NUMERICAL SIMULATION OF AGGLOMERATION AND FILTRATION OF COLLOIDAL SUSPENSIONS

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ABSTRACT

Recently, many new processes and methods for the production of nanoscale particles have come into the focus of current research and development. Thereby the synthesis of these products often takes place in electrolyte solutions, where particles normally acquire a non-zero surface charge. This finally results in the formation of an electric double layer. From the DLVO theory it is well known that the electrostatic interactions have a main influence on the structure of agglomerates but also on the behavior in the liquid, like the sedimentation velocity. In the present paper numerical simulations are used to give further insight in the underlying physical principles.

For a small number of particles direct numerical simulation can be used, where the geometry of the particles is fully resolved by a overlay grid technique. To take into account the effects of the electrical double layer it is necessary not only to consider the Navier-Stokes equations for the fluid flow, but also a Poisson equation for the electric potential as well as the Nernst-Planck equation that describes the ion transport in the electrolyte. In this way all nonlinear interactions between the particles are included in the simulation. Especially we investigate the electrokinetic interactions in periodic cubic arrays of spheres and in random suspensions.

By increasing the particle number it is necessary to overcome the huge computational costs of a direct numerical simulation. Therefore we use a combination of a stochastic rotation dynamics (SRD), which is a coarse grained fluid description, and a discrete element method (DEM) including the DLVO potential. We use our model to simulate a cake filtration and predict the permeability of the filter cakes depending on a change of the compressive load, the particle size and the agglomeration of the particles. The latter is thereby determined by the particle charge and the ionic strength of the suspension. We show that our results agree qualitatively with experimental data obtained from colloidal boehmite suspensions.

From the literature it is known that the permeability of the filter cake increases with decreasing particle size and the mechanical dewatering becomes more and more difficult. One possibility to improve the filtration kinetics is the process of magnetic field enhanced cake filtration, which results from the combination of classical cake filtration and magnetic field driven separation. Experimental results prove that different magnetic field effects influence the filtration process positively. Therefore DEM simulations are performed to give a deeper understanding in the mechanisms of structuring effects of the filter cake and the interaction of magnetic, hydrodynamic and mass forces.

BIOGRAPHY, SHORT SKETCH

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