The breakthrough of large particles in small devices of counter-swirling flows with top strikers

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Abstract. The work considers the breakthrough effect of large particles in a small diameter device on counter-swirling flows. The dependences of particle breakthrough on different diameter devices were built. An experiment was carried out on a device of 100, 200, 300 and 400 mm with top paddle strikers installed at the axial outlet. A comparative analysis is made with the calculated and experimental data of the researchers in this area. The results of devices with small diameter are obtained and presented in the visual graphs and conclusions.

Introduction

In terms of production a pollutant is emitted - dust. To prevent negative impact on environmental safety, dust collectors are installed at enterprises. The development and appearance of new devices operating according to the inertial principle on vortex swirling flows (VZP) has a positive effect on the operation of dedusting ventilation systems [1].

The general operation principle of a vortex dust collector with counter-swirling flows is that dust contained gas enters the device through two inlets simultaneously. The gas swirls under the centrifugal forces action of the two streams and the dust particles move to the cylindrical device walls. The interaction of the streams directs the pollutant into the dust collector. The cleaned gas is discharged through the axial outlet [2].

The creation history of the VZP dust collectors begins in Germany. In 1953, scientists E. Schaufller and H. Zenneck received the Federal Republic of Germany patent №1092281 "Vortex chamber for separating solid and liquid aerosol particles using an additional swirling gas flow", shown in Fig. 1 [3]. The main feature of this dust collector was that dust contained gas was supplied to the lower stream, and pure compressed gas to the upper stream.
Next, the scientist H. Klein, taking the work of his German colleagues as a basis, presented the first experimental results and a description of the device operation [4].

During the operation of dust collectors with a gas flow, uncaught dust particles, especially fine impurities, can be carried away through the axial outlet.

Scientist L. A. Blinov in 1987 proposed a design in which fine impurities coagulate in a dust collector [5].

One year later, Soviet scientists B.S. Sazhin, L.I. Gudim. etc., the design of a dust collector was presented, where a nozzle is installed at the axial outlet and a conical shell is installed in the upper part of the body, forming an annular chamber for additional cleaning [6].

In 1997, the Ural TNP Joint Stock Company received a patent. The design feature is the presence of a filter made of fluffy threads, installed at the axial outlet of the purified gas. As the clogging progresses, the filter element is regenerated by shaking the sieve and blowing the filter element with compressed air [7].

A year later, a design of the vortex dust collector was protected by Samarskaya Yu.G, which provided an increase in the efficiency of dust collection due to the elimination of unwanted vortices in the separation chamber in the area of secondary gas flow formation [8].

Western scientists also contributed to the development of VZP devices. James G. C. and Burnard G. K. presented a patent for a device in which many small chambers are sprayed with liquid, and additional cleaning is carried out with the use of a wet filters complex [9].

At the moment, several authors have successfully defended their Ph.D. thesis on improving aspiration systems using devices on counter swirling flows [10-13].

In the history of VZP development, the problem of catching small dust particles was addressed. This problem was partially solved by operating devices of small sizes (up to 400 mm), but the next problem appeared - the breakthrough of large dust particles.

**Objective and tasks of research**

The main aim of the research is to analyse the calculated and experimental data of VZP devices, which are exists in the enterprises environmental safety system, and compare with experimental data obtained by the selected VZP for the study, based on the fractions breakthrough effect of the of large and small dust particles. Assessment and proposal of the optimal size with the top paddle strikers as alternatives for industrial use in order to prevent the large dust particles breakthrough.

**Objective and tasks of research**

This work consists of the next main parts:

- case studies selection: small diameter VZP devices;
• assessment of existing dust collection systems with a use of small diameters VZPs and results comparison in terms of breakthrough effect and device sizes; assessment of the possibility to use devices in industrial production;
• increasing the fractional efficiency of collection, reliability and energy efficiency of dusting ventilation systems with dust collectors on counter-swirling flows by comparing VZP devices;
• results analysis, formulation of conclusions and recommendations.

Materials and methods

VZP device with small diameter and top paddle strikers

The authors have proposed a dust collector on counter swirling flows of small diameter with attachment to the axial outlet of the paddles to prevent the large particles breakthrough. The device has proven itself in industrial cement production plants.

The dust collector contains a cylindrical metal body, equipped with a conical dust collector in its lower part, and a straight pipe for dust contained air inlet, installed in the upper part of the body, as well as a tangential pipe for dust contained air inlet, installed in the lower part of the body, coaxial with the vertical axis of the device, and axial a branch pipe for the outlet of cleaned gas. On the lower part of the outlet pipe, there are fixated paddle strikers, designed to prevent large dust particles from entering the stream of cleaned air (Figure 2).

![Figure 2. VZP device: 1 – body; 2 – dust collector; 3 - upper branch pipe; 4 – axial output; 5 – pipeline; 6 – lower branch pipe; 7 – swirler; 8 – striker washer; 9 – shutter; 10 – additional shutter; 11 – paddle strikers](image)

The main list of studied parameters

The main list of the studied VZP devices with paddle strikers and the breakthrough effect of dust particles in them, is presented in Table 1.

| VZP diameter, [mm] | The size of researched dust, [μm] |
|--------------------|----------------------------------|
| 100                | 2.5-50                           |
| 200                |                                  |
| 300                |                                  |
| 400                |                                  |

VZP devices with paddle strikers with diameters of 100, 200, 300 and 400 mm were researched, and a comparative analysis with the used dust collectors of these sizes without strikers was made.

In the work were used experimental datas from works. [14 - 15].
Results and discussion
The obtained experimental data for VZP devices with paddle strikers of 100, 200, 300 and 400 mm diameters after comparison with the calculated and experimental data of the authors [14 - 15], who studied VSF devices, are presented in the dependencies form (Figures 3 - 6).

The authors experimental data were made on the cement production dust.

**Figure 3.** Dependence of the 50 μm dust particles breakthrough on the size of VZP device: 1 – authors experimental data; 2 – authors calculated data; 3 – experimental data of VZP with paddle strikers; 4 – experimental data of standard VZP

**Figure 4.** Dependence of the 10 μm dust particles breakthrough on the size of VZP device: 1 – authors experimental data; 2 – authors calculated data; 3 – experimental data of VZP with paddle strikers; 4 – experimental data of standard VZP

**Figure 5.** Dependence of the 2.5 μm dust particles breakthrough on the size of VZP device: 1 – authors experimental data; 2 – authors calculated data; 3 – experimental data of VSF with paddle strikers; 4 – experimental data of standard VZP
Figure 6. Dependence of the breakthrough on the dust particles size of the VZP – 200 device: 1 – authors experimental data; 2 – authors calculated data; 3 – experimental data of VZP with paddle strikers; 4 – experimental data of standard VZP

Summary

The research showed, that the particles of 2,5 microns are captured poorly by the devices, but at the same time VZP - 100 and VZP - 200 with paddle strikers show the results close to the calculated values.

The aim of the research was to identify the optimal size of the VZP device with top strikers, as a device with the high indicators of reliability and efficiency, and at the same time with less energy and resource consumption. Obtained results showed that the VZP device with a separation chamber of 200 mm diameter shows the highest operation quality. The emission of small fractions into the atmosphere is reduced by 12% for 2,5 microns, by 7% for 10 microns and by 4% for 50 microns.

Further research of dust particles in construction industries and modernization of their operating and design parameters is required.

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