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# Determination of fiber filter dust collecting efficiency depending on particles distribution of industrial dust

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Abstract
The data on dustiness of machinist operating space of processing equipment of crushing and concentration plants, mining and processing plants, crushing and sizing plants of mines are given. The calculation of efficiency of industrial dust collecting by fiber filter depending on dust particles distribution was carried out.
Key words: FIBER FILTER, INDUSTRIAL DUST, PARTICLES DISTRIBUTION, ASPIRATION HOOD, DUSTINESS, DUST COLLECTING, MEDIAN SIZE, EFFICIENCY

A large amount of dust is liberated when processing of any mineral raw materials (iron ore, construction materials, etc.). When inserting into processing equipment machinists and operating personnel body, this dust may cause their occupational diseases such as chronic dust bronchitis and pneumoconiosis. For prevention of the dust intrusion into atmosphere of operating space, all the sources of dust are equipped with hoods and exhaust ventilation systems (aspirations). A large amount of dust is liberated when overloading of mineral raw materials on sloping or vertical chutes. At that, in the aspiration hood under unfavorable conditions (dry mineral raw materials, lack of hood tightness etc.), the dust concentration can reach 1.5-2 g/m$^3$, air dustiness of machinist operating space of breaking machines (screens) and conveyors of crushing and sizing plants and concentration plants of MPP is 9.1-12.2 mg/m$^3$ and 10.8-15.9 mg/m$^3$ respectively, and of mines – 4.0-6 5 mg/m$^3$ and 5.7-7.1 mg/m$^3$ respectively at the maximum permissible concentration 1.2 mg/m$^3$.

Many scientific papers of famous scientists such as I.M. Logachov, O.D. Neykov, V.V. Nedin, I.I. Afanas'ev, A.Yu. Val'dberg, V.P. Oleksandrov, O.M. Golishev, O.E. Lapshin, V.O. Minko, V.I. Mulyavko, O.V. Kalmikov, K.G. Rudenko, A.M. Kirichenko, A.A. Nemchenko and many others are devoted to the problem of dust collection during the processing of mineral raw materials [1-5].

Aspiration dust-collector hoods, where filtering devices of various designs (cyclone filters, bag filters, electrofilters etc.) are installed, are used in order to reduce the load on the aspirating towing installations fine filters and the probability of coarse dust deposit in horizontal and low-inclined areas of aspiration systems pipelines. The alternative choice is the fiber filter design for the aspiration hood executed as a set of double fiber curtains made of synthetic materials with different signs of electrostatic charge (Fig. 1).

Dust deposition in the fiber filter hood is caused by diffusion, gravitational, inertial and electrostatic forces. The intensity of dust deposition is influenced by a number of factors: distance from dust particle to the fiber surface, particles size, the amount of motional energy of particle moving with the air flow, the time of the particles location within the hood dust deposit part, values of the particles charges and curtains fibers.

