Simulation of flow and solid particles in a deflector wheel classifier

Trennscharfer Abweiseradsichter für die Trockenfraktionierung submikroner Partikeln bei hohen Beladungen mit integrierter Materialsortierung

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In Short

- Extension of the flow simulations to include the particle phase using the Euler-Lagrange approach (particle tracking)
- Calculation of the separation curves at different operating points
- Optimisation of the classifier for enhancing the separation efficiency, employing variations of the blade and peripheral geometry designs

In mechanical process engineering, air classifiers are used to separate and classify particles according to their size. In the reality, two different materials would be given to the classifier and both of the materials will be separated according to the particle sizes of each material and the fine particles are then transferred to a triboelectric separator to be separated from each other. The concept of the whole separation process is illustrated in figure 1. The simulation of the particles inside the triboelectric separator is also in the plan of this project. The separation process inside the wheel classifier is based on the fluid forces acting on the particles in an airstream (drag and centrifugal forces). Particles in an airstream in rotating machines are under two main kinds of fluid forces, which are drag forces, mainly because of the inlet airflow and centrifugal forces, mainly because of the rotation of the blades. For small particles with low mass, the drag forces are greater than centrifugal forces and the particles are drawn by the airflow towards the blades and could be transferred to the fine material outlet, while for the coarse particles with greater mass, the centrifugal forces are greater and thus the particles stay in the outer space of the machine and could be transferred to the coarse material outlet. The project aims to design and investigate a wheel classifier that separates the particles in the range of micrometer with a separation efficiency of 0.6. For that purpose, a deflector wheel classifier (HAS) has been designed and experimentally investigated. The second part of the investigation is based on numerical simulations of the classifier. First, only the airflow in the classifier has been simulated and the separation efficiency has been calculated theoretically and compared to the experimental data, as in figure 2. In the current and next step, the

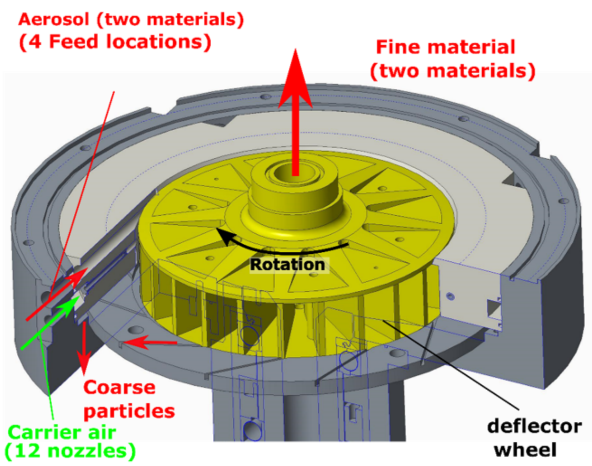


***Figure 1:** Concept of the particle separation process in the deflector wheel classifier (HAS)*

solid phase of the particles should be included in the simulations and the particle tracking should be implemented for a deep understanding of the separation process and the particle behavior in the classifier. The aim of the project is then to introduce new designs for the blade and the periphery of the classifier to improve the separation process.

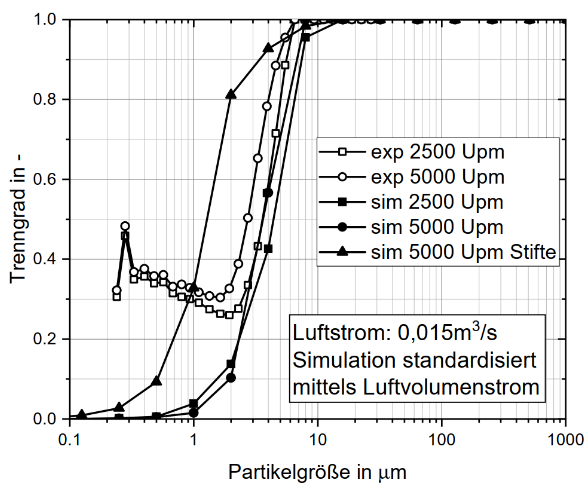
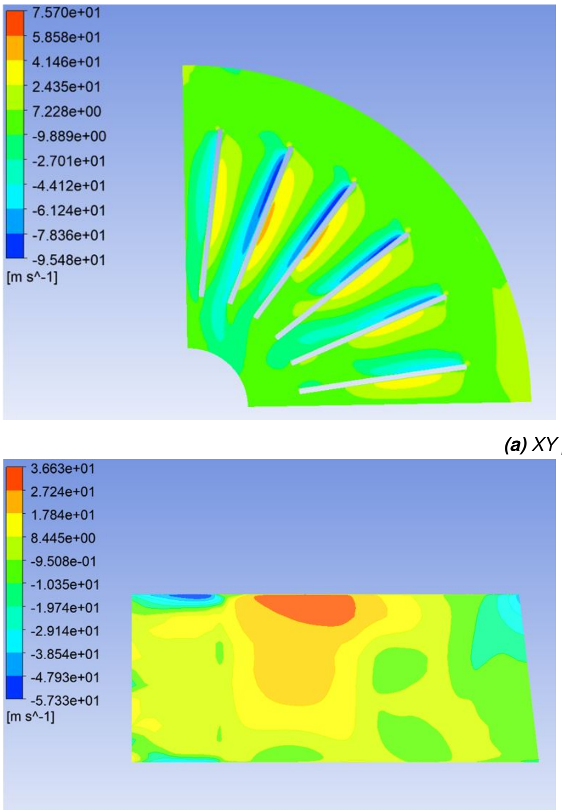


