on croit que le degré de reproductibilité des résultats des essais au tamis à jet d'air devrait être du même ordre que celui que l'on obtient avec le procédé de la perméabilimétrie à l'air de Blaine qui sert à déterminer la surface spécifique des ciments.

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INTRODUCTION

Fineness has long been regarded as one of the important physical properties of cement because it influences the rate of reaction of cement with water. The CSA standard A5-1961 specifies that the fineness of cement shall be determined by hand sieving using a 74-micron (No. 200) sieve conforming with ASTM standards*. The ASTM specification on fineness of cement allows both the No. 200 sieve and specific surface methods**. The determination of fineness by the No. 200 sieve is an unsatisfactory method and has a number of inherent drawbacks, e.g., operator error and unspecified total sieving time. The methods of fineness determination in terms of the specific surface are no doubt superior to the hand sieving method but are not as simple and involve some calculations.

This report describes the Alpine Air Jet Sieve, compares the results obtained on 20 identical pairs of cement samples using the Air Jet sieve and hand sieving, and outlines the advantages of the new method.

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*ASTM Specification for Sieves for Testing Purposes (E11-61), 1961 Book of ASTM Standards, Part 4, p. 1479.

**Standard Method of Test for Fineness of Hydraulic Cement by the No. 200 Sieve (C 184-44), 1961 Book of ASTM Standards, Part 4, p. 144.

Standard Method of Test for Fineness of Portland Cement by Air Permeability Apparatus (C 204-55), 1961 Book of ASTM Standards, Part 4, p. 149.

Standard Method of Test for Fineness of Portland Cement by the Turbidimeter (C 115-58), 1961 Book of ASTM Standards, Part 4, p. 156.

ALPINE AIR JET SIEVING APPARATUS

The Alpine Air Jet Sieve*, is a new type of apparatus for carrying out the dry sieving of cement and other fine materials. The method of sieving does not appear to affect the material being sieved.

Principle

The principle of the Air Jet Sieve consists 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 Air Jet Sieve is shown in Figure 1. A diagrammatic tangential section through the working part is shown in Figure 2. It shows the housing (1), which forms the dish (2), the sieve drum (3), with cover (4), and the slit nozzle (5), which rotates around a vertical axis.

The cement to be sieved is placed on the sieve surface (6). The slit nozzle (5), moves slowly in the clockwise direction below the sieve surface. The current of air (7) produced by a suitable fan blows up through the sieve surface and blows the mesh free. The cement particles are suspended in air and are separated. On its return path the air carries the fine material down through the sieve into the dish, and through the outlet (8). 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 (5), is connected through a hollow shaft and suction connection with the outside so that air can flow in. The pressure in the dish is controlled by the manometer, which is attached to the apparatus at (9).

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*Manufactured by Alpine Aktiengesellschaft, Germany.
Canadian distributors: Williams and Wilson Limited, Montreal.