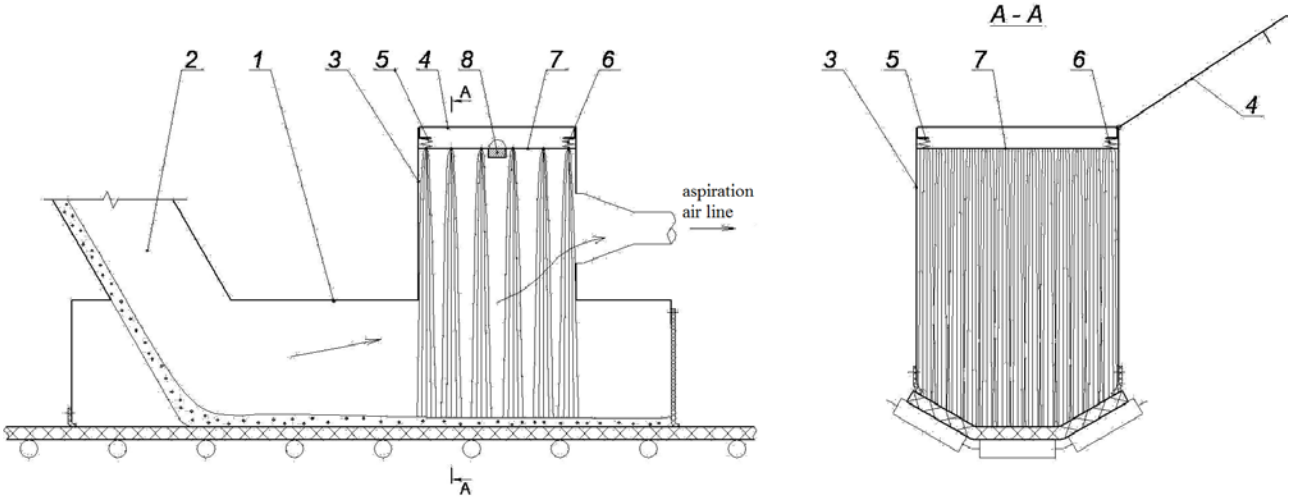


**Figure 1.** Diagram of fiber filter for aspiration hood of transfer unit: 1- aspiration hood; 2 - loading chute; 3 - suction duct; 4 – cover; 5 – supports; 6 - springs; 7 - fiber filter; 8 – vibrator

Let us determine the effect of dust particles size (particles distribution) to fiber filter dust collecting efficiency. Analysis of different industrial dusts particles distribution (median size $d_m$, root-mean-square deviation of dust particles distribution function lg $\sigma_p$), which was carried out on the basis of graphic presentation of integral distribution in probabilistic-logarithmic coordinate system $D(d_p)$, is shown in Table 1.

**Table 1.** Analysis of industrial dusts particles distribution

| No | Industrial dust | $d_{15,9}$, micron | $d_m$, micron | lg $\sigma_p$ | $\sigma_p$, micron | $d_p$, micron |
|---|---|---|---|---|---|---|
| 1. | From conveyors hoods (iron ore up to 70 mm) | 12 | 33.5 | -0.45 | 0.35 | 33.5±0.35 |
| 2. | -“- (agglomerate) | 15.5 | 36.5 | -0.37 | 0.43 | 36.5±0.43 |
| 3. | -“- (sintering ore) | 9 | 35 | -0.59 | 0.26 | 35±0.26 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4. | -“- (finished pellets) | 7.5 | 30 | -0.60 | 0.25 | 30±0.25 |
| 5. | -“- (pellets spill) | 6.6 | 29 | -0.64 | 0.23 | 29±0.23 |
| 6. | -“- (pellets bedding) | 8 | 29.5 | -0.57 | 0.27 | 29.5±0.27 |
| 7. | -“- (coke breeze and anthracite fines) | 8 | 30 | -0.57 | 0.27 | 30±0.27 |
| 8. | -“- (limestone) | 13 | 30 | -0.36 | 0.44 | 30±0.44 |
| 9. | From the primary gyratory cone crusher hood (iron ore) | 4.5 | 26 | -0.76 | 0.17 | 26±0.17 |
| 10. | -“- place of sintering machine loading (charge) | 10 | 23 | -0.36 | 0.44 | 23±0.44 |
| 11. | -“- disk feeding gate (sinter return) | 16 | 40 | -0.40 | 0.40 | 40±0.40 |
| 12. | -“- place of indurating machine loading (pellets) | 8.5 | 23 | -0.43 | 0.37 | 23±0.37 |
| 13. | -“- screen (pellets) | 3 | 10 | -0.52 | 0.30 | 10±0.30 |
| 14. | -“- overload | 1.5 | 4 | -0.43 | 0.37 | 4±0.37 |
| 15. | -“- vibrating feeder (concrete block) | 11 | 30 | -0.44 | 0.36 | 30±0.36 |

As the distribution of dust particles, which are subject to collecting, is log-normal, let us calculate the fiber filter efficiency parameters for different number of its double fiber curtains based on the formula [6]:

$$\eta = 0,5(F(x) + 1), \quad (1)$$

where $F(x)$ - normal distribution function, and argument $x$ is found in the dependence:

$$x = \frac{\lg(d_m / d_{50})}{\sqrt{\lg^2 \sigma_\eta + \lg^2 \sigma_p}}, \quad (2)$$

where $d_{50}$ – diameter of particles which are deposited with the efficiency of 50%, microns; $\lg \sigma_\eta$ – root-mean-square deviation of the distribution function of fractional cleaning coefficients.

