STUDY ON PERFORMANCE OF ELECTROKINETIC FILTRATION USING ROTARY DRUM VACUUM FILTER

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It was found in our previous paper that an electrokinetic filtration could considerably increase the filtration flow rate in comparison with that of the conventional filtration, because electrophoresis in the slurry and electroosmosis in the cake were caused by the electric field. This method is especially applicable to the filtration of slurries such as bentonite slurry, which is difficult to filter by mechanical pressure because of gelatinous cake formation. In this experiment, an electrokinetic filter made by modifying an Oliver filter was used and its performance was investigated. Calcium carbonate, white clay and bentonite were used as suspended particles. As a result, it was confirmed that electrokinetic filtration is applicable to practical filtration and that the equation for the electrokinetic filtration proposed in this paper is applicable to the design of a practical filtration process.

Introduction

Recently, the application of interfacial electrokinetic phenomena to filtration has been studied by some investigators. Moulik *et al.*^{3,4)} reported that the filtration rate was enhanced because of decreasing particle deposition on the filter medium in the case of clarifying filtration. A solid-liquid separation process based on crossflow and electrofiltration was investigated by Henry *et al.*²⁾ to prevent deposition of particles on filter medium with a kaolin clay suspension and an oil-in-water emulsion. According to the previous investigation⁷⁾, a batch electrokinetic filtration in which a D. C. electric field was applied to constant-pressure filtration considerably enhanced the filtration flow rate in comparison with that of conventional filtration because electrophoresis occurring in the slurry decreased cake formation and electroosmosis in the filter cake increased the filtration flow rate at the same time. Therefore, this method is expected to be especially applicable to the practical filtration of slurries such as bentonite slurry, which is difficult to filter by mechanical pressure alone because of gelatinous cake formation. In this paper, the performance of electrokinetic filtration is examined in comparison with a conventional vacuum filter with calcium carbonate slurry, white clay slurry and bentonite slurry forming the gelatinous cake. The test filter used in this experi-

ment was a rotary drum vacuum filter, modified by electrical attachments. As a result, it was confirmed that electrokinetic filtration is applicable to industrial operation. An equation for continuous electrokinetic filtration was derived based on the equation for batch electrokinetic filtration, and it was found to be applicable to practical filtration. The relation between filtrate volume and electric power consumption could be represented by an empirical equation similar to that of batch electrokinetic filtration⁷⁾.

1. Equation for Continuous Electrokinetic Filtration

The equation for batch electrokinetic filtration, which has been presented previously and confirmed experimentally⁷⁾, is expressed as follows:

$$dt/dV = (2/K_R)(V + V_0) \quad (1)$$

in which

$$K_R = \frac{2(\Delta P_H + \Delta P_E)A^2}{\mu\alpha\nu}, \quad V_0 = \frac{R_m A}{\alpha\nu}, \quad \nu = \nu_0 \left(\frac{E_{cr} - E}{E_{cr}} \right) \quad (2)$$

Equation (1) is rewritten in terms of filtrate volume per unit filtration area $v = V/A$ and fictitious filtrate volume per unit area $v_0 = V_0/A$ as follows:

$$dt/dv = 2(v + v_0)/k_R \quad (3)$$

in which

$$k_R = \frac{K_R}{A^2} = \frac{2(\Delta P_H + \Delta P_E)}{\mu\alpha\nu}, \quad v_0 = \frac{R_m}{\alpha\nu} \quad (4)$$

In continuous filtration with a rotary drum filter, the

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filtration time t at which the appointed unit filtration area rotates i times is i/N when N is the number of revolutions per unit time. Therefore, the real filtration time $t_r = tF = F(i/N)$ where F is the submergence ratio of drum filter. It is assumed here that the cake formed on the rotary drum filter is scraped off every i -th revolution and that the filtration resistance of the filter cake on the filter surface does not change whether the filter surface is immersed or not. Integrating Eq. (3) under conditions that $v=0$ at $t=0$ and $v=v$ at $t=t_r$, the relationship between v and t_r in electrokinetic filtration for each i revolutions is obtained under conditions of constant filtration pressure and constant strength of electric field as follows^{1,6)}:

$$\frac{t_r}{v} = \frac{F(i/N)}{v} = \frac{v + 2v_0}{k_R} \quad (5)$$

The equation for the filtration flow rate is given by Eqs. (3) and (5) as follows:

$$\frac{dv}{dt} = \frac{k_R}{2\sqrt{k_R F(i/N) + v_0^2}} \quad (6)$$

Although the filtrate flow through the cake formed on the surface of a rotary drum filter is not precisely one-dimensional, it may be considered to be one-dimensional when the thickness of the filter cake is negligibly small compared with the diameter of the drum filter⁵⁾.

