Pergamon

Cement and Concrete Research, Vol. 25, No. 7, pp. 1403-1405, 1995
1995 Elsevier Science Ltd

0008-8846/95 $9.50+.00

0008-8846(95)00134-4

SURFACE AREA OF FLYASHES

R.S. Iyer and B.R. Stanmore
Department of Chemical Engineering
University of Queensland Australia

(Communicated by J.P. Skalny)
(Received February 23, 1995)

Abstract

The flow properties of cement or flyash slurries are partly determined by the surface area of the particles. This area is generally measured with the Blaine apparatus which relies on frictional drag of air flowing through a packed bed. A comparison is presented here between the areas of two flyashes, each measured by the Blaine method and also by calculation from mean particle diameter as determined by laser diffraction. There appear to be advantages in using the laser diffraction method.

Introduction

The flow behaviour of dense slurries of cement or flyash is partly determined by the surface area of the solid particles. This area is conventionally measured by means of the Blaine apparatus [1], in which a fixed volume of solid is packed into a cylinder and a flow of air passed through the bed. Since the flow is laminar, the pressure drop through the bed is generated by skin friction and hence is proportional to area. In practice, the time taken for a fixed volume of air to pass is recorded, using a manometer to monitor pressure. A variation of the Kozeny-Karman relationship [2] is then used to calculate the surface area by

$$S_w = \frac{k(\varepsilon \rho_f t)^{0.5}}{(1-\varepsilon)\,\rho\,\mu^{0.5}} \quad (1)$$

where

S_w	=	surface area	(m^2kg^{-1})
k	=	apparatus constant	14.84
ϵ	=	bed porosity	0.510 (-)
ρ_f	=	density of manometer fluid	860.428(kg m^{-3})
t	=	elapsed time	(s)
ρ	=	true density of the solid	(kg m^{-3})
μ	=	viscosity of air at test temperature	1.825E-0.05(Pa s)

The Blaine method is an indirect method and suffers from a number of weaknesses, including variable particle shape and bed tortuosity [3]. In addition, the bed porosity ϵ is assumed to be 0.51, which can lead to serious error with some (non-cement) materials. The mass of flyash m which must be taken to form the bed is calculated [4] from

$$m = \rho V(1 - \varepsilon) \tag{2}$$

where V is the bed volume $(4.875(10^{-6})m^3$

As part of an investigation into dense flyash slurries, the surface areas of two samples of Queensland flyashes were measured in both a Blaine and a laser diffraction apparatus. The latter represents a more direct method of determining surface area as it measures particle size, from which area can be calculated geometrically. The main determinant of area is in fact particle size, and the technique is particularly suitable for flyash because the particles are predominantly spherical in nature, see e.g. [5]. Then

$$S_w = \frac{6}{\rho d_m} \tag{3}$$

where d_m is a mean particle diameter.

Experimental

The Blaine equipment was a Prolab Air Permeability apparatus manufactured by Production Supplies of Melbourne, while the laser instrument was a model 2600 manufactured by Malvern Instruments.The test on the Laser instrument was done with ultrasound to break aggregates.The ashes tested were supplied from the Gladstone and Tarong power stations, which burn Curragh and Tarong coal respectively. The samples were taken from the first hopper of the electrostatic precipitator, and covered a wide size range.Their particle densities as found by water displacement are recorded in Table 1.

The mass of Curragh ash required was found from Equation (2) to be 5.47 g and that for Tarong to be 5.07 g. However only about 75% of the calculated mass of Tarong ash could be packed into the Blaine cylinder, as the porosity of the material was greater than 0.51. The test was therefore carried out with the limited amount filling the cylinder. It is of interest to note that the staff of Tarong power station report that Tarong ash is very cohesive and difficult to handle.

The laser-derived diameter chosen for calculation of area was the Sauter mean diameter d_{23}, which is based on surface area.

Results and Discussion

The variables and results for the two tests are given in Table 1.

Ash	Density (kg m^{-3})	Flow Time t (s)	d_{23} (μm)	Blaine Area (m^2 kg^{-1})	Malvern Area (m^2 kg^{-1})
Curragh	2290	96	7.9	324	330
Tarong	2110	70	18.4	301	155

The Curragh ash is much finer than the Tarong, with its mean particle diameter approximately half that of the latter. This results in its geometric (Malvern) surface area being approximately twice that of Tarong. There is reasonable agreement between the Blaine and Malvern areas for the Curragh flyash, which is well-behaved in the Blaine apparatus.

However the Blaine area for Tarong is of the same order of magnitude as for Curragh, principally because the value of ϵ in Equation (1) is taken as 0.51, when in fact it would have been much smaller. The Blaine equipment would probably give a good result if the operating procedure was modified to handle materials which do not readily pack to the accepted porosity. Both methods require the measurement of particle density.

Conclusions

1. The skin friction (Blaine) and laser diffraction (Malvern) techniques agree well for a well-behaved powder.
2. The operating procedure for the Blaine apparatus needs to be modified to handle cohesive powders.
3. For flyashes, the laser-sizing approach is recommended.

Acknowledgement

The authors wish to thank Queensland Cement Pty Ltd for use of their Blaine apparatus.

References

1. **vom Berg M.** Magazine for Concrete Research 31, 211-216 (1979)
2. **McCabe W.L and Smith J.C.** Unit Operations in Chemical Engineering, McGraw Hill 1956 p. 97
3. **Viswanathan K.** Indian Chemical Engineer 35, 117-121 (1993)
4. Australian Standard AS 2350-8 1987 "Blaine Surface Area/Australian Fineness Standard Index of Portland Cement by Air Permeability Method"
5. **Smith R.D.** Prog. Energy Comb. Sci. 6, 53-119 (1980)