Determination of the aerodynamic characteristics of a concentrator with adjustable parameters

Rashid Sharapov and *Aleksandr* Agarkov*

Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

Abstract: The paper considers a new type of dust-concentrator device. The scheme of this concentrator is presented. According to the design scheme of the concentrator, flows of particles of dusty air and changes in the velocities of the motion of air flows in it are considered. Based on this, the conclusion is made about the pressure in different sections of the concentrator.

1 Introduction

To increase the efficiency of dust-collecting devices, we proposed a dust-settler [1], differing in that structural and technological parameters can change in it [2-9].

In Fig. 1 shows the design diagram of such a concentrator.

The main parameters of any apparatus that purifies process air are the speed and pressure of air in it. These parameters significantly affect the important indicator, such as the efficiency of the dust concentrator.

2 One-dimensional equation of airflow dynamics

The flow of air in the concentrator is considered (Fig. 1). We introduce the coordinate system: the axis Oz is directed vertically down, and the axis Ox is directed to the left.

* Corresponding author: AgarkovAM@mgsu.ru

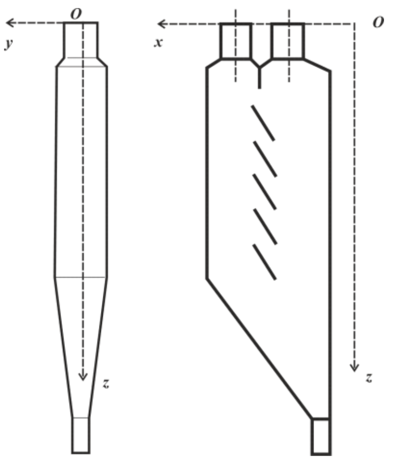

Fig. 1. Coordinate system of the inertial concentrator

We will consider the flow of particles in the selected region (Fig. 2) with the cross-sectional area S_1 and S_2. As a result of the flow of air from region 1 to region 2, the velocity of the descending air (u) and the velocity of the ascending stream (ϑ) change along the axis z. To determine these velocities, we apply the approach presented in [10-11].

For the allocated volume V we write down the law of conservation of momentum:

$$\int_S \rho \vec{\mathbf{u}} u_n dS = \int_V \vec{\mathbf{f}} dV + \int_S \vec{\mathbf{p}}_n dS, \tag{1}$$

where $\vec{\mathbf{u}}$ - the air velocity vector, u_n - the projection of velocity on the outer normal $\vec{\mathbf{n}}$ to the surface S, ρ - the density of the air, $\vec{\mathbf{f}}$ - the vector of mass forces, $\vec{\mathbf{p}}_n$ - the stress vector of the surface forces applied to the site dS with the external normal $\vec{\mathbf{n}}$. The mass forces of the intercomponent interaction can be represented in the form [11-18]

$$\vec{\mathbf{f}} = \rho C_X \beta \frac{S_p}{V_p} \frac{(\vec{\mathbf{v}} - \vec{\mathbf{u}})|\vec{\mathbf{v}} - \vec{\mathbf{u}}|}{2}, \tag{2}$$

where $\vec{\mathbf{v}}$-s the velocity of the particle, C_X - the coefficient of the aerodynamic resistance of the particle, S_p - the area of the midsection of the particle, V_p - the volume of the particle, β - the volume concentration of the particles in the stream.

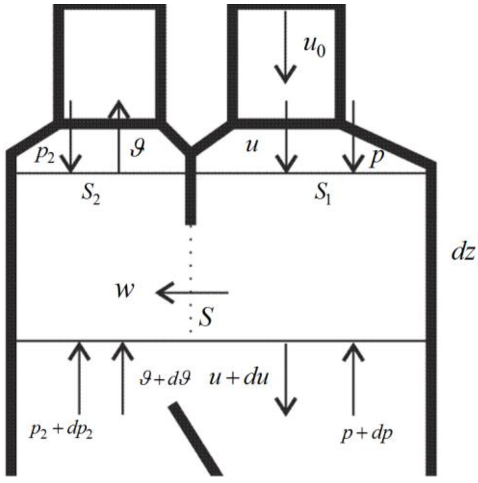

Fig. 2. The design scheme

Knowing Δp the particle $\vec{\mathbf{v}}$ velocity u and ϑ performing certain calculations and transformations, the velocity can be found, and the pressure p, p_2

The velocity of the downward flow of air

$$u = \frac{S}{S_1}\sqrt{2\frac{|\Delta p|}{\rho}z} + u_0. \tag{2}$$

The graph of the change in the velocity of the downward flow of air $u(z)$ for a different ratio $\frac{S}{S_1}$ is shown in Fig. 3.

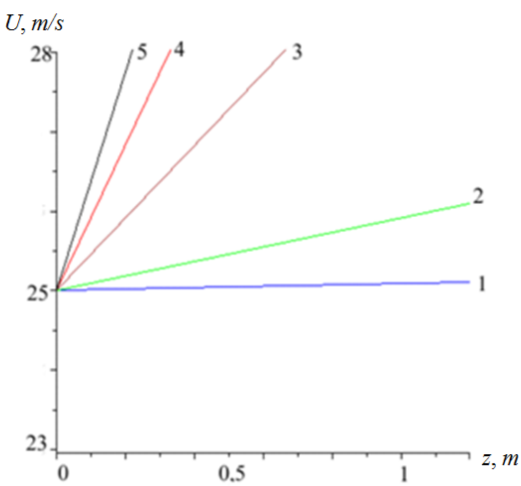

Fig. 3. Speed $u(z)$ at different ratios S/S_1:

1- 0,01; 2- 0,1; 3- 0,5; 4- 1,0; 5- 1,5

It can be seen from the graph that, at an S/S_1 equal to 0.01, the velocity of the downward flow of air $u(z)$ along the axis Oz practically does not increase. And with an S/S_1 equal 0.5, the velocity of the downward flow of air $u(z)$ relative to the axis Oz increases from 25 m/s to 28 m/s when passing 0.5 m. The sharpest increase in the velocity of the downward air $u(z)$ flow from 25 m/s to 28 m/s occurs $S/S_1 = 1{,}5$ when passing 0.25 m along the axis Oz.

