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Development of the Basic Equations of Tangential Motion of Gas with Particles in a Dust Collector by a Vortex Swirling Flow

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ABSTRACT: The motion of a two-phase system at different distances from the axis of symmetry is considered, however, the approach about the independence of the influence of the solid phase on the flow of the carrier medium is also used here. It should be noted that a general numerical study of the equations of interpenetrating continuums for various Stokes numbers is not given in this paper.

KEYWORDS: tangential, vortex dust collectors, numerical methods, swirling vortex flow.

I. INTRODUCTION

In subsequent years, in the foreign practice of dust collection, a normal geometric series of dust collectors for swirling vortex flows with a maximum unit gas capacity of up to 8 m3 / s and apparatus body diameters from 40 to 2000 mm was created; m3/s. At present, two types of swirling flow dust collectors have been established as the main ones, differing from each other in the way the secondary flow is introduced into the dust collector.[1-2]

Swirling flows of multiphase media are widely used in the development of modern technological lines for the intensification of heat processes. and mass transfer and separation. The optimal design of both the entire line as a whole and its individual units, for example: gas cleaning devices, combustion chambers, etc., requires knowledge of all hydrodynamic flow parameters. Since in most cases both the devices themselves and the processes occurring in them are quite complex, the determination of the hydrodynamic structure of the flow is possible only on the basis of a computational experiment.[3]

Conducting a computational experiment based on a mathematical model of the flow:

Equations of interpenetrating continuums are used as a mathematical model. The numerical method is based on the well-known, both in our country and abroad, the method of large particles [4]. This numerical method is universal and suitable for calculations on any computer.

In this paper, the study of swirling dispersed flows was carried out on the example of the operation of apparatuses with counter swirling flows used to clean industrial emissions from coarse. and fine dust (Fig. 1.1).

In the upper part of the body of the apparatus there is a swirler (4), to which a secondary dusty flow in the amount of G2 is tangentially supplied through the inlet channel of the collector (2). The number of primary G1 and secondary G2 dusty flows is determined by the area of the flow section in the swirlers (4). Thus, in the cylindrical part of the apparatus (8) there is an interaction of counter dusty flows swirling in one direction. The interaction of flows due to the speed mode of the device is organized in such a way that the secondary flow reaches the rebound vibe (7), turns around and moves along with the primary flow

towards the outlet pipe (5). Dust particles under the action of centrifugal forces are thrown to the side wall of the apparatus, where they are carried by the secondary flow through the annular slot (9) into the dust collector (3). The stream cleared from a solid phase through an exhaust branch pipe (5) is removed from the device.

II. FORMULATION OF THE PROBLEM

Despite the considerable variety of methods of direct adaptive control, most of them are based on the Since the movement of gas and particles in a vortex swirling flow depends on a number of geometric and hydrodynamic defining parameters, then, by assigning certain values to these parameters, it is possible to ensure that all particles fall into the

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dust collector (3), or into the outlet pipe, or part of the particles fell into the dust collector, and some . into the outlet pipe.[5-6]

