FRACTIONATION OF A POLYDISPERSE AEROSOL BY A GRANULAR FILTER

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Results are presented on the performance of a granular filter handling aerosols in relation to volume and initial mass concentration of the dispersed phase.

Passage through a granular filter is a promising method of separating a solid dispersed phase from a gas [1-5].

At high z_i ($>1 \cdot 10^{-3}$ kg/nm^3), the process usually involves deposition of the material on the surface of the filter.

After a certain initial period, a layer of particles accumulates on the surface that acts as a self-sustaining filter [6]. If a polydisperse aerosol passes through such a bed, we have [7]

$$K = f(d_e, \bar{d}_m, D, H, w, z_i, \nu, \rho_p, \rho_g, \sigma, \tau, \varphi, \psi). \tag{1}$$

Under industrial conditions, the process usually occurs for w = const, while there are only slight changes in temperature of the gas flow on passage through the bed and in the steady-state mode of flow [8, 9].

For this reason, the values of ν, ρ_g, and D are constant for given physicochemical parameters of the flow ($\bar{d}_m$, ρ_p, σ, ψ)* and filter (d_e, H, φ).

In that case, we merely have to examine the particular relation

$$K = f(z_i, \tau). \tag{2}$$

The apparatus of Fig. 1 was used to examine (2).

The membrane compressor 1 supplies air to the dust generator 2, and the resulting flow passes through the stabilizing vessel 3 to the granular filter 4 and after the filter tubes 5 passes to the air extractor 6. The flow rate of the dusty air is controlled by valves 7 and monitored by rotameter 8 and rheometer 9. The pressure difference in the bed and the static reduced pressure are monitored by the gauges 10.

The system allows one to measure the pressure difference at various positions in the filter.

We initially used quartz dust taken from an industrial gas cleaning system, which had the following parameters for the log-normal size distribution: $\bar{d}_m = 3.7 \cdot 10^{-6}$ m, $\sigma = 0.4$.

The parameters of the dusty flow and granular filter (quartz sand) were as follows: w = 0.4 m/sec, $\rho_g = 1.20$ kg/nm^3, $z_i = (1.2\text{-}7.0) \cdot 10^{-3}$ kg/nm^3, $d_e = 1.15 \cdot 10^{-3}$ m, ($d_b = 2.25 \cdot 10^{-3}$ m, $\varepsilon = 0.38$, $\varphi = 0.8$), H = 0.06 m.

The values of K were determined by the method of [11] as the means from two parallel measurements and calculated from

$$K = \frac{z_f}{z_i}. \tag{3}$$

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*A previous study [10] deals with the effects of $\bar{d}_m$ and σ over wide ranges.

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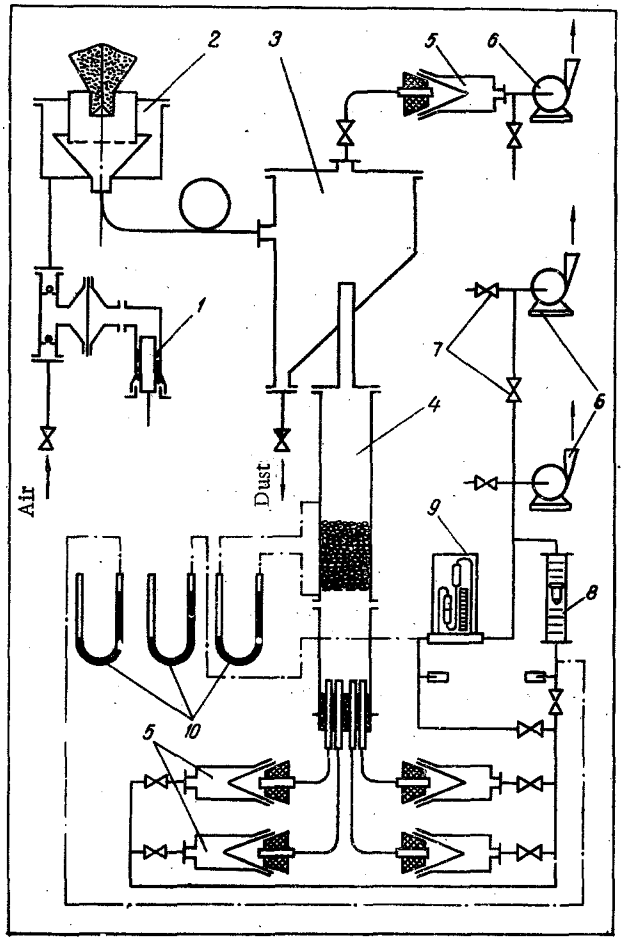