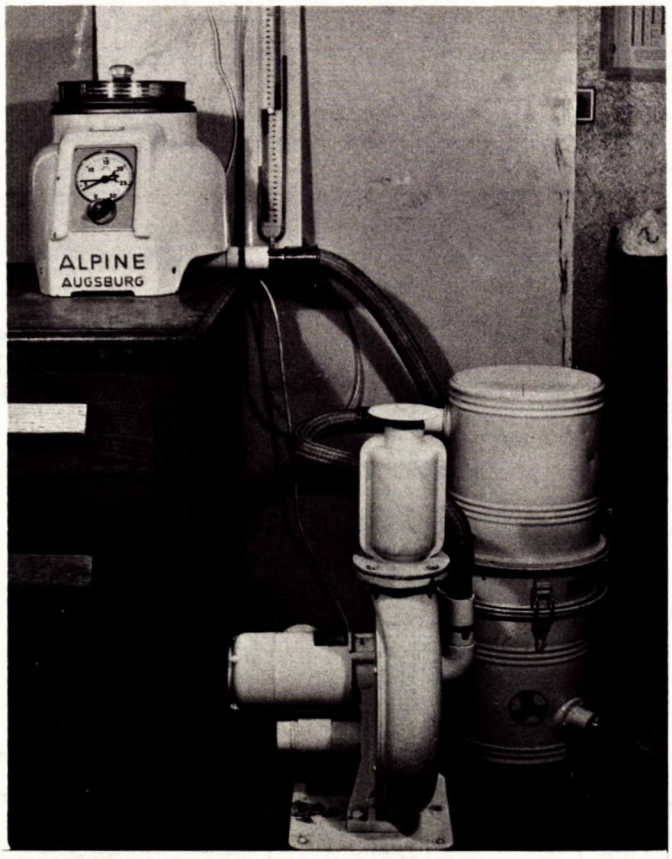

Figure 1. Alpine Air Jet Sieve

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, sieve No. 200* is placed on the sieve housing and the weighed amount of cement (not be exceed 50 g) is added. The cover is put on 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 the plastic hammer supplied. After the end of sieving the apparatus is switched off. The sieve is removed, the residue retained is weighed and the percentage residue is calculated.

A close up view of the sieve in action is given in Figure 3.

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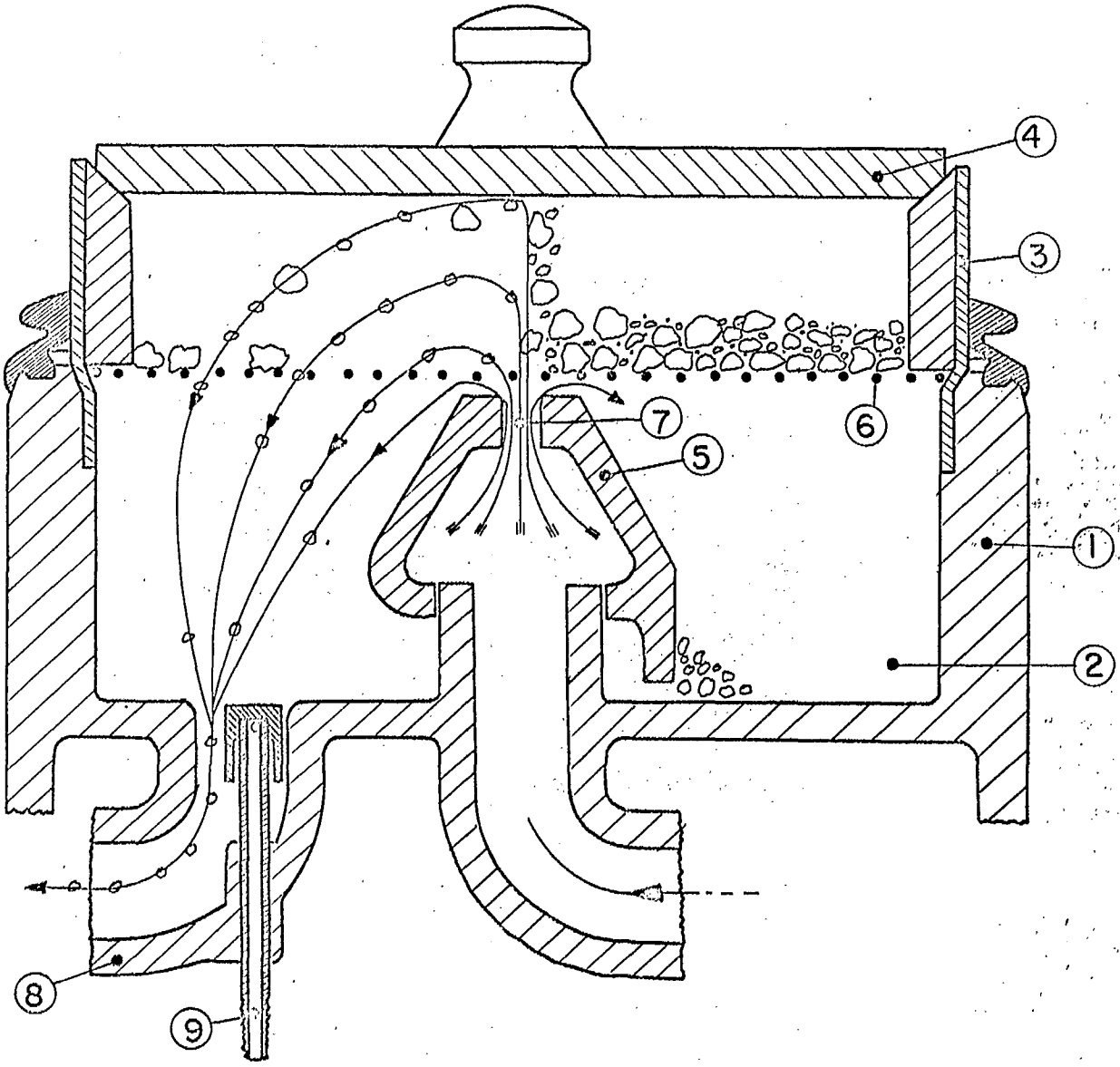
* Sieve designations other than No. 200 can be used, provided the frame is standard 8 in. size.



