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EXPLORATION OF ESTIMATING KINETIC RESIDUE FOR PULVERISED MINERAL COAL USING RATE METHOD

Muhammad Ayub Khan Yousuf Zai

Department of Applied Physics, University of Karachi, Karachi-32

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The kinetic residue (R_{KE}) for pulverised mineral coal was estimated by rate method on Ro-Tap electrical sieving machine. The value of kinetic residue for this type of coal has been computed as 12.90% which gives a linear decay rate on semilog paper after 40 minutes of sieving time. It has been established that when the logarithmic decay describes the rate of sieving is obtained then the size distribution function of coal powder passing the sieve remains constant.

Key words: Kinetic residue, Pulverised mineral coal, Automatic sieving.

INTRODUCTION

The probability of a fineparticle passing through an aperture is related to the aperture distribution function as well as method of agitation [1, 7].

It is useful to arrange the kinetics of fineparticles on a sieve so that probability theory can be applied to relate the distribution function of the powder and the aperture distribution function of the sieve to the rate of movement of powder through the sieve [1-3, 7]. Under certain specified sieving conditions, it has been shown that possibility of deducing size distribution parameter of the powder being sieved could be analysed using algorithm for the automatic computation of the kinetic residue [6-9].

Automatic sieving procedures would be a great assistance to industry. In order to tackle the problem associated with the fact that on a wire mesh sieve with a significant range of apertures present in the sieving surface. The term kinetic residue of a sieve has been introduced by Kaye and co-workers [2, 7]. All the fineparticles in the size range of the apertures will pass through the sieve at a rate governed by the following equation

$$R_t = R_{KE} + Ae^{-\lambda t} \quad (1)$$

Where R = Kinetic residue of the sieve which is defined as the measure of the fractionating power of the sieve. The equation (1) can be rewritten as follows: (1) can be rewritten as follows:

$$\log_{10} (R_t - R_{KE}) + Kt + C \quad (2)$$

The equation (2) with deduced kinetic residue would apply to the sieving of powders on the 8" sieve using commercially available sieving equipment such as Ro-Tap electrical sieving machine [3, 7, 9-11].

The purpose of this communication is to explore the possibility of computing kinetic residues for pulverised coal by the sieving rates on Ro-Tap electrical sieving machine. The size distribution functions of coal powder passing through the sieve in successive time intervals are displayed.

MATERIALS AND METHODS

The sieving of pulverised coal was done on the Ro-Tap sieving machine. This machine was selected for this study because it is being used extensively in powder sieve testing laboratories. Its sieving action combines horizontal sifting and vertical tapping motion. A model SS-21 mounted on solid table (with three bolts) equipped with a standard 1/4 h.p. 60 Hz motor, 115 Volts is used with 8" dia. 65 mesh, 210 micrometer sieve containing powder as shown in Fig. 1 [10, 11].

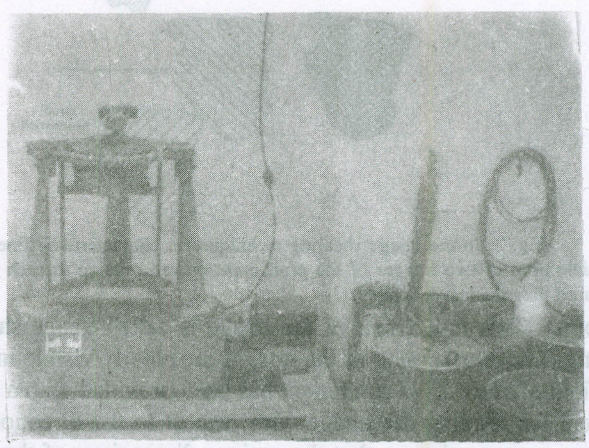

Fig. 1 Display of Ro-Tap sieving machine from Tyler Company.

The shape of a typical aperture in a wire woven sieve is a trapezoid as shown in Fig. 2. In this paper the size of an aperture on the sieve surface as viewed through a microscope is taken to be magnitude of the distance between the mid-point of the sides of the trapezoid. The microscope is fitted with an image shearing eye piece [7, 12].