Fig. 1. The apparatus: 1) compressor; 2) PG-1 dust generator; 3) stabilizing vessel; 4) granular filter; 5) filter chambers; 6) VL-1 fans; 7) valves; 8) RS-5 rotameter; 9) T-2-80 rheometer; 10) U-tube manometers.

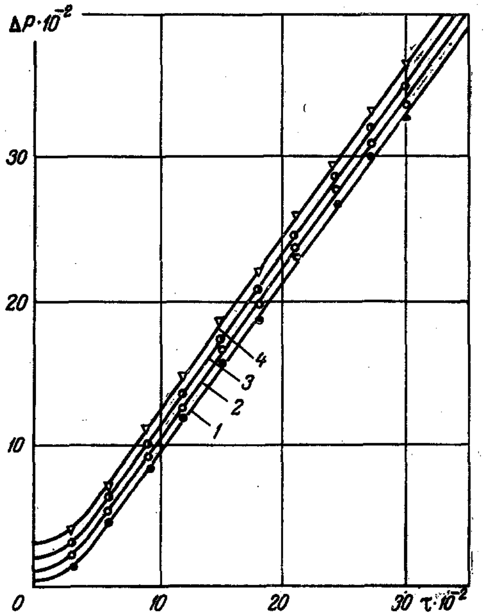

Fig. 2. $\Delta p = f(\tau)$ curves for $z_i = 1.4 \cdot 10^{-3}$ kg/nm^3 and $H(\cdot 10^3)$, m of: 1) 10; 2) 20; 3) 40; 4) 60. Δp in N/m^2 and τ in sec.

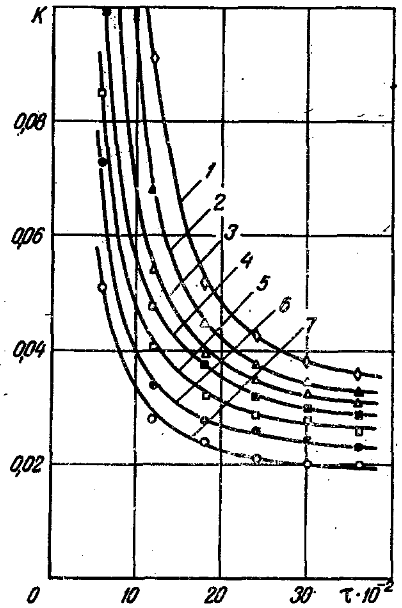

Fig. 3. $K = f(\tau)$ curves for z_i $(\cdot 10^3$ kg/nm$^3)$ of: 1) 7.00; 2) 4.90; 3) 3.86; 4) 2.67; 5) 2.17; 6) 1.52; 7) 1.23. τ in sec.

The significance of the self-maintaining filter was examined from the distribution of the pressure difference over the bed in relation to the run time.

Figure 2 shows that the layer supporting the self-maintaining filter has an important effect on the total pressure difference, which indicates that deposition on the filter surface plays a major part.

Figure 3 shows measurements designed to test (2), and it is clear that K falls as z_i and τ increase.

It is thus clear that K shows a trend opposite to that of z_i and τ not only in filtration involving gradual pore blockage [10], but also when the deposited material is retained at the surface.

The data were processed by least squares with a "Rasa" desk-top calculator to represent (2) as

$$K = (32 - 2.8 \cdot 10^4 \tau^{-1} + 3.5 \cdot 10^3 z_i + 7.4 \cdot 10^5 \tau^{-1} z_i)^{-1}. \tag{4}$$

The empirical model was checked by the method of [12] to show that (4) represents the data adequately: F = 2.3, while the tabulated value is $F_{0.05}$ (5; 7) = 4.0.

