



IFPRI Project Abstract

Detailed insight into microscopic phenomena using 3D-tomography data to develop a better model for dead-end filtration

Principle Investigator(s): Thomas Leißner, Urs A. Peuker

PhD-Student(s): Mashia Brockmann, Erik Löwer

Affiliation(s): TU Bergakademie Freiberg

Project Start Date: 01.10.2017

Abstract Date: 29.05.2020

Project Objective:

The project aims at the connection of the disperse particle properties with characteristics of the resulting filter cake structures. These include particle size, shape and wettability and the resulting particle-particle interactions. Finally, these investigated relationships will help to better understand the relevant process properties such as the dewatering behavior or the washability of these systems. For this purpose, mainly X-ray tomographic investigations of the filter cake structures are carried out.

Approach:

Material: Al₂O₃ (compact particles) and CaSiO₃ (fibres) were selected as particle systems, and for hydrophobization, we used silane as a coating agent.

Filtration approach: Using different vol.-% of ethanol to investigate the wettability effect on the filter cake in the VDI nutsche and in-situ cell. We carried out long-term scans for in-situ filter cakes which differed in ethanol vol.-%. We selected the 20, 40, 60, 80 and 100 vol.-%. This year we present mainly results using an aqueous phase to validate the data exploitation of the image processing.

Image processing approach: The main scope of the last year was on finalizing the data exploitation methods. This is due to the fact, that commercial software solutions did not deliver satisfying quantitative results. Therefore, individual models and algorithms have been implemented to extract much more information out of the X-ray images.

Recent Results:

For the analysis of the solid structure several self-developed methods are available, such as determination of particle size, shape, local void volume fraction, coordination number, pore size and pore connections as well as the determination of tortuosity. Going over to two fluid phases (describing de-saturation) within the void structure, the determination of the capillary length as well as the measurement of the local contact angle becomes a matter of additional interest. Furthermore, the size and shape of the hydraulically isolated liquid bridges can also be determined, quantifying local saturation.

In combination of both method steps, such as coordination number and fluid bridge formation or tortuosity and capillary length, conclusions on the dewatering behavior can be derived. For this purpose, a stepwise in-situ dewatering of a filter cake was carried out

within the μ CT to determine the capillary pressure distribution in connection with the saturation. These results represent a capillary pressure curve.

By supportive conventional laboratory experiments these results are validated, as far as the individual local parameters are experimentally accessible by the macroscopic experiments. Otherwise the comparison with integral values is made.

In a parameter study with hydrophobized Al_2O_3 particles the influence on the internal cake structure was investigated. The approach was to change the mother liquid from a water-based suspension to an alcohol-based suspension by stepwise adding ethanol. Where the aqueous suspension stands for a non-wetted particle system. The addition of ethanol decreases step by step the wetting angle and finally the suspension with 100 % ethanol shows nearly perfect wetting ($\gamma = 10^\circ$). We observed that filter cake porosity is a function of ethanol content within the suspension. It could be shown that with decreasing contact angle from $\gamma = 72^\circ$ to 10° and thus better wettability the local porosity decreased significantly by 7 %-points, but the mean pore size and mean coordination number showed less change. The effect of the change in wetting, particle interactions respectively, seems to be more on the shape of the pore size distribution, where the span between the 25% and 75% quantile increased in a certain concentration range of the ethanol.

The decreased amount of the porosity is in strong relation to the change of the surface tension and wetting properties. To validate the wettability change on hydrophobic Al_2O_3 filter cakes, we compared experimental filtration data with tomographic extracted porosity data.

Next Steps:

Since now we have the methods for structural analysis in place and we are able to extend the previous experiments. Next, we will investigate plate-shaped or fibrous (CaSiO_3 - fibres) particle systems. For the renewal, we propose to extend the scope of the research and to add investigations on washing experiments of these particle systems and the resulting structural changes. The methods will also be applied to centrifuge sediments. To increase the resolution of the 3D-analysis, we will try to incorporate some FIB-analysis into our portfolio.