Peculiarities of Calculation of Vortex Dust Collectors by Determining its Geometry

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ABSTRACT

The article deals with issues related to the need to extract expensive dusts from process gases. For this purpose, a dry method of cleaning is recommended, against the use of a wet method. The principle of operation of a dust collector with counter swirling flows is described, based on the interaction of two swirling gas flows created in one apparatus.
The results obtained for the operation of these devices give every reason to consider them competitive.

Keywords: dust collector, gas purification, flow, swirlers, gas purification

At the moment, one of the most important problems in the industry is the problem of environmental protection.

At the same time, thousands of tons of the most valuable materials are irretrievably lost for the national economy, so in a number of cases it becomes necessary to extract expensive dusts from process gases. For this purpose, it is more advantageous to use the dry method of cleaning, since the use of the wet method leads to limited use of the trapped dust, although the cleaning of gases is carried out with greater efficiency.

In the last three decades abroad and in our country, research has been carried out and dust collectors with counter swirling flows have been introduced into industry. The obtained results on the operation of these devices give full reason to consider them competitive with all types of dry mechanical gas cleaning devices.

The principle of operation of a dust collector with counter swirling flows is based on the interaction of two swirling gas flows created in one apparatus. One of these streams moves in the apparatus along a spiral trajectory along the axis from bottom to top, the second one enters the upper part of the apparatus and moves in the near-wall region along a spiral trajectory from top to bottom.

In a dust collector with counter swirling flows, the flow structure is favorable for centrifugal dust separation.

The primary flow twists the secondary flow at the lower section of the body. The concentration of dust in the secondary stream, as in the case of cyclones, increases towards the wall of the housing from top to bottom. Dust from the primary flow is squeezed out by centrifugal forces to the interface between the primary and secondary flows and then transported down by the secondary flow. The primary flow in the lower part of the housing has a maximum swirling intensity and at a certain height prevents secondary entrainment of dust by radial effluents from the secondary about the flow. Thus, in the apparatus with counter swirling flows in the lower section with the maximum dust concentration, there are no radial drains into the flow core. This leads to the elimination of reentrainment and, along with a favorable swirling flow structure, increases the efficiency of dust collection.

Obviously, the optimal aerodynamic situation in the working cavity of the apparatus will be observed when the primary and secondary flows are supplied with the same angular velocity of rotation.

An analysis of the experimental data of various authors confirms this hypothesis. In other words, two jets swirling in the same direction, flowing from the flow swirlers, should create a vortex zone along the height of the apparatus, rotating according to the laws of a solid body.

A model for calculating a vortex dust collector is proposed, based on the constancy of the angular velocity of rotation of flows over the entire height of the working cavity of the apparatus. According to this model, according to the given geometry of the swirlers, it is possible to determine the ratio of the flow rates of the primary and secondary flows, or, according to the given ratio of the flow rates, to determine the geometry of the swirlers.

The algorithm for solving the first problem will be as follows:

1. The axial velocity of moving streams is found from the expressions:

$W = Q/\mathrm{A}$ (1)

$W = \omega\ l$ (2)

where Q is the flow rate; A is the cross-sectional area of the supply couple, ω is the angular velocity of the rotating flow; l is the distance from the axis of the cylindrical channel to the flow velocity vector.

From formulas (1) and (2) we have:

$Q = A\omega l$ (3)

2. The flow rates through the primary and secondary swirlers will be:

$Q_1 = \mathrm{A}_1\omega l_1, Q_2 = \mathrm{A}_2\omega l_2$ (4)

where the indices “1” and “2”, respectively, indicate that the parameters belong to the primary and secondary flows.

3. The ratio of flow rates through swirlers:

$\varepsilon = \frac{Q_2}{Q_1+Q_2} = A_2 l_2/(A_1 l_1 + A_2 l_2)$ (5)

When determining the geometry of swirlers, one finds:

1. Diameters of swirlers according to the formula:

$d = (4Q/(\pi V))^{0.5}$ (6)

where Q and V are the flow rate and the average velocity of the gas over the cross section.

2. Cross-section of branch pipes for supplying dusty gas - according to the formula (1).

3. The distance from the axis of the cylindrical channel to the flow velocity vector - according to the formula

$$c_2\rho_2\frac{\partial t_2(r,\tau)}{\partial\tau} = \frac{\partial}{\partial r}\left(\lambda_2\frac{\partial t_2(r,\tau)}{\partial r}\right) + \frac{2\lambda_2}{r}\frac{\partial t_2(r,\tau)}{\partial\tau},$$

$\xi < r < r_{\text{к}}$ (7).

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