The Simulation of Alumina Feed in the Reactor of Dry Gas Treatment Plant

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Abstract

The specialists of SibVAMI at UC RUSAL have developed a modern technology for the dry treatment of waste gases from the production of aluminium by electrolysis. This technology is complex and includes various processes and technical solutions. Today, the dry gas treatment plants (DGTP) designed by UC RUSAL are successfully operated at the Irkutsk and Bratsk aluminium smelters.

The gases treated at the DGTP of UC RUSAL comply with environmental requirements. At the same time, given the complexity and diversity of the processes within the DGTP, there remains the opportunity for the further enhancement of the individual process solutions and further improvement of its economic and technological efficiency. One of the units successfully functioning today, but having the potential for additional optimisation, is the alumina feed unit to the DGTP reactor. The design of this unit affects the uniform distribution of alumina in the gas flow.

In order to optimise the design of the alumina feed unit for the DGTP reactor, the ability to reliably simulate the alumina feed process into the gas flow is necessary. The aim of this paper is to select a computational model for this process. The paper compares the results obtained using the Euler-Euler medium interaction model and the Euler-Lagrange model in the ANSYS CFX software package. The paper analyses the compliance of the calculated models of the motion of solid particles in gases with the experimental patterns of the motion of solid particles. As a result, it was proposed to use the Euler-Euler model to simulate a unit for alumina feed into the gas flow

Key words: Alumina feed reactor, dispersed system, particle, Euler-Euler model, Euler-Lagrange model.

1. Introduction

The improvement of mathematical simulation tools of hydrodynamic processes in dispersed systems is triggered by the need for a detailed study of the physical processes that occur in dry gas treatment plants (DGTP). DGTP plants are used for the purification of process waste gases from the production of aluminium by electrolysis. The purification of gases in DGTP is carried out by the adsorption process, the intensity of the adsorption depends on the distribution of the adsorbent (alumina particles) in the gas flow. The introduction of alumina into the gas flow is carried out through a nozzle installed in the neck of the reactor. The design of the nozzle affects the uniformity of the alumina distribution in the gas flow.

The aim of this work is to develop a computational model that will reliably predict the effect of the structure on the distribution of alumina in the flow in the DGTP.

Our paper focuses on a three-dimensional (3D) stationary mathematical model, making it possible to carry out the computational analysis of the movement of alumina particles from the reactor to the tilting chamber of the DGTP. The paper compares the results obtained using either the **Euler-Euler model** of media interaction or the **Euler-Lagrange model**. To solve the problem, the CFD (Computational fluid dynamics) ANSYS CFX software package has been employed, which allows simulating dispersed systems.

The layout of the studied computational model is shown in Figure 1.