Having accepted for calculations $\sigma_\eta = \frac{1-\eta}{2}$ (corresponding to the results of laboratory tests of fiber filter) and transformed the equation (2), let us calculate the diameter of particles, which are deposited with the efficiency of 50%, in the fiber filter with the number of double fiber curtains from two to six (for dust used in the laboratory installation):

for 2 curtains:

$$\lg d_{50} = \lg d_m - \sqrt{x^2(\lg^2 \sigma_\eta + \lg^2 \sigma_p)} = \lg 29 - \sqrt{(-0,32)^2(\lg^2 0.157 + \lg^2 0.276)}$$

=

= 1.15

$d_{50}$ = 14.13 microns

- for 3 curtains:

$$\lg d_{50} = \lg 29 - \sqrt{0.3^2(\lg^2 0.096 + \lg^2 0.276)}$$

= 1.11

$d_{50}$ = 12.88 microns

- for 4 curtains:

$$\lg d_{50} = \lg 29 - \sqrt{0.59^2(\lg^2 0.07 + \lg^2 0.276)}$$

= 0.71

$d_{50}$ = 5.13 microns

- for 5 curtains:

$$\lg d_{50} = \lg 29 - \sqrt{0.95^2(\lg^2 0.043 + \lg^2 0.276)}$$

= 0.05

$d_{50}$ = 1.12 microns

- for 6 curtains:

$$\lg d_{50} = \lg 29 - \sqrt{1.41^2(\lg^2 0.02 + \lg^2 0.276)}$$

= -1.06

$d_{50}$ = 0.10 microns

The calculation results are shown in Table 2.

Table 2. Calculation of the fiber filter efficiency parameters

| Number of curtains in fiber filter | General efficiency $\eta$ | F($x$) | $x$ | $\sigma_\eta$ | $d_{50}$, micron |
|---|---|---|---|---|---|
| 2 | 0.687 | 0.374 | -0.32 | 0.159 | 14.13 |
| 3 | 0.809 | 0.618 | 0.30 | 0.096 | 12.88 |
| 4 | 0.861 | 0.722 | 0.59 | 0.070 | 5.13 |
| 5 | 0.915 | 0.830 | 0.95 | 0.043 | 1.12 |
| 6 | 0.960 | 0.920 | 1.41 | 0.020 | 0.10 |

Since for further design, the fiber filter with six double fiber curtains (effectiveness is 96%) is recommended, let us calculate the approximate efficiency of filter dust collection using formulas (1) and (2) for industrial dusts shown in the Table 1. The calculation results can be seen in the Table 3.

**Table 3.** Dust collecting efficiency of six-row fiber filter for industrial dusts of various particles distributions

| No | Industrial dust | $d_{15,9}$, micron | $d_m$, micron | lg $\sigma_p$ | $\sigma_p$, micron | $d_p$, micron |
|---|---|---|---|---|---|---|
| 1. | From conveyors hoods (iron ore up to 70 mm) | 33.5 | -0.45 | 1.44 | 0.9251 | 96.3 |
| 2. | -“- (agglomerate) | 36.5 | -0.37 | 1.47 | 0.9293 | 96.5 |
| 3. | -“- (sintering ore) | 35 | -0.59 | 1.41 | 0.9207 | 96.0 |
| 4. | -“- (finished pellets) | 30 | -0.60 | 1.37 | 0.9147 | 95.7 |
| 5. | -“- (pellets spill) | 29 | -0.64 | 1.36 | 0.9131 | 95.7 |
| 6. | -“- (pellets bedding) | 29.5 | -0.57 | 1.38 | 0.9162 | 95.8 |
| 7. | -“- (coke breeze and anthracite fines) | 30 | -0.57 | 1.38 | 0.9162 | 95.8 |
| 8. | -“- (limestone) | 30 | -0.36 | 1.43 | 0.9237 | 96.2 |
| 9. | From the primary gyratory cone crusher hood (iron ore) | 26 | -0.76 | 1.30 | 0.9032 | 95.2 |
| 10. | -“- place of sintering machine loading (charge) | 23 | -0.36 | 1.36 | 0.9131 | 95.7 |
| 11. | -“- disk feeding gate (sinter return) | 40 | -0.40 | 1.49 | 0.9319 | 96.6 |
| 12. | -“- place of indurating machine loading (pellets) | 23 | -0.43 | 1.35 | 0.9115 | 95.6 |
| 13. | -“- screen (pellets) | 10 | -0.52 | 1.13 | 0.8708 | 93.5 |
| 14. | -“- overload | 4 | -0.43 | 0.91 | 0.8186 | 90.9 |
| 15. | -“- vibrating feeder (concrete block) | 30 | -0.44 | 1.41 | 0.9207 | 96.0 |

Analyzing the obtained results (Table. 3), we can conclude that the efficiency of filter fiber dust collecting will range from 90.9 to 96.6% depending on the particles distribution of industrial dust, which is liberated during various technological processes of mineral raw materials processing in the mines and mining and processing plants.

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