

Analytical centrifugation for characterization of sludge filterability: centrifugal consolidation kinetics supported by x-ray analysis of sediment structure

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Background: The knowledge of pressure dependency of filterability (particle volume fraction ϕ and specific cake resistance α) is essential for optimization of sludge dewatering operations (settling, centrifugation, dead-end filtration-consolidation). The analytical centrifugation is a promising alternative to the classical laboratory methods of the filterability measurement (constant pressure dead-end filtration, compression permeability experiments) due to the possibility of automated many samples characterization.

A number of methods are available for the analysis of centrifugal consolidation data (i.e., dependency of centrifugal consolidation kinetics and sediment height on centrifugal acceleration) and characterization of sludge filterability, which are based on the idealized representation of a sample (usually, concentrated and aggregated suspension) behaviour in the centrifugal field [1-4]. However, recent works suggest that centrifugal consolidation can be influenced by side different effects (as wall friction [5] and particles segregation [6]) that must be taken into account (or eliminated by appropriate choice of the experimental protocol) for the correct characterization of filterability.

Objective: Our current work is devoted to the development of a new method and protocols for the determination of pressure dependency of filterability of concentrated aggregated suspensions (pressure dependency of particle volume fraction ϕ and specific cake resistance α) from the centrifugal consolidation data (two-stage and multistage centrifugal consolidation kinetics).

Methods: The method is based on the comparison of experimental characteristic consolidation time with the values tabulated for samples with different filterability. The tabulated values of characteristic consolidation time are obtained by the numerical solution of basic consolidation equation [7] for moderately compressible samples. The method was tested on the aqueous kaolin suspensions.

Different experimental protocols were studied (Lumisizer):

- a) single stage centrifugation different constant centrifugal accelerations;
- b) two-stage centrifugation (centrifugal pre-consolidation at low centrifugal acceleration followed by centrifugation at different higher accelerations);
- c) multistage centrifugal consolidation (pre-consolidation followed by centrifugal acceleration ramping);

Results: The x-ray transmission analysis (Lumireader x-ray) revealed that the single stage centrifugation can result in formation of nonhomogeneous sediment (probably, due to the

particles segregation at high centrifugal acceleration), while two-stage and multistage experiments yields sediments with homogeneous solid pressure distribution.

Conclusions: Sample pre-consolidation at low centrifugal acceleration is necessary for the correct analysis of the filterability by the method of centrifugal consolidation. The kinetics of two- and multistage centrifugal consolidation can be analyzed with the help of the developed method in order to determine the pressure dependency of the specific cake resistance in the wide solid pressure range.

Literature

- [1] M. D. Green, M. Eberl, K. A. Landman. Compressive yield stress of flocculated suspensions: determination via experiment. *AIChE Journal*, 42 (1996), 2308.
- [2] T. Murase, M. Iwata, T. Adachi, L. Gmachowski, M. Shirato. An evaluation of compression-permeability characteristics in the intermediate concentration range by use of centrifugal and constant-rate compression techniques. *Journal of Chemical Engineering of Japan*, 22 (1989) 378.
- [3] S. P. Usher, L. J. Studer, R. C. Wall, P. J. Scales. Characterisation of dewaterability from equilibrium and transient centrifugation test data. *Chemical Engineering Science*, 93 (2013) 277.
- [4] M. Loginov, M. Citeau, N. Lebovka, E. Vorobiev. Evaluation of low-pressure compressibility and permeability of bentonite sediment from centrifugal consolidation data. *Separation and Purification Technology*, 92 (2012) 168.
- [5] S. Skinner, A. D. Stickland, L. White, S. P. Usher, P. J. Scales, D. Lester. Analysis of centrifugal settling of strongly flocculated suspensions. 12th World Filtration Congress, April 11-15, 2016, Taipei, Taiwan.
- [6] M. Loginov, N. Lebovka, E. Vorobiev, A. Zierau, D. Kaviani, J. I. Martinez Sanchez, T. Sobisch, D. Lerche. Laboratory method for determination of filterability: combination of centrifugation & X-ray analysis. 2nd European Conference on Fluid-Particle Separation, October 15-17, 2014, Lyon, France.
- [7] M. Shirato, H. Kato, K. Kobayashi, H. Sakazaki. Analysis of thick slurries due to consolidation. *Journal of chemical Engineering of Japan*, 3 (1970) 98.