1	Housing	6	Sieve mesh
2	Dish	7	Current of air
3	Sieve drum	8	Outlet
4	Sieve cover	9	Manometer connection
5	Slit nozzle		

Figure 2. Diagrammatic tangential section through the working part of the Alpine Air Jet Sieve

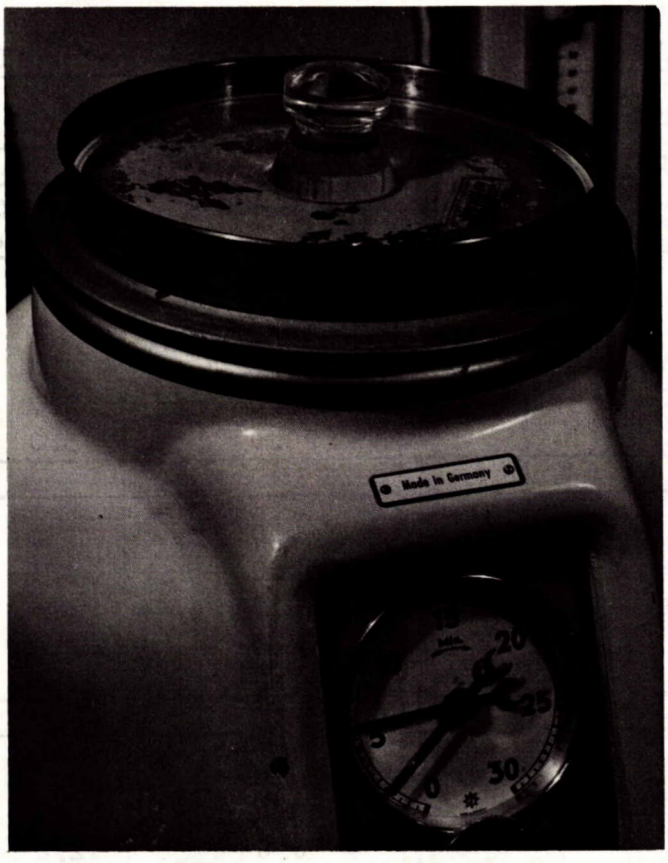


Figure 3. A close-up view of the Alpine Air Jet Sieve during operation.

Time of Sieving

In order to determine the time required for efficient sieving, a series of 4 test runs, each consisting of 5 tests, was carried out. The sieving times used were 2, 4, 6 and 7 min. The test results are summarized in Table 1. A sieving time of 6 minutes was considered to be the minimum for efficient sieving.

