

# Pressure Filtration of Aqueous Suspension of Nanometer-sized Ceramic Particles

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## 1. Introduction

In a pressure filtration process, analysis of the relationship of consolidation energy-packing density-microstructure is very important. When the relationship is clarified, the forming process of colloidal particles using pressure filtration can be scientifically controlled. This thesis reports the analysis of consolidation process of flocculated and dispersed aqueous suspensions including nanometer-sized particles (24 nm hydroxyapatite, 30 nm SiC, 68 nm Yttria-stabilized zirconia (YSZ), 150 nm Al<sub>2</sub>O<sub>3</sub> and 800 nm SiC) using newly developed pressure filtration apparatus.

In the analysis of the experiments, we found that the established filtration theory could not explain the experimental results. In order to clarify this deviation, a newly developed filtration model was constructed for a flocculated suspension. This theory was compared with the pressure filtration results at a constant compressive rate and constant pressure.

## 2. Results and Discussion

The pressure and energy required to consolidate an aqueous suspension of nanometer-sized colloidal particles were continuously measured using a developed pressure filtration apparatus. The calculated interaction energy of 30 nm particles decreases to 1/100 of the interaction energy of 800 nm particles. The packing characteristic of colloidal particles larger than 150 nm is greatly influenced by the surface charge. The surface charge of the colloidal particles smaller than about 70 nm does not affect the packing density. The consolidation energy ( $E_c$ ) for 1 cm<sup>3</sup> particles increased as the particle size decreased and was high for highly dispersed particles than for flocculated particles. The ratio of energy ( $W$ ) applied between two particles during consolidation to the interaction energy ( $E_i$ )

between highly charged two particles in a suspension was calculated to be in the range from  $10^3$  to  $10^5$ . This ratio is greatly influenced by particle size. The low packing density of 20-30 nm particles was improved by steric stabilization with dispersants (phenylalanine, N-lauroylsarcosine and PAA).

The consolidation behavior of nanometer-sized particles was examined using a pressure filtration apparatus at a constant compressive rate and constant pressure. The relation of applied pressure ( $\Delta P_t$ )-volume of dehydrated filtrate ( $V_f$ ) was compared with the established filtration theory for the well dispersed suspension. The theory was effective in the early stage of the filtration but deviation between the experiment and the theory started when  $\Delta P_t$  exceeded a critical pressure ( $\Delta P_{tc}$ ). It was found that this deviation is associated with the phase transition from a dispersed suspension to a flocculated suspension at  $\Delta P_{tc}$ . The factors affecting  $\Delta P_{tc}$  are zeta potential, concentration and size of particles. Based on the colloidal phase transition, a new filtration theory was developed to explain the  $\Delta P_t$ - $h_t$  (height of piston) relation for a flocculated suspension. A good agreement was shown between the developed theory and experimental results.

## 3. Conclusions

The applied pressure and suspension height during consolidation of an aqueous suspension of nanometer-sized particles were continuously recorded using a pressure filtration apparatus. The packing density decreased when particle size was less than 70 nm. The final packing density of 150 - 800 nm particles at 19 MPa was strongly influenced by the surface charge. The low packing density of 20 - 30 nm particles was improved by steric stabilization. Based on the colloidal phase transition, a new filtration theory was developed to explain the  $\Delta P_t$ - $h_t$  (height of piston) relation for a flocculated suspension. A good agreement was shown between the developed theory and experimental results.