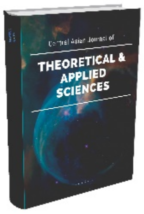

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Numerical Simulation of Two-Phase Flux in Centrifugal Separator

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Abstract: *In this paper, it was demonstrated that the new two-dimensional model is a low-axis and well describes highly swirling turbulent flows. Therefore, the purpose of this paper is a comparison of various approaches to turbulence to simulate a two-dimensional axisymmetric turbulent flow in the air centrifugal separator, which is used in the processes of separation and classification of particles, obtaining powders of the desired quality. Two-fat model. The numerical results of these models are compared not only among themselves, but also with experimental data for the dispersed composition of the separated powder.*

KeyWords: *centrifugal separator, Navier-Stokes Equation, turbulence model, dimensionless speeds, physical and mathematical formulation, RANS model.*

Introduction:

The new development of a two-lifted approach after more than 30 years of a break was obtained in the recently published work of one of the authors [1-5] of this article. In this paper, it was demonstrated that the new two-dimensional model is a low-axis and well describes highly swirling turbulent flows.

Therefore, the purpose of this paper is a comparison of various approaches to turbulence to simulate a two-dimensional axisymmetric turbulent flow in the air centrifugal separator, which is used in the processes of separation and classification of particles, obtaining powders of the desired quality. To do this, used well-tested and having good accuracy of the RANS model with the involvement of the Boussinesque SARC hypothesis [6-8] and SST-RC [9], one of the variants of the Reynolds voltage method SSG / LRR-RSM-W2012 [10,11], as well as the mentioned new Two-fat model.

The numerical results of these models are compared not only among themselves, but also with experimental data for the dispersed composition of the separated powder.

Physical and mathematical formulation of the problem

The concept of the centrifugal separator is shown in fig. The principle of the separator is presented in Article [12,13].

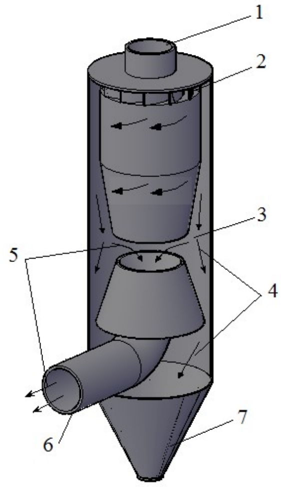

Figure. 1. Scheme of the calculated air-centrifugal separator

For a numerical study of the task, the Navier-Stokes Equations system averaged over Reynolds in the tensor form, taking into account the interaction between the phases.

$$\begin{cases} \rho\frac{\partial \overline{U}_i}{\partial t}+\rho\overline{U}_j\frac{\partial \overline{U}_i}{\partial x_j}+\frac{\partial \overline{p}}{\partial x_j}=\mu\frac{\partial^2 \overline{U}_i}{\partial x_j \partial x_j}+\frac{\partial}{\partial x_j}\left(-\rho\overline{v_i' u_j'}\right)-\sum_{k=1}^{N}\frac{\rho_k}{\rho}k_k\left(\overline{U}_i-\left(\overline{U}_{pk}\right)_i\right), \\ \frac{\partial\left(\overline{U}_{pk}\right)_i}{\partial t}+\overline{U}_j\frac{\partial\left(\overline{U}_{pk}\right)_i}{\partial x_j}=k_k\left(\overline{U}_i-\left(\overline{U}_{pk}\right)_i\right), \frac{\partial \rho_k}{\partial t}+\overline{U}_j\frac{\partial \rho_k}{\partial x_j}=\frac{\partial}{\partial x_j}\left(\frac{\partial \rho_k}{\partial x_j}\right), \frac{\partial \overline{U}_i}{\partial x_j}=0 \end{cases}$$

Here $\overline{U}_i$ - airflow speeds; $\left(\overline{U}_{pk}\right)_i$ - Similar components for the K-oh dust fraction; $\overline{p}$ - hydrostatic pressure; ρ - gas density; μ - its molecular viscosity; $\overline{v_i' u_j'}$ - Reynolds voltage tensor components; dust mass density; ρ_k -dust mass density; k - coefficient of interaction between air and N- the number of dust fractions.