***Figure 2:** Separation curve calculated from airflow simulations compared to experimental data at different operating parameters*

Inside the classifier and between the blades, there are flow vortices that badly affect the separation process as the flow near the vortices carries the fine particles again to the outer space, and the particles are then transferred to the coarse particles outlet. The formation of the vortices can be observed by the radial flow velocity as in figure 3, where the flow vortices are present in the XY and the XZ planes. By implementing new designs for the blades and



***(a)** XY plane*

***(b)** XZ plane*

***Figure 3:** Radial flow velocity at the rotor domain represnting flow vorticies in XY plane and XZ plane*

also the periphery of the classifier, the formation of these vortices can be reduced, which can improve the separation process. The first step of the optimization is the comparison between the results of the particle tracking with the experimental data as a validation of the simulations. It will be followed then by the examination and their comparison to the old ones at different operating parameters to obtain the best performance of the classifier. The work packages are described in the main proposal text. The investigation will be performed using the commercial CFD software ANSYS CFX using the Euler-Lagrange approach for particle tracking and the Euler-Euler approach in some cases for comparison. The requested computing and storage capacities are therefore to enable performing simultaneous steady and unsteady CFD simulations for the different work packages, as described in the main proposal text. Performing simulations, including the solid particle phase, have some challenges. One of these challenges is the shape of the particles. CFX by default simulates the particles as spherical particles while in reality, the particles have different shapes (cube, pyramids, etc.). Defining the sphericity of the particles for the simulation is therefore difficult and could be iteratively achieved. Another challenge is the particle tracking limits such as the maximum tracking time and distance which should be also iteratively defined as a compromise between low simulation time and getting a large number of particles out of the domain without exceeding these limits. The preliminary results of the CFD simulations with particle tracking are plotted in figure 4

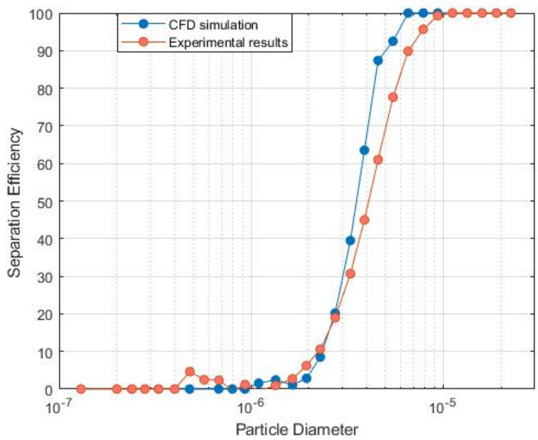


***Figure 4:** Separation curve of CFD simulations with particle tracking and corrected separation curve from experimental results at one of the operating parameters of the study (ω =5000 rpm, $\dot{v}$ = 80 m^3/h)*

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Optimierung eines Abweiseradsichters

More Information

[1] B. Furchner, S. Zampini, *Ullmanns Encycl. Ind. Chem.* (2009). doi:10.1002/14356007

[2] A. C. Benim *Computational Fluid Dynamics An International Journal*(2005). doi: 10.1504/PCFD.2005.007067

Project Partners

Institut of applied mechanics, TU-Clausthal

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