AERODYNAMIC METHODS FOR INCREASING THE EFFICIENCY OF DUST CATCHERS IN THE PRODUCTION OF REFRACTORIES.
3. EFFICIENT DISTRIBUTION OF DUST-AND-GAS FLOWS IN SYSTEMS AND INSTALLATIONS FOR DUST CATCHING

V. I. Éntin, 1 N. M. Anzheurov, 1 and Yu. V. Krasovitskii 1


Conditions and methods of efficient distribution of dust-and-gas flows in grain filters are considered. Various designs of distributing devices are suggested. It is shown that separating walls are more advantageous than distributing grids. Various variants of reflecting walls for the uniform distribution of the dust-and-gas flow are recommended for cylindrical porous filtering elements of dust catchers, swirlers that provide a minimum consumption of power are presented. Some design solutions for an efficient distribution of the dust-and-gas flow in electric filters are considered.

The preceding articles of the series [1, 2] allow us to estimate the effect of the nonuniformity of the distribution of the dust-and-gas flow on the efficiency of dust catchers, determine their hydraulic resistance, and pass to an expedient distribution of the dust-and-gas flow over the functional cross section of the installation. Special attention should be devoted to the grain filtering layers which have good prospects for organizing dust arresting in the refractory industry 2 [2], vortex devices, and electric filters.

It is known that the equipment with stationary grain layers is characterized by a relatively small inlet into the functional zone. Therefore, the inhomogeneity depends on the conditions of the feeding of the dust-and-gas flow into the grain layer. In addition, the operation of the grained layer is accompanied by pulsation of the flow, vibration, displacement of the grains, local compaction, and "air holes" through which the flow penetrates.

At the same time, the penetrability of the layer near the walls of the installation changes with the appearance of radial porosity. Figure 1 presents various profiles of dimensionless velocities behind the bulk layers (d is the grain size, R is the radius of the functional zone of the installation). The near-wall effect shown in Fig. 1 is connected with the action of the force of gravity onto the layer, the pressure drop, and the tangential stresses that appear due to the friction of the particles of the layer against the wall. As a result, the cross-sectional structure of the layer becomes nonuniform.

The resistivity of the layer ζ has a special importance for leveling the layer. Its optimum value can be found using the formula

$$\zeta_{\text{opt}} \approx 33.3 \left( \frac{F_k}{F_0} \right)^{0.6},$$

where $F_k$, $F_0$ are the cross sectional areas of the functional zone (casing) of the installation and at the inlet into it, $N_0$ is the coefficient of the kinetic energy (Coriolis') at the inlet into the installation. This dependence holds true at $10 < N_0 (F_k / F_0) < 200$, i.e., in the range of the existing designs of actual grain filters. If the grain layer is placed directly onto the bottom of the installation with an opening or if the distance $H$ from the inlet to the front of the layer is considerable, the relative depth $H_g$ of the grain layer on which the jet spreads to the whole of the cross section of the
Fig. 1. Profiles of velocities $w_i/w_k$ directly behind the bulk grain layer: 1) quartz sand ($d_s = 0.004$ m, $d_g/R_k = 0.03$); 2) the same ($d_s = 0.002$ m, $d_g/R_k = 0.02$); 3) glass balls ($d_s = 0.003$ m, $d_g/R_k = 0.02$); 4) steel balls ($d_s = 0.005$ m, $d_g/R_k = 0.04$); 5) the same ($d_s = 0.006$ m, $d_g/R_k = 0.075$); 6) ceramic Rashig rings $10 \times 10 \times 1.5$ mm in size ($d_s = 0.006$, $d_g/R_k = 0.04$); 7) ceramic Berl saddles $12.5$ mm in size ($d_s = 0.006$ m, $d_g/R_k = 0.08$); 8) steel Pall rings $15 \times 15 \times 0.4$ mm in size ($d_s = 0.010$ m, $d_g/R_k = 0.07$).

Installation is determined as a function of the grain size $d_g$ (accurate to 15%) by the formula

$$H_{g,i} = \frac{H}{d_v} \approx 50 \left[ 1 - \left( \frac{F_0}{F_k} \right)^{0.5} \right].$$

Equations (1) and (2) have an important practical significance in the formation of the layer and optimization of the aerodynamic conditions of the motion of the dust-and-gas flow through the layer.

Passing to an analysis of the methods for leveling the flow in installations with a grain layer we should note that the existing tendency to increasing the thickness of the layer relative to the computed one is unacceptable because it causes a power loss, worsens the regeneration conditions, and leads to an unnecessary increase in the mass of the filter material.

A more reliable method consists in a preliminary or full distribution of the flow over the cross section independently of the functional layer. Figure 2 presents various variants of the distribution. The considered methods for distributing the flow (see Fig. 2) can only be an auxiliary means for its leveling. A full leveling requires additional devices among which flat grids and shortened partition walls are the simplest and most compact. At $F_k/F_0 > 4$ the grids would be placed successively; their number $n$ is determined by the formula

$$n \approx 0.7 \left( \frac{F_k}{F_0 N_0^{0.5}} \right)^{0.5}.$$  

For a grain layer and moderate requirements to its efficiency we can recommend the following proportions:

- $n = 1$ for $3 < \frac{F_k}{F_0} \leq 6$,
- $n = 2$ for $6 < \frac{F_k}{F_0} \leq 20$,
- $n = 3$ for $20 < \frac{F_k}{F_0} \leq 50$.

When designing the inlet devices three cases should be taken into account, namely,

1. $\zeta_{g,1} > 2 \times 10^2$; here the admissible inhomogeneity of the flow ($M_k \leq 1.15$) is attained without distributing devices by choosing the values of $F_k/F_0$ and $H_{g,i}$;
2. $10^2 < \zeta_{g,1} < 10^3$; the distributing device (dd) should have a small size ($F_{dd} \leq F_k$);
3. $\zeta_{g,1} \leq 10^2$; the distributing device should cover over the whole of the cross-sectional area of the installation ($F_{dd} \approx F_k$).

Thus, a distributing device in front of the layer should be mounted at $\zeta_{g,1} < 2 \times 10^3$.

---

3 The distributing devices presented in Fig. 2 require a preliminary cleaning with diminishing the dust content of the flow at the inlet into the air filter to 0.5 - 1.0 g/m$^3$. 

---

Fig. 2. Various distributing devices [3]: a, b, e) pipes bent 90° upward; c, d, f, g) pipes bent 90° downward; h) packing with a solid hood; i) packing with side openings; j) packing with a perforated hood; k, l) system of ring diffusers.