The following result was obtained by processing the data by the generalized-variable method:

$$K = \left(32 - 10^7 \mathrm{Ho}^{-1} + 4.2 \cdot 10^3 \frac{z_i}{\rho_g} + 33 \cdot 10^7 \frac{z_i}{\rho_g} \mathrm{Ho}^{-1}\right)^{-1}. \tag{5}$$

The relation (5) applies for $10^{-3} < z_i/\rho_g < 6 \cdot 10^{-3}$ and $2 \cdot 10^5 < \mathrm{Ho} < 10^6$.

Equations (4) and (5) were used in calculating the filter performance when the filter was the second stage in dust removal in the stock gas from a 597D drying drum.

The following were the parameters of the dusty air flow reaching the filter from the drum: $w = 0.42$ m/sec, $z_i = 4 \cdot 10^{-3}$ kg/nm³, $\rho_g = 0.86$ kg/nm³ (t = 147°C).

The parameters of the log-normal size distribution for the particles were those of the model dust.

The filter bed considered of river quartz sand: $\varphi = 0.8$ [1], fraction $(3\text{-}5) \cdot 10^{-3}$ m ($d_e = 2.14 \cdot 10^{-3}$ m), H = 0.06 m.

The run time $\tau = 3000$ sec was restricted by the acceptable pressure difference across the filter ($\leq 2 \cdot 10^3$ N/m²).

The values for $\mathrm{Ho} = 0.59 \cdot 10^6$ and $z_i/\rho_g = 4.65 \cdot 10^{-3}$ were such that (5) could be used, which gave K = 0.0274; other studies [13] have shown that the observed K under these conditions are 0.029-0.031, so the agreement between the observed and calculated K is satisfactory.

NOTATION

$\bar{d}_m$, mass median diameter of dispersed particles, m; d_b, arithmetic mean diameter of bed particles, m; d_e, equivalent diameter of channels in bed, m; D, diffusion coefficient of dispersed particles, m²/sec; F, F-ratio; $F_{0.05}(5;7)$, Fisher quantile at 5% significance level; H, height of bed, m; Ho, homochronous criterion; K, filter transmission factor; t, temperature of gas—dust flow before the bed, °C; w, velocity, m/sec; z, mass concentration of dispersed phase in aerosol, kg/nm³; p, pressure drop, N/m²; ε, porosity of granular bed; ν, kinematic viscosity, m²/sec; ρ_g, gas density, kg/m³; ρ_p, density of dispersed particles, kg/m³; σ, standard deviation of logarithm of particle diameter; τ, filtration time, sec; φ, shape factor for bed particles; ψ, shape factor for dispersed particles. Indices: i, initial; f, finite.

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AN EFFECTIVE APPROACH TO THE SOLUTION OF TWO-DIMENSIONAL HEAT-CONDUCTION PROBLEMS FOR MULTICONNECTED COMPOSITE BODIES OF COMPLEX SHAPE

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An algorithm to solve two-dimensional nonstationary heat-conduction problems for multiconnected bodies of complex shape, constructed on the basis of potential theory methods with preliminary application of the Rothe method in the time variable, is described. Results of computations are presented for a single- and multilayer strip with holes of arbitrary outline.

It is known that serious calculational difficulties must be encountered in solving boundary-value problems of mathematical physics generally, and of heat conduction, in particular, for domains of complex shape, for example, for those whose boundaries do not agree completely with the coordinate lines of the chosen reference system. Noticeable successes in overcoming these difficulties have been achieved in the construction of calculation algorithms on the basis of variational methods using R-functions to select the coordinate system, finite elements, and summary representations methods [1-3].

For example, the difficulties noted have been overcome sufficiently successfully in [4] in the problem of a homogeneous strip with circular holes. The efficiency of using integral (potential) representation methods for the desired functions [5, 6] is demonstrated below in examples of homogeneous and inhomogeneous strips weakened by holes of arbitrary outline.

§1. Let an infinite strip be weakened by holes arranged periodically over its length. Let us examine part of this strip within the limits of one period and let us formulate the following heat-conduction boundary-value problem for a doubly connected domain Ω (the exterior part of its boundary is the rectangle $0 \le x \le a$, $-b \le y \le b$, and the interior part is an arbitrary closed curve L):

$$\frac{\partial u}{\partial \mathrm{Fo}} = \Delta u, \qquad (1.1)$$

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