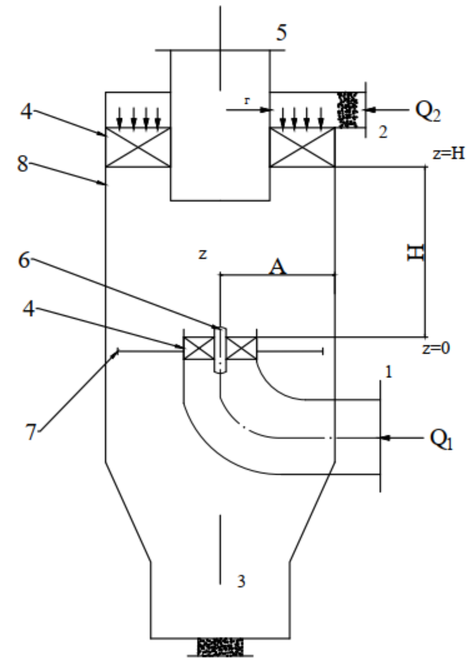

Figure. 1. Schematic diagram of the apparatus with a vortex swirling flow

As shown in fig. 1.1, the vortex swirling flow apparatus is a vertical cylindrical body, into the lower part of which, through an axially bladed or screw-type swirler (4), coaxially along the inlet pipe (1), a dusty flow is supplied, hereinafter referred to as "primary". In the central part of the swirler (4) there is a fairing (6). A baffle washer (7) is located on the outer side of the swirler, separating the body of the vortex dust collector from the hopper (3). The diameter of the baffle washer (7) is equal to 0.95 D (D is the diameter of the cylindrical part of the housing (4), which provides an annular gap for transporting dust to the dust collector bin).

III. SOLUTION OF THE TASK

As already noted, the subscript i = 1 will be referred to the parameters of the carrier phase; i = 2 . to the parameters of particles flying in the primary gas flow; 1= 3 . to the parameters of particles flying in the secondary gas flow. In addition to the main assumptions of 2.1, we will make the following additional assumptions that simplify the mathematical description of the mixture:

a) the mixture is monodisperse, i.e. the second and third dispersed phases in each elementary macrovolume δV are present in the form of spherical inclusions of the same diameter d ; moreover, the volume concentration of both the second and third phases is small:

a) $$\alpha_2 << 1, \alpha_3 << 1 (\alpha_i = \frac{g_i}{g_i^0}$$

where f_i^0. true particle density.

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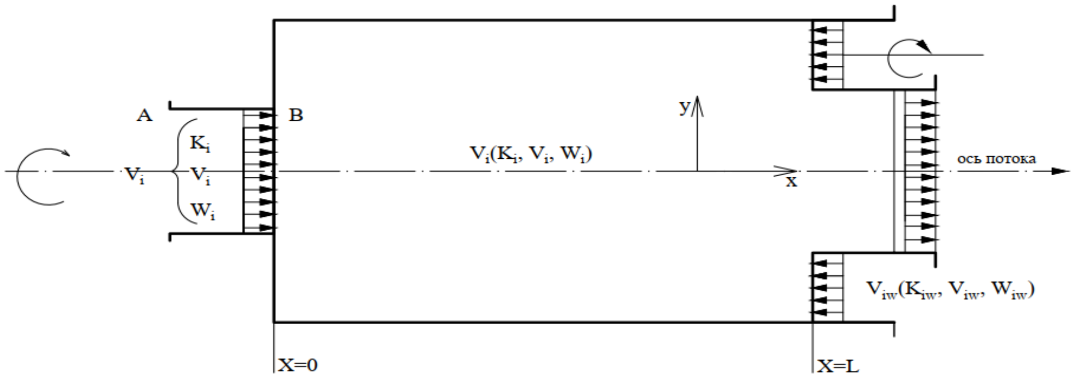

Figure. 2. Schematic representation of the longitudinal section of the apparatus with a vortex swirling flow

b) one can neglect the energy and other effects (including Brownian) internal (rotation and deformation) motions of dispersed particles.

c) direct interaction and collisions between particles of the same phase can be neglected.

d) there are no processes of crushing, sticking (coagulation) and the formation of new dispersed particles. Let us write down the equations describing, in the framework of the three-velocity, three-temperature model of interpenetrating continuums, the unsteady two-dimensional motion of a three-phase medium in a channel:

continuity equations for gas and particles (1 = 1, 2, 3):

$$\frac{\partial g_i u_i}{\partial t}+\frac{\partial g_i u_i}{\partial x}+\frac{\partial g_i v_i}{\partial y}+\frac{g_i v_i}{y}=\delta J_{ji} \tag{1.1}$$

equations of motion for the gaseous and dispersed phases:

$$\begin{gathered}\frac{\partial g_i}{\partial t}+\frac{\partial g_i u_i^{2}}{\partial x}+\frac{\partial g_i u_i v_i}{\partial y}+\frac{g_i u_i v_i}{y}=(\delta-1)\frac{\partial p}{\partial x}-f_{ij}^{x}+\delta J_{ij}u_j,\\ \frac{\partial g_i v_i}{\partial t}+\frac{\partial g_i v_i u_i}{\partial x}+\frac{\partial g_i v_i^{2}}{\partial y}+\frac{g_i v_i^{2}}{y}=(\delta-1)\frac{\partial p}{\partial y}-f_{ij}^{x}+\frac{g_i w_i^{2}}{2}+\delta J_{ij}v_j,\\ \frac{\partial g_i w_i}{\partial t}+\frac{\partial g_i w_i u_i}{\partial x}+\frac{\partial g_i w_i v_i}{\partial y}+\frac{2g_i w_i v_i}{y}=f_{ij}^{y}+\delta J_{ij}w_j,\\ i\neq j; i, j=1,2,3\end{gathered} \tag{1.2}$$

equations for the total energy of the mixture and the internal energy of the particles:

$$\begin{gathered}\sum_{i=1}^{3}\left[\frac{\partial g_i E_i}{\partial t}+\frac{\partial(g_i E_i+\delta p)u_i}{\partial x}+\frac{\partial(g_i E_i+\delta p)v_i}{\partial y}+\frac{(g_i E_i+\delta p)v_i}{y}\right]=0,\\ \frac{\partial g_i e_i}{\partial t}+\frac{\partial g_i e_i u_i}{\partial x}+\frac{\partial g_i e_i v_i}{\partial y}+\frac{g_i e_i v_i}{y}=\vec{f}_{ij}(\vec{v}_j-\vec{v}_i)+J_{ji}\left[\frac{1}{2(\vec{v}_j-\vec{v}_i^{\,2})}+e_j\right], i, j=2,3\end{gathered} \tag{1.3}$$

Here is the subscript $1\neq j$; 1 , j = 1, 2, 3 refers to the parameters of gas and particles flying along with the primary and secondary flow; ρ_i, $\vec{v}_{1}$, e_1, E_1 ,reduced density, velocity vector, internal and total energy of the 1st phase; ρ. pressure in the gas, $\vec{f}_{1j}$. intensity vector of force interaction between phases.

$$\vec{f}_{23}=g_2 g_3(\vec{v}_2-\vec{v}_3)/\beta_{32}^{(v)},\text{, где }\beta_{32}^{(v)}=\frac{g_2^{0}d}{k^{(r)}g_{200}R} \tag{1.4}$$

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. parameter of speed non-uniformity of particles of the 2nd and 3rd phases;

$$J_{32} = \frac{g_2 g_3 |\vec{v}_3 - \vec{v}_2|}{\beta_{32}^{(m)}}, \beta_{32}^{(m)} = \frac{g_2^0 d}{k^{(J)} g_{200} R} \quad (1.5)$$

parameter of intensity of mass transfer between particles of the 2nd and 3rd phases due to collisions. For this type of task$\beta_{32}^{(\vartheta)} = \beta_{32}^{(m)}$.

It should be noted that the parameters$\beta_{32}^{(v)}$ and $\beta_{32}^{(m)}$ vortex swirling flow does not have a significant effect on the flow of gas suspension in the working area of the apparatus, with the exception of individual modifications of the apparatus, which will be discussed below. Since, at low relative velocities of flow around a particle, the main contribution on the right-hand side of (1.5) comes only from the first term, in the first approximation, instead of $\beta^{(v)}$, Re_λ one parameter can be considered, namely the Stokes number Stk = $\frac{27}{4}\beta^{(v)} Re_\lambda$.

IV. CONCLUSION

The article formulates a boundary value problem and writes out the basic equations for the motion of gas-dispersed swirling flows in rectangular regions. The correctness of setting the boundary conditions for the solid phase on the side wall of the apparatus by a vortex swirling flow is discussed. Using as characteristic parameters of the problem: the linear size of the apparatus, the physicochemical and kinematic characteristics of the phases at the entrance to the vortex swirling flow, the main similarity criteria are obtained that simulate the operation of a wide class of vortex-type apparatuses.

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