Mathematical modeling of a two-phase flux based on a new two-dimensional turbulence model

To describe a two-phase flux in a centrifugal separator, the system of equations of the new two-particle model will write in the tensor form.

$$\begin{cases} \frac{\partial \overline{V_i}}{\partial t}+\overline{V_j}\frac{\partial \overline{V_i}}{\partial x_j}+\frac{\partial \overline{p}}{\rho \partial x_i}=\frac{\partial}{\partial x_j}\left[\nu\left(\frac{\partial \overline{V_i}}{\partial x_j}+\frac{\partial \overline{V_j}}{\partial x_i}\right)-v_j v_i\right]-\sum_{k=1}^{N}\frac{\rho_k}{\rho}k_k\left(\overline{U}_i-\left(\overline{U}_{pk}\right)_i\right), \\ \frac{\partial v_i}{\partial t}+\overline{V_j}\frac{\partial v_i}{\partial x_j}=-\rho v_j\frac{\partial \overline{V_i}}{\partial x_j}+\frac{\partial}{\partial x_j}\left[\nu_{ji}\left(\frac{\partial \overline{V_i}}{\partial x_j}+\frac{\partial \overline{V_j}}{\partial x_i}\right)\right]+\frac{F_{si}}{\rho}+\frac{F_{fi}}{\rho}, \nu_{ji}=3\nu+2\left|\frac{v_i v_j}{def(\vec{V})}\right| \quad npu \ i\neq j, \\ \nu_{ii}=3\nu+\frac{1}{div\vec{v}}\left|\frac{v_k v_k}{def(\vec{V})}\right|\frac{\partial v_k}{\partial x_k}, \vec{F}_f=-\rho K_f\vec{v}, \quad \vec{F}_s=\rho C_s rot\vec{V}\times\vec{v}, \ \frac{\partial \rho\overline{V_j}}{\partial x_j}=0. \end{cases}$$

In fig. 2 illustrate air velocity profiles in cross section $z=3.5$ here U/U_{ref}, W/U_{ref}

Dimensionless speeds.

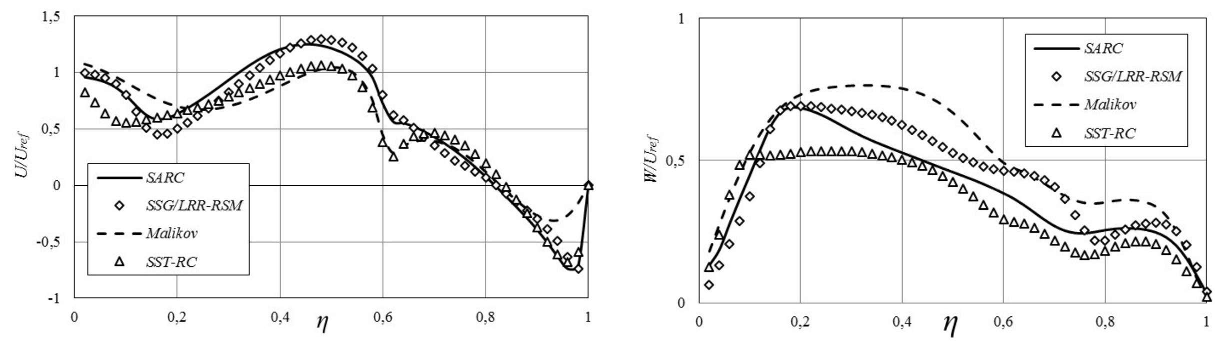

Figure. 2. Profiles, axial and tangential flow rates in cross section $z=3.5$

From the figure it can be seen that in this section, the results of various models are qualitatively coincided. This is because, apparently, this section meets the zone with the greatest turbulence, which is adequately described by all models. [14,15]

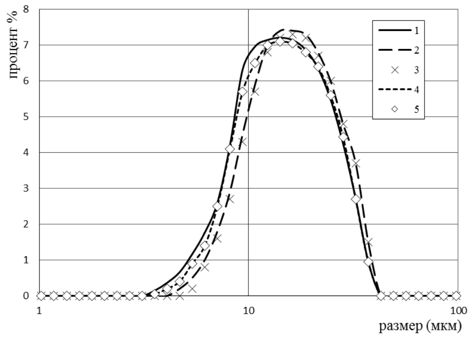

Fig.3. Dispersed analysis of the composition of the zinc powder from the separator bunker. 1-SSG / LRR-RSM, 2-SARC, 3-SST-RC, 4-new two-dimensional model, 5 - analyzer data.

Figure (3) shows the calculated graphs of various models for the dispersed distribution of zinc particles set in the separator. [16-18] For comparison, in this figure, a dispersed distribution of particles obtained by a laser analyzer is also given.

The analysis was carried out for the captured dust by the separator. It can be seen from this pattern that the closest results for experimental data has a two liquid turbulence model.

Conclusion

Comparison of the numerical results of fundamentally different turbulence models shows that they quantify different results for gas flow parameters. Thus, the experience presented, as well as experience from the article [1], suggest that a new two-dimensional model may be effective when modeling centrifugal separators.

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