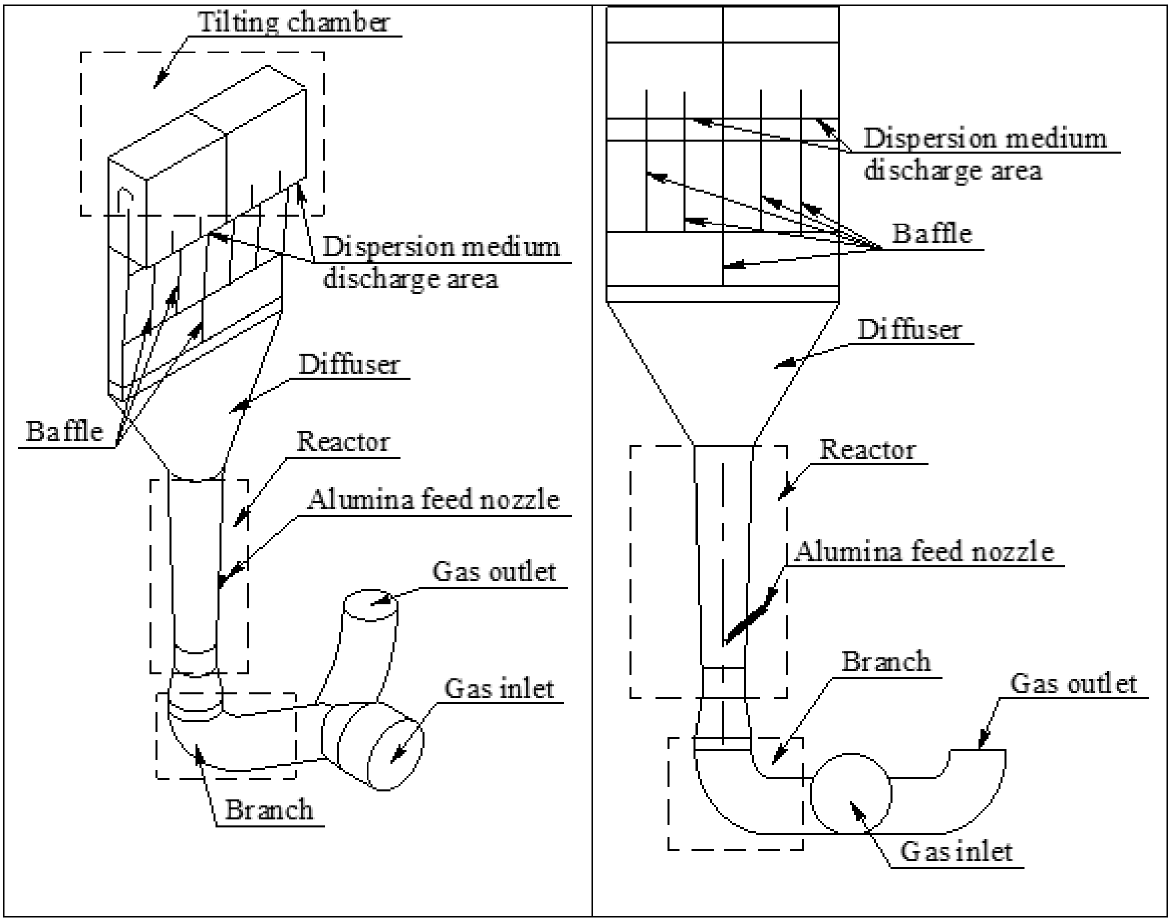

Figure 1. Layout of the studied computational model.

2. Setting Up the CFD Software

Modern CFD software makes it possible to use several mathematical models to simulate the motion of the solid particles in a gas flow. Such models describe the various effects and processes occurring during the motion of a two-phase medium:

- Particle distribution in the flow (media interaction model);
- Accounting for particle resistance (model of the exchange of momentum between the particle and the gas medium);
- The motion of the gaseous phase, taking into account turbulence (model of the motion of the gaseous medium).

Figure 7 shows the distribution of solid particles at the alumina feed nozzle outlet in an operating 'dry' gas treatment plant. Upon comparison of this image with the colour maps in Figure 6, it was found that the **Euler-Lagrange** media interaction model yields an unreliable distribution of solid particles in the area of the alumina feed **nozzle**.

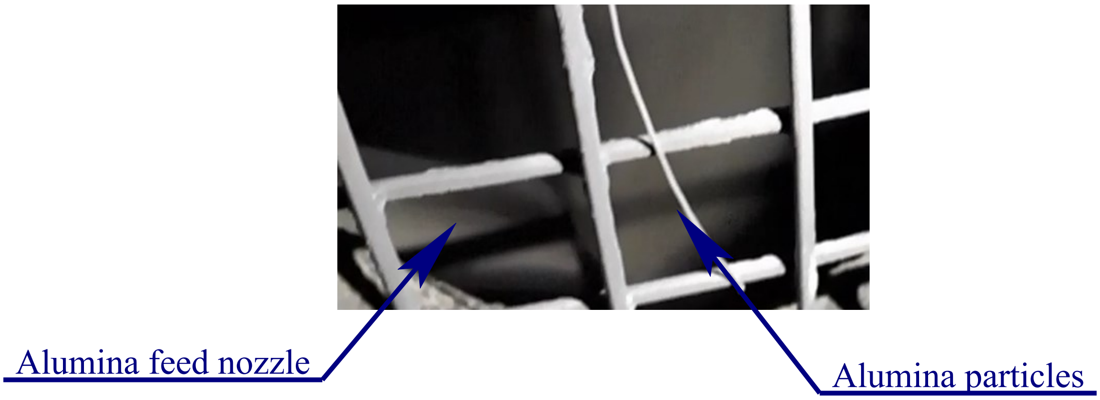

Figure 7. Distribution of solid particles at the outlet of the alumina feed nozzle in an operating DGTP.

4. Conclusions

The developed mathematical model makes it possible to estimate at the design stage the local disturbances associated with the distribution of smelter-grade alumina in the flow in the DGTP. Moreover, the study of the media interaction models has made it possible to establish that the use of the **Euler-Euler model** allows for the qualitative prediction the distribution of solid particles in the area of the alumina feed nozzle while the **Euler-Lagrange model** does not yield a reliable alumina distribution of alumina in this particular region – refer to Figure 6-B).
Since ANSYS-CFX supports only two media interaction models, it is clear that, in the future, SibVAMI JSC and RUSAL ETC LLC will use the **Euler-Euler model** of media interaction when performing computational work on DGTP simulation.

5. References

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