TABLE 1

Alpine Air Jet Sieve - Determination of Sieving Time

Series No.	Sieving Time, min	Test No.	Before Sieving Weight, g	After Sieving Weight Retained, g	After Sieving Per cent Retained
1	2	1	50.0	3.1	6.2
		2	50.0	2.9	5.8
		3	50.0	3.1	6.2
		4	50.0	3.2	6.4
		5	50.0	3.0	6.0
					Av. 6.1
2	4	1	50.0	2.4	4.8
		2	50.0	2.4	4.8
		3	50.0	2.5	5.0
		4	50.0	2.5	5.0
		5	50.0	2.6	5.2
					Av. 5.0
3	6	1	50.0	2.4	4.8
		2	50.0	2.4	4.8
		3	50.0	2.4	4.8
		4	50.0	2.4	4.8
		5	50.0	2.4	4.8
					Av. 4.8
4	7	1	50.0	2.4	4.8
		2	50.0	2.4	4.8
		3	50.0	2.4	4.8
		4	50.0	2.4	4.8
		5	50.0	2.4	4.8
					Av. 4.8

TEST PROCEDURE AND RESULTS

Twenty identical pairs of cement samples were prepared from the same cement lot by riffling. One 50-g sample from each pair was used for fineness determination by hand sieving as outlined in section 7.2. of CSA standard A5-1961. The companion 50-g sample was used to determine the percentage retained on a No. 200 sieve using the Air Jet Sieve and a time of 6 min. The test results are given in Tables 2 and 3.

TABLE 2

Test Results - CSA Standard Method

Sample No.	Sieving Time, min	Before Sieving	After Sieving	
		Weight, g	Weight Retained, g	Per cent Retained
1	24	50.0	2.97	5.94
2	22	50.0	2.88	5.76
3	22	50.0	3.42	6.84
4	24	50.0	3.38	6.76
5	23	50.0	3.13	6.26
6	22	50.0	3.20	6.40
7	21	50.0	2.97	5.94
8	21	50.0	2.88	5.76
9	21	50.0	2.58	5.16
10	21	50.0	3.02	6.04
11	22	50.0	2.97	5.94
12	21	50.0	3.31	6.62
13	21	50.0	3.19	6.38
14	22	50.0	3.07	6.14
15	22	50.0	3.00	6.00
16	21	50.0	3.02	6.04
17	21	50.0	3.14	6.28
18	21	50.0	3.38	6.76
19	21	50.0	3.35	6.70
20	21	50.0	3.06	6.12

TABLE 3

Test Results - Air Jet Sieve Method

Sample No.	Sieving Time, min	Before Sieving	After Sieving	
		Weight, g	Weight Retained, g	Per cent Retained
1	6	50.0	2.41	4.82
2	6	50.0	2.42	4.84
3	6	50.0	2.40	4.80
4	6	50.0	2.56	5.12
5	6	50.0	2.47	4.94
6	6	50.0	2.47	4.94
7	6	50.0	2.42	4.84
8	6	50.0	2.53	5.06
9	6	50.0	2.47	4.94
10	6	50.0	2.51	5.02
11	6	50.0	2.37	4.74
12	6	50.0	2.33	4.66
13	6	50.0	2.36	4.72
14	6	50.0	2.46	4.92
15	6	50.0	2.41	4.82
16	6	50.0	2.48	4.96
17	6	50.0	2.37	4.74
18	6	50.0	2.40	4.80
19	6	50.0	2.47	4.94
20	6	50.0	2.43	4.86

STATISTICAL ANALYSIS OF TEST RESULTS

Explanation of Statistical Terms

Test results were analysed using standard statistical methods. The maximum and minimum values, average, standard deviation and coefficient of variation, which are defined below, were calculated.

Maximum and Minimum Values

These are the maximum and minimum test values obtained in any of the individual tests.

Average (Arithmetic Mean)

It is the average value of all the results of any individual test, i.e.,

$$\overline{X} = \frac{X_a + X_b + X_c + X_d + \text{------} + X_z}{n}$$

where X_a, X_b, X_c -----X_z are the results for any individual test, and n is the total number of test results. Thus the average represents the value about which test results have a tendency to centre.

