Coupling of CFD- and DEM-methods to determine the transport and deposition behaviour of particles on filter fibres

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The deposition behaviour of particles on fibrous filters has an important influence on the separation efficiency and the lifetime of filter elements. During the deposition so called dendrites can be generated and these dendrite structures have an elementary impact on the separation process. Significant parameters are the flow velocities around the fibre and dendrites, the pressure drop, the porosity of the dendrite structures and the increasing blockage effect due to the deposited particles during the filtration period. To determine the deposition behaviour both the particle transport and the motion and reallocation of the dendrite structures have to be considered. The calculation of particle charged fluid flows normally takes place in two steps. First, the fluid flow regime is determined, for example by using CFD-(Computational Fluid Dynamics) simulation tools. Thereafter, depending on the current geometrical, dynamical and material properties of the fluid flow, for example the Reynolds number or the volume fraction of the particle phase, a suitable model is chosen to determine the particle transport. Well-known models among others are the Euler-Lagrange- and the Euler-Euler-Method. When calculating the particle deposition on fibre surfaces the motion of single particles is primarily determined by the fluid flow forces acting on the particles, for example the drag force and the buoyancy force. To account also for the influence of the particles on the motion of the fluid, the classical two-way-coupling has to be considered. The blockage effect of deposited particles on the filter surface is considered by the spatial extent of the particles

If the fluid flow forces on single particles are of minor importance compared to particle-particle and particle-wall contact forces, Discrete Element Methods (DEM) are used to determine the transport behaviour of the particles. Thereby, the particle motion bases only on particle-particle and particle-wall collisions as well as electrostatic forces and van-der-Waals forces. The Discrete Element Method can also be used to simulate the multi body kinematics between the particles in the dendrite structures. With this procedure the moving and the reallocation of dendrite structures can be determined during the loading process. The deposition of particles on fibre elements is influenced by both hydrodynamic forces and contact forces due to collisions, van-der-Waals forces or electrostatic forces. To calculate the transport behaviour correctly both the forces resulting from flow dynamics and particle interaction effects have to be considered. The CFD software Fluent™ is used to compute the multiphase flow regime focusing on the deposition behaviour. Additionally, the calculation of motion and reallocation of particles inside the dendrite structures, which bases on multi body kinematics, is done by using the DEM software EDEM™.

The aim of the investigation is the development of a simulation method which accounts for the transport behaviour of particles in the vicinity of the single fibre and describes the particle deposition on this correctly. Two coupling schemes are used to connect the Fluent™ software with the EDEM solver, the Euler-Lagrange as well as the Euler-Euler coupling. In this study both methods will be compared to each other and with results when the motion and reallocation of dendrite structures is neglected. Furthermore, the numerical results are compared to experimental data. The investigations will be expanded further by calculation of the transport behaviour of non spherical particles. The motion and reallocation of dendrite structures on fibre elements which are built-up from non spherical particles is investigated.

To determine the transport behaviour of non spherical particles in the fluid flow in respect of the finite size of the particles a simulation method is applied which bases on dynamic mesh algorithms. The results indicate the great influence of the particle shape on the dendrite formation and on the ambient flow regime.