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# Numerical Study of Two-Phase Flow in Centrifugal Dust Collectors

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**Annotation.** In this article, a numerical study of a turbulent swirling air flow with solid particles in a centrifugal dust collector is carried out. A modified Spalart-Almaras turbulence model (SARC) was used to compile the mathematical model and the interaction between solid particles and air mass was taken into account. The Lagrangian approach was used to study the trajectory of solid particles.

**Keywords:** Lagrangian approach, Spalart-Almaras model, finite difference scheme, numerical solution.

Multiphase turbulent swirling flows are widely used to intensify heat and mass transfer processes in various industrial devices. Examples of such devices can be chemical reactors, combustion chambers, dust collectors, separators, etc

It is known that swirling flows are characterized by a strong curvature of the current lines, the emergence of recirculation zones, the location and size of which largely depend on the intensity of the twist and the configuration of the boundaries. In addition, such flows are turbulent.

Therefore, their study requires the involvement of effective turbulence models. Recently, quite effective turbulence models have appeared [1-2]. In the future, these methods were modified for turbulent flows with a small twist [3-4]. However, the verification of these models for strongly swirled flows showed that their accuracy is insufficient [5] and they models for rotating flows do not have an advantage over others. Therefore, in this paper, a well—proven modification of the k -ε model for swirling flows is used for numerical investigation of the flow in the dust collector [6]. Almost all previous modifications of the k—ε model were associated with changing the expressions for the empirical constants c2 or (and) cμ. In the same paper, an attempt is made to modify the term in the ε equation associated with generation so as to empirically take into account additional correlations arising in the swirling flow.

The equations in a cylindrical coordinate system with the z axis along the channel axis and the radial coordinate r have the form

As for the modeling of kinematics for calculating the motion of particles in a turbulent two-phase flow, there is no unified idea of the correct approach to this problem [7]. The model based on the concept of "trajectory particles" is considered incorrect due to the lack of consideration of the effect of Reynolds stresses on the particle. On the other hand, there are undeniable advantages of the Lagrangian approach, which is closer to real processes and allows obtaining the necessary information about the trajectories of particles, the time spent by particles in the apparatus, and the minimum size of captured particles [8-11]. For this reason, in this paper, a Lagrangian approach is used to model the efficiency of a centrifugal separator:

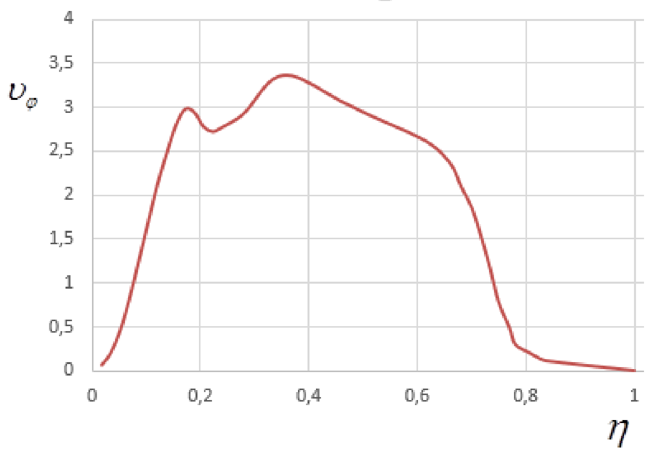
In this system of equations, the left part is a substantial derivative, and the parameters with index p refer to the velocities of dust particles. The effect of gas on dust particles is determined by the Stokes parameter:

In this expression - the density of the material of dust particles, - the "effective" diameter of the particles.

The principle of operation of this device is that a vacuum zone is created at the end of the discharge pipe 3-3 by air intake. As a result, a dust-air stream enters the separator inlet, which passes through a tangential swirler, where the flow is twisted. The swirled flow after the swirler enters the coaxial space 1-1 in cross section .

In this area, dust particles are displaced to the wall of the outer cylinder due to centrifugal force. In the cross section, the conical part of the dust collector begins, where large dust particles along the inner wall of the cone are directed down by inertia and in the cross section fall into a sealed hopper. And the air is sent to the exhaust pipe, i.e. to zone 3-3. Together with it, small fractions of powder are sent there. Thus, the installation allows you to divide the powder into two fractions. For an experimental study of the characteristics of the separator, a dust powder was fed into the entrance to the equipment, which was carried away by air into the device. In the laboratory stand, the air after the discharge pipe entered the bag filter, where small fractions were captured that did not settle in the centrifugal separator.

To ensure stability in the numerical solution of system (2), a difference scheme against the flow was used, and the diffusion terms were approximated by the central difference. The Poisson equation for the current function was also approximated by the central difference and the upper relaxation iteration method was used to resolve it. As for the numerical realization of the equations of motion of particles (2), the Euler method with recalculation was used. Therefore, this system of equations was integrated with second-order accuracy.




The profile of the dimensionless tangential velocity of the air flow in the cross section

The dispersed analysis of the powder was carried out by a Malvern laser analyzer. To compare the results of numerical calculation with experimental data, a dispersed analysis of dust from a bag filter, i.e. not

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captured dust by a centrifugal dust collector, was carried out.

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