Standard Deviation (of a population)

It is a measure of the spread of observations about the central value. The standard deviation of the population is found by extracting the square root of the average of the squares of deviations of individual test values from their average

$$\sigma = \sqrt{\frac{(X_1 - \overline{X})^2 + (X_2 - \overline{X})^2 + \text{----} + (X_n - \overline{X})^2}{n}}$$

For ease of computation, when a calculating machine is available, standard deviation can be obtained by dividing the sum of the squares of the individual observations by the number of observations,

subtracting the square of their average and extracting the square root, i.e.,

$$\sigma = \sqrt{\frac{X_1^2 + X_2^2 + X_3^2 + \text{-------} + X_n^2}{n} - (X)^2}$$

or by re-arranging,

$$\sigma = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}{n}}$$

Standard Deviation (of a sample)

In computing Standard Deviation of a sample, the divisor "n" in the above calculations is replaced by (n-1), i.e.,

$$S = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}{n-1}}$$

This latter definition has been used for the calculations in this instance. The difference due to the use of (n-1) instead of n becomes significant when the number of test results is less than 30.

Coefficient of Variation

The Coefficient of Variation (C.V.) is simply the Standard Deviation expressed as a percentage of the Arithmetic Mean, i.e.,

$$\text{C.V.} = \frac{\text{Standard Deviation} \times 100}{\text{Arithmetic Mean}}$$

The main use of this function is to illustrate the degree of dispersion in terms of the mean.

Summary of Analysis

The summary of the analysis is given in Table 4.

TABLE 4

Summary of Analysis

	CSA Hand Sieving Method	Alpine Air Jet Sieve Method
No. of Test Results	20	20
Maximum Percentage Retained	6.84	5.12
Minimum Percentage Retained	5.16	4.66
Average Percentage Retained	6.19	4.87
Standard Deviation of Percentage Retained	0.42	0.14
Coefficient of Variation, Per cent	6.8	2.8

DISCUSSION OF RESULTS

The coefficients of variation for the percentage retained on No. 200 sieve were 2.8 and 6.8 per cent (Table 4) for the Air Jet Sieve and the CSA standard hand sieving method, respectively. The sieving time for the former method was only 6 min whereas the time required for the latter method varied from 21 to 24 min. The non-manual operation of the Air Jet Sieve combined with the fixed sieving time essentially explains the low coefficient of variation. The "operator error" is one of the biggest drawbacks to CSA hand sieving procedures. This was clearly demonstrated in the CSA interlaboratory Cement Testing Programme--Phase I (1), in which the coefficient of variation for fineness determination varied from 11.5 to 33.4 per cent. It is, of course, realized that the use of non-standard and worn sieves could have partly contributed to these high values; nevertheless they are very high. The use of the Air Jet Sieve method would not eliminate errors caused by the use of substandard sieves but by eliminating the "operator error" would greatly reduce the variation for the fineness test and particularly so in an interlaboratory study.

In the Air Jet Sieve the material that passes through the sieve cannot be recovered. This is of little consequence as far as the fineness of cement is concerned.

No comparative tests were carried out between the Air Jet Sieve and the Blaine's Air Permeability methods. However, the coefficient of variation for the two methods should compare favourably. In the CSA testing programme the coefficient of variation for the specific surface as determined by the Blaine method varies from 1.8 to 4.5 per cent. This is of the same order as the corresponding values for fineness given in Table 4. Further, the Air Jet Sieve method is simpler, quicker and involves no calculations.

CONCLUSIONS

From the results of this investigation it is concluded that:

1. The determination of fineness of cement by the Alpine Air Jet Sieve gives more consistent results than the hand sieving method as given in section 7.2 of the CSA standard A5-1961.

2. The Air Jet Sieve method is independent of operator error and is therefore ideally suited for long term inter-laboratory studies for fineness determination of cement.

3. The reproducibility of fineness test results by the Air Jet Sieve method should compare favourably with those obtained by Blaine Air Permeability method.

REFERENCE

1. N.G. Zoldners and V.M. Malhotra, "CSA Cement Testing Programme--Phase I". Mines Branch Investigation Report IR 62-102, Department of Mines and Technical Surveys, Ottawa (1962).

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