Figure 4 shows a graph $u(z)$ for a different value Δp

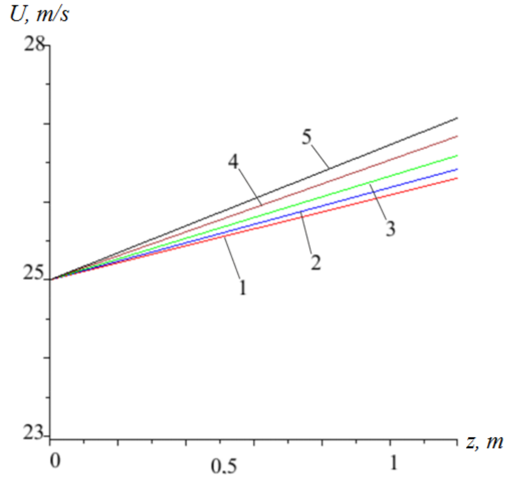

Fig. 4. Speed $u(z)$ at various differentials Δp

1 – 5.25; 2 – 6.3; 3 – 7.8; 4 – 10.5; 5 – 13.5 mm Hg

It can be seen from this graph that, with a pressure difference Δp of 5.25 mm Hg, the velocity of the downward flow of air $u(z)$ increases from 25 m/s to 26 m/s when passing 1 m along the axis Oz. The maximum increase in the velocity of the downward air flow from 25 m/s to 26.75 m/s when passing 1 m along the axis Oz occurs at a pressure Δp drop of 13.5 mm Hg.

The pressure p will be equal to

$$p = -2\left(\frac{S}{S_1}\right)^2 |\Delta p| z^2 + \frac{S}{S_1}\sqrt{2\frac{|\Delta p|}{\rho}} u_0 z - \rho\frac{u_0^2}{2}. \tag{3}$$

The pressure p_2 will be equal to

$$p_2 = p_a - 8\frac{S^2}{S_2^2}|\Delta p| z^2 - \rho\frac{\vartheta_0^2}{2}. \tag{4}$$

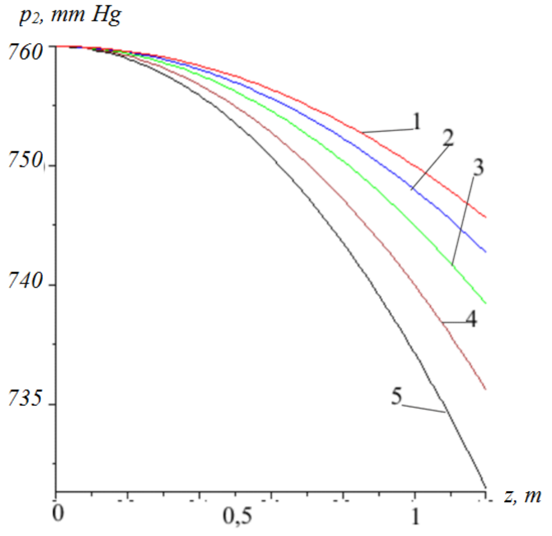

Fig. 5. Air pressure p_2 at various differentials

1- 3.75; 2 – 4.5; 3 – 5.6; 4 – 7.5; 5 – 9.6 mm Hg

Ascending air velocity

$$\vartheta = \frac{S}{S_2}\sqrt{2\frac{|\Delta p|}{\rho}z} + \vartheta_0. \tag{5}$$

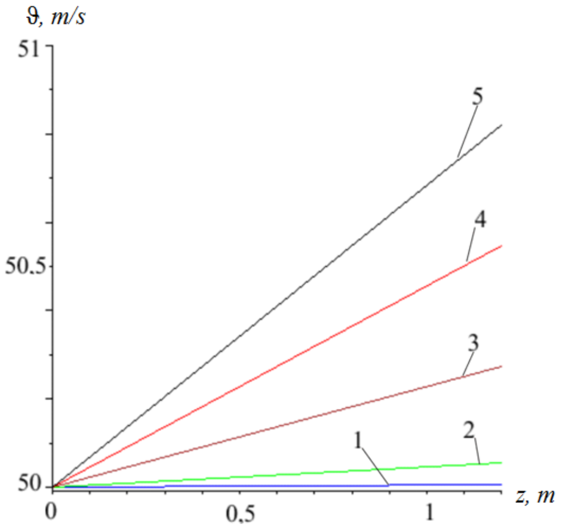

Fig. 6. Speed $\vartheta(z)$ at different ratios $\frac{S}{S_2}$

1 - 0,01; 2 - 0,1; 3 - 0,5; 4 - 1,0; 5 - 1,5

Figure 6 shows that all the presented dependencies have an increasing character, i.e. With increasing distance z, the velocity of the ascending air $\vartheta(z)$ flow increases.

With a minimum value $\frac{S}{S_2}$ of the ratio equal to 0.01, the velocity of the ascending air flow practically does not change. The largest change in the velocity of the ascending air flow occurs at a ratio $\frac{S}{S_2}$ of 1.5.

3 Conclusions

Thus, a solution is obtained for the problem of finding the velocity of the ascending and descending airflow, and also the pressure in different sections of the concentrator in the absence of phase slip in a one-dimensional formulation.

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