2. Experimental Apparatus and Procedure

The outline of the experimental apparatus and the detailed diagram of the rotary drum filter are shown in Figs. 1 and 2, respectively. The filter is an acrylic resin cylinder with a diameter of 340 mm, a length of 120 mm and an effective filtration area of 1180 cm². The number of filter chambers is 16 and the filtration is carried out in four of them, i. e. $F=0.25$. Filtrate in the filter chamber is discharged through the holes bored in rotary valve ① and fixed valve ⑧ in Fig. 2. The filter paper used as the filter medium is Toyo-Roshi No. 131 or No. 405 (ζ -potential is negative). The electrode inside the filter paper and the electrode in the slurry are copper or stainless steel gauze with an opening of 1 mm, and the distance between the two electrodes is 3 cm. The filter chambers are evacuated by hand aspirator (As) and the filtration pressure ΔP_H is kept constant at 10 cm Hg (1.33×10^4 N/m²) or 20 cm Hg (2.67×10^4 N/m²) by the regulating valve (Rv). Slurry is fed from the head tank ⑨ to the slurry tank ⑦ and the submergence ratio of the drum filter is kept constant by overflowing the slurry. N is 1.04 ($\pm 1.0\%$) r.p.m. (the tangential speed is 1.86 cm/s). The filtration time is measured for every constant filtrate volume of 300 cm³ for calcium carbonate slurry, 120 cm³ for white clay slurry and 40 cm³ for bentonite slurry. Temperature changes of both filtrate and slurry with time are measured by the thermistor

Fig. 1 Outline of experimental apparatus for continuous electrokinetic filtration

Fig. 2 Detailed diagram of rotary drum filter

thermometer (T) and the specific conductivity of the filtrate is measured by the conduct meter (C). These values and the value of the electric current are recorded by two recorders (RE). Slurry is gently agitated by the reciprocal agitator so as not to settle. Calcium carbonate (density $\rho_p=2.67$ g/cm³, median diameter $d_{pm}=5 \mu\text{m}$ and positive ζ -potential), white clay ($\rho_p=2.72$ g/cm³, $d_{pm}=2 \mu\text{m}$ and negative ζ -potential) and bentonite ($\rho_p=2.48$ g/cm³, $d_{pm}<1 \mu\text{m}$ and negative ζ -potential) are dispersed in city water as suspended particles. The average concentrations of these slurries s_{av} are 0.0529 ($\pm 16\%$) for calcium carbonate, 0.0544 ($\pm 12\%$) for white clay and 0.0506 ($\pm 3.0\%$) g-solid/g-slurry for bentonite, respectively. The polarity of both electrodes is determined in consideration of the polarity of ζ -potential of particles in

Fig. 3 Relation between $(i/v)_{20}$ and v with strength of electric field as parameter for CaCO_3 slurry

Fig. 4 Relation between $(i/v)_{20}$ and v with strength of electric field as parameter for white clay slurry

order that cake formation may be decreased by electrophoresis in the slurry and the filtrate flow rate may be increased by electroosmosis in the cake. The filter cake is not scraped off during the experiment. After the experiment, sample cake is collected from the cake on the filter medium in order to measure the mass of cake solid per unit filtrate volume v .

To obtain the values of the average specific filtration resistance α and the electroosmotic filtration pressure ΔP_E , another experiment of continuous electrokinetic filtration was performed under the same conditions. The filtration was continued under the filtration pressure ΔP_H alone, after the electric field was cut off in the course of electrokinetic filtration. In the filtration under ΔP_H , k_R is got from the experi-

Fig. 5 Relation between $(i/v)_{20}$ and v with strength of electric field as parameter for bentonite slurry

mental relation between $(i/v)_{20}$ and v , and α is obtained by the following equation.

$$\alpha = 2\Delta P_H / (k_R \cdot \mu_{20} \cdot v^*) \quad (7)$$

By substituting α , ΔP_H and k_R obtained from the electrokinetic filtration into the following equation,

$$\Delta P_E = k_R \cdot \mu_{20} \cdot v^* \cdot \alpha / 2 - \Delta P_H \quad (8)$$

ΔP_E is estimated assuming that the respective values of α in the former and the latter experiments are equal and constant. In Eqs. (7) and (8), v^* at a given value of E is calculated by the linear equation fitted to the observed values of v and E by the method of least square.

3. Experimental Results and Discussion

Figures 3, 4 and 5 