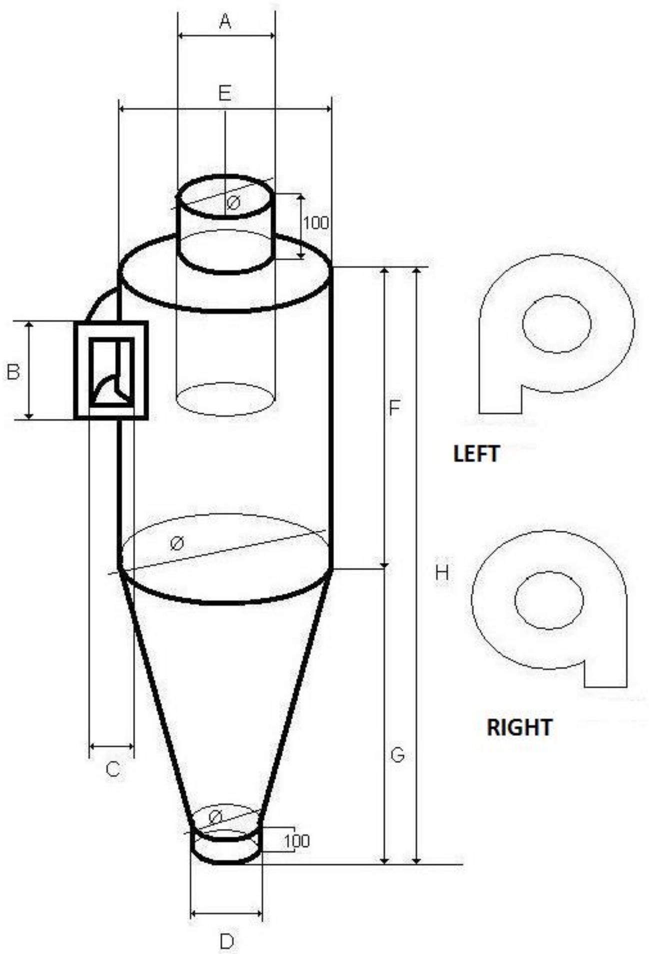
Calculation No. 1

Cyclone

Cyclone scheme:



Main date:

1. The cleaning air volume Q = 3,07 m^3/s $(+0{,}5\cdot n)$ =3,07+0,5$\cdot 5 = 5{,}57\ m^3/s$;
2. The concentration of contaminants in the air, C = 946 mg/m^3 $(-10\cdot n)$ =946-$10\cdot 5 = 896\ mg/m^3$;
3. Particle density $g_d = 1{,}84\cdot 10^3\ kg/m^3$;
4. Gas dynamic viscosity $\mu = 18{,}8\cdot 10^{-6}\ Ns/m^2$;

n - Student sequence number in the list, in the example n = 5

Used in the comparisons cyclone CN-15 data:

1. Optimum air velocity in cyclone w_{opt} = 3,5 m/s;
2. Particle density $g_{dL} = 1{,}93 \cdot 10^3 \ kg/m^3$;
3. Gas dynamic viscosity $\mu_L = 22{,}2 \cdot 10^{-6} \ Pa/s$;
4. Cyclone diameter D_L = 0,6 m.

Cyclone calculation:

1. *Cyclone-sectional area:*

$$F = \frac{Q}{w_{opt}}, \ m^2 ; \tag{1}$$

Where: Q – The quantity of air to be cleaned operating conditions, m^3/s

w_{opt} – optimum speed in the cyclone, m/s .

$$F = \frac{5{,}57}{3{,}5} = 1{,}591 \ m^2 .$$

2. *Cyclone diameter:*

$$D = \sqrt{\frac{F}{0{,}785 \cdot N}}, \ m ; \tag{2}$$

Where: F – Cyclone-sectional area, m^2;

N – the number of cyclones.

$$D = \sqrt{\frac{1{,}591}{0{,}785 \cdot 1}} = 1{,}424 \ m.$$

3. *Actual air velocity in cyclone:*

$$w = \frac{Q}{0,785 \cdot D^2 \cdot N}, \ m/s \ ; \qquad (3)$$

Where: Q - The quantity of air to be cleaned operating conditions, m^3/s ;

D – Cyclone diameter, m ;

N - the number of cyclones.

$$w = \frac{5,57}{0,785 \cdot 1,424^2 \cdot 1} = 3,499 \ m/s \ .$$

4. *Cyclone hydraulic resistance coefficient:*

$$\xi = K_1 \cdot K_2 \cdot \xi^c_{6500} + K_3 \qquad (4)$$

Where: K_1 – correction factor for the diameter of the cyclone;

K_2 – correction factor for the concentration of dust;

K_3 – correction factor for additional pressure drop;

ξ^c_{6500} - single cyclone aerodynamic resistance coefficient.

For the tables found:

K_1 = 0,9

K_2 = 1,05

K_3 = 36

ξ^c_{6500} = 148

$$\xi = 0,9 \cdot 1,05 \cdot 148 + 36 = 175,86 \ .$$

5. *Pressure losses in cyclone:*

$$\Delta p = \xi \frac{g \cdot w^2}{2}, Pa \qquad (5)$$

Where: g – density of air (at 20^0 C temperature) , kg/m^3;

w - certain air speed in cyclone , m/s;

ξ - Cyclone hydraulic resistance coefficient.

$$\Delta p = 175{,}86 \cdot \frac{1{,}205 \cdot 3{,}499^2}{2} = 1297{,}2 \ Pa.$$

6. *diameter fractions precipitated with 50% probability:*

$$d_{50} = d_{50}^{L} \sqrt{\left(\frac{D}{D_L}\right) \cdot \left(\frac{g_{DL}}{g_D}\right) \cdot \left(\frac{\mu}{\mu_L}\right) \cdot \left(\frac{W_{opt}}{W}\right)}, \ \mu\text{m}; \qquad (6)$$

Where: d_{50}^{L} - diameter particles deposited with a 50% probability comparative cyclone, μm;

D_L – comparative cyclone diameter, m;

D – the diameter of calculated cyclone, m;

g_{DL} – particle density in the comparative cyclone, kg/m^3;

g_D – particle density in the calculated cyclone, kg/m^3;

μ_L – dynamic viscosity of the gas in the comparative cyclone, $N \cdot s/m^2$;

μ – dynamic viscosity of the gas in the calculated cyclone, $N \cdot s/m^2$;

W_{opt}– the optimum velocity of the gas in the comparative cyclone, m/s;

W - the actual velocity of the gas in the calculated cyclone, m/s.

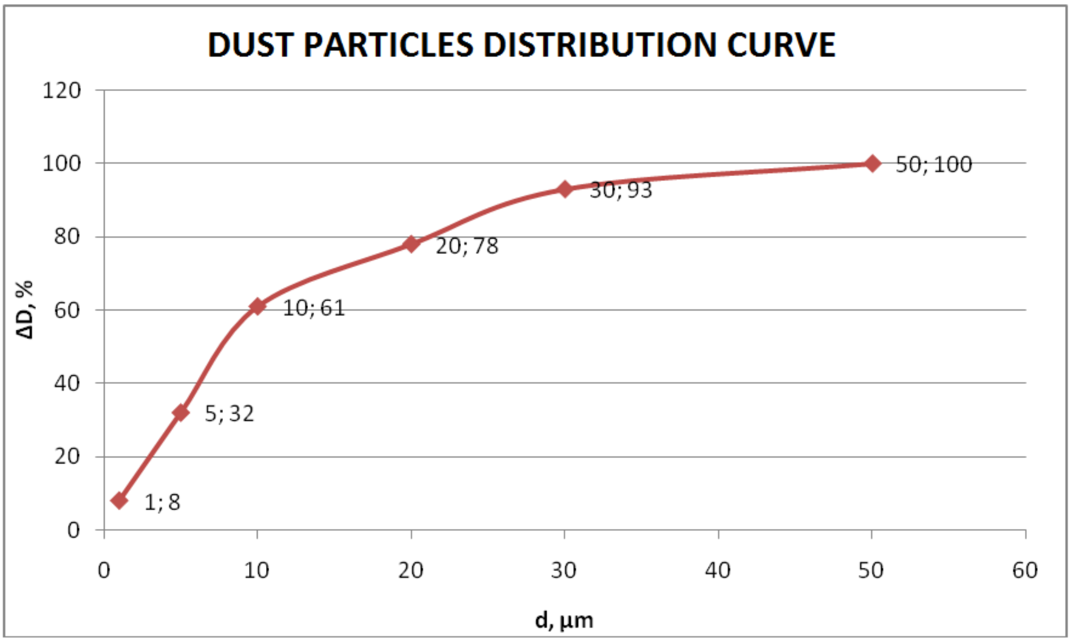
$$d_{50} = 4{,}5 \sqrt{\left(\frac{1{,}424}{0{,}6}\right) \cdot \left(\frac{1{,}93 \cdot 10^3}{1{,}84 \cdot 10^3}\right) \cdot \left(\frac{18{,}8 \cdot 10^{-6}}{22{,}2 \cdot 10^{-6}}\right) \cdot \left(\frac{3{,}5}{3{,}499}\right)} = 6{,}535 \ \mu m.$$

7. *Dust dispersion composition:*

d, μm	0,5-1,0	1,0-5,0	5,0-10,0	10,0-20,0	20,0-30,0	30,0-50,0
$\Delta D, \%$	8,0	24,0	29,0	17,0	15,0	7,0

ΔD converted into the mass of particulate D, having a certain dimension smaller than the diameters of some particles d:

d, μm	1,0	5,0	10,0	20,0	30,0	50,0
$D, \%$	8,0	32,0	61,0	78,0	93,0	100



According to the obtained value D on the logarithmic square grid draw dust particle size distribution curve and find value dm.

8. The root mean square error of the allocation function $lg_{\delta D}$:

$$lg_{\delta D} = lgd_{15,9} - lgd_{m};$$

Where: d_m –particle diameter at which the smaller particles dm is the same as larger than dm.

$d_{15,9}$ – the abscissa of the point on the ordinate has the meaning 15,9 %, $d_{15,9}$=2,3 (values found from the graph, corrected interpolation)

$$lg_{\delta D} = |lg2,3- lg7,8| = 0,530.$$

9. calculation parameter X:

$$X = \frac{\left|\lg\left(\frac{d_m}{d_{50}}\right)\right|}{\sqrt{\lg^2 \delta_\eta + \lg^2 \cdot \delta_D}} \quad ; \qquad (7)$$

$\lg \delta_\eta$ =0,35 partial cleaning coefficient, standard error , the same for all cyclones

$$X = \frac{\left|\lg\left(\frac{7,8}{6,535}\right)\right|}{\sqrt{0,35_\eta^{\ 2} + 0,530^2}} = 0,121.$$

10. Cyclone air cleaning efficiency:

$$\eta = 50 \cdot \left[1+\varphi\left(x\right)\right] = 50 \cdot \left[1+0,548\right] = 77,40\ \%.$$

$\phi(x)$ = 0,548 from the table.

11. According to the received cyclone treatment efficiency calculated emissions remaining after cyclone:

$$C_1 = \frac{(100 - \eta) \cdot C}{100}, \ mg/m^3 \quad (8)$$

$$C_1 = \frac{(100 - 55{,}13) \cdot 896}{100} = 402{,}04 \ mg/m^3 .$$