Image shearing technique. This technique for sizing fineparticles was originally developed by Timbrell [4, 7]. In this technique there are two images separated by using special prisms which can be rotated relative to each other.

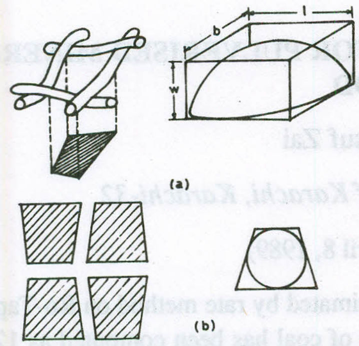

Fig. 2. (a) Apertures formed in a wire woven sieve are trapezoids. (b) The effective size of an aperture can usefully be defined by the size of the sphere just able to pas the sieve aperture.

The two images of the fineparticles profiles are moved with respect to each other as shown in Fig. 3. First the images are coincident then one image is moved from the

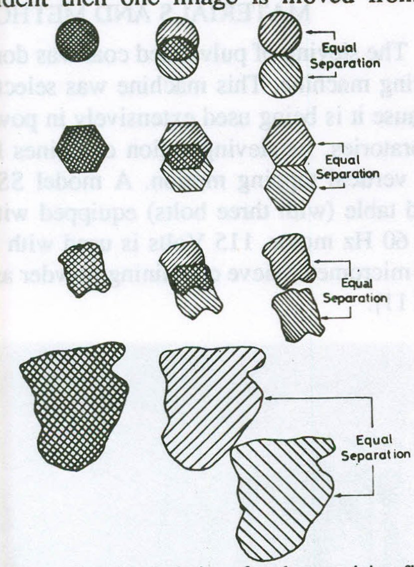

Fig. 3. In the image shearing technique for characterizing fine particle profiles two images of the profile are moved relative to each other until they are just separated.

other. This movement of the image is called image shearing. The overlapping of the images are clearly visible in the field of view. This equipment has been provided with a system for rotating the image with respect to the direction of image separation so that the various dimensions of the fineparticle profile can be measured. It has been shown that this type of measurement give an estimate of profile size which is operator fatigue is minimized by using this type of technique [4].

Magnification of image shearing microscope is (4×10) used throughout the experiments. A photograph of Image Shearing microscope is shown in Fig. 4. This microscope was used to size various types of powders and marketted from Vicker's Instrument Company [4, 7, 12].

EXPERIMENTAL

Deduction of kinetic residue of pulverised British coal. A sample of 100 grams of coal was placed on the 65 mesh,

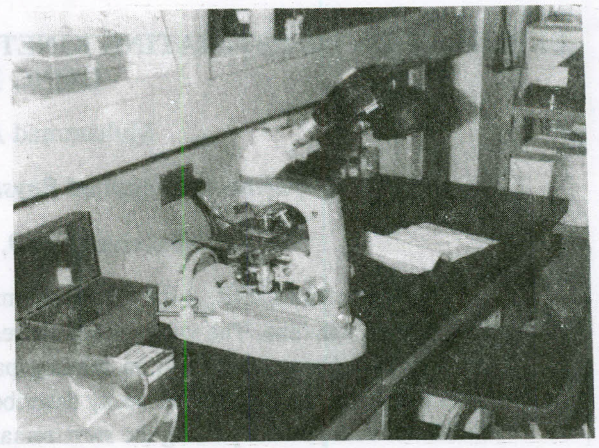

Fig. 4. Image shearing equipment used to size coal powder, marketted by Vickers Instrument Company.

8" dia. 210 micrometer nominal size sieve of Canadian Standard. The coal powder was shaken for 120 minutes on the Ro-Tap sieving machine and amount passed after each ten minutes was collected and weighed. The residue retained after each interval of time was tabulated using the following formula:

$$R_t = \frac{W - \sum_{i=1}^{i=n} Wi}{W} \times 100 \qquad (3)$$

where R_t = residue retained on the sieve at the time t.

W = Initial weight of the powder.

ΣWi = sum of the amounts passing through the sieve.

Analysis of size distribution function of coal powder. When characterizing the size distribution of coal fineparticles, it is necessary to take into account the fact that there is no direct way of describing the size of irregular fineparticles. It has been assumed that coal fineparticles were examined through the image shearing microscope and they are in the position of maximum stability and that it is reasonable to propose that the third non-visible dimension is equal to width of the profile as inspected through the microscope. On this basis the size parameter is based on the following mathematical relation.

$$D = 3\sqrt{W^2 \times L} \qquad (4)$$

where W = width of the coal fineparticles.

L = Length of the coal fineparticles.

This formula can be used to describe the size of the irregular fineparticles. In order to establish the size distribution of the coal powder 200 fineparticles were viewed through the microscope. Their length and widths were measured using the image shearing eye pieces. This image shearing eye piece was rotated to estimate the maximum length of the profile and the dimension at right angles to this measurement was also found and taken to be the width of the profile.

RESULTS AND DISCUSSIONS

To investigate the effects of shape on the kinetics of sieving and to explore the possibility of deducing kinetic residue for different types of industrial powders the experiments carried out by Kaye [7, 9] using spherical glass beads on the Ro-Tap electrical sieving machine, are repeated for pulverised mineral coal. The powder would highlight any essential difference between the probability of the passage of smooth and irregular fineparticles.

A basic assumption made in the derivation of the equation No. 2 for deducing kinetic residues is that the number of fineparticles still capable of passing through the sieve is small and total number of fineparticles remaining on the sieve is large, then the P (E) probability of the passage of stated size of fineparticles is independent of time and size, if this is true then the decay of the sieve residue with time is exponential leading to the relationship of the equation No. 2. Moreover if this assumption is correct then the size distribution function of the various fractions of powder passing through the sieve at different intervals of time should be essentially constant [2, 3, 7, 9].

Kaye [1-4, 7, 9] has suggested that after prolonged sieving the actual residue is often 1 to 2% kinetic residue. Therefore, a useful procedure for estimating the kinetic residue is to subtract an amount of the order of 1% from the last value of R. Refined estimate are then made until a value of R in a linear relationship between log $(R_t-R'_{KE})$ VS t. is obtained.

The data for R_t at a series of values of t are summarised by the decay curve for the residue retained on the sieve is shown in Fig. 5a. A graph of log $(R_t-R'_{KE})$ for various estimates of the kinetic residue is depicted in Fig. 5b. Thus a straight line relationship for the log $(R_t-R'_{KE})$ is obtained. R'_{KE} = 12.90% for coal and this is taken to be the deduced value of the kinetic residue. This experimental value manifests that the equation developed by Kaye [2, 6, 7] for a specialised sieving process can also be used to de-

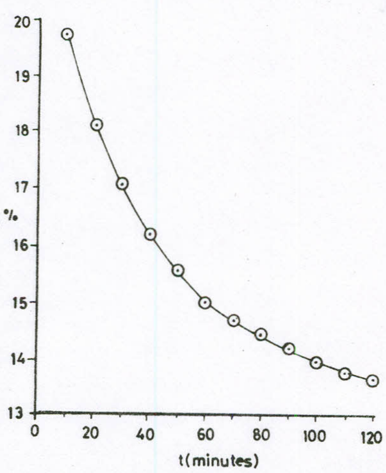

Fig. 5a. Decay rate of the residue of coal powder sieved on 65 mesh sieve.

t = time in minutes. R_t% = Percentage weight of original powder retained on the sieve at time t.

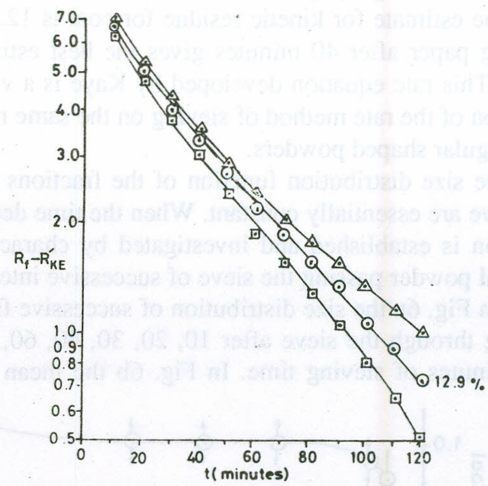

Fig. 5b. Graphical deduction of kinetic residues for coal powder sieved on 2 Ro-tap sieving device.

t = time in minutes. R_t = Percentage residue at time t. R'_{KE} = estimated kinetic residue.

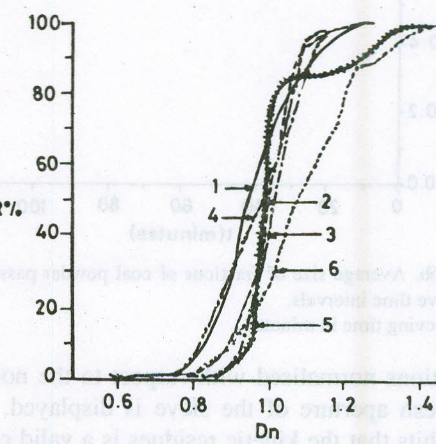

Fig. 6a. Size characterization of successive fractions of coal passing a 65 mesh sieve.

Dn = Size of coal normalized with nominal size of thesieve.
R% = Weight percentage less than or equal to stated diameter.

0-10	1 ———	= Weight distribution of coal fractions passing through the sieve in the interval of 0-10 minutes of sieving time.
10-20	2 - - -	= Weight distribution of coal fractions passing through the sieve in the interval of 10-20 minutes of sieving time.
30-40	3 — - —	= Weight distribution of coal fractions passing through the sieve in the interval of 30-40 minutes of sieving time.
50-60	4 — - - - —	= Weight distribution of coal fractions passing through the sieve in the interval of 50-60 minutes of sieving time.
70-80	5 ++++++	= Weight distribution of coal fractions passing through the sieve in the interval of 70-80 minutes of sieving time.
110-120	6 - - - - - -	= Weight distribution of coal fractions passing through the sieve in the interval of 110-120 minutes of sieving time.

scribe the rate of sieving using Ro-Tap electrical sieving machine. This fact could be useful in the development of automatic sieving equipment [5-7].

The estimate for kinetic residue for coal is 12.90% on semilog paper after 40 minutes gives the best estimate of the R. This rate equation developed by Kaye is a valid description of the rate method of sieving on the same machine for irregular shaped powders.

The size distribution function of the fractions passing the sieve are essentially constant. When the time decay rate situation is established and investigated by characterizing the coal powder passing the sieve of successive intervals of time. In Fig. 6a the size distribution of successive fractions passing through the sieve after 10, 20, 30, 40, 60, 80 and 120 minutes of sieving time. In Fig. 6b the mean size of

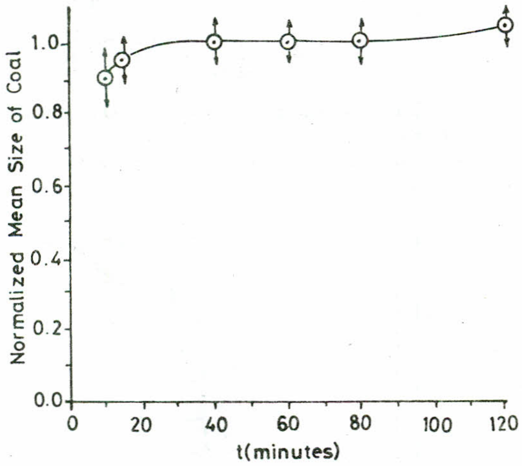

Fig. 6b. Average size of fractions of coal powder passing the sieve in successive time intervals.
t = Sieving time in minutes.

coal fractions normalised with respect to the nominal size of the mesh aperture of the sieve is displayed. This data also exhibits that the kinetic residues is a valid concept for automating the sieving of irregular powders on commercially available sieving equipment such as Ro-Tap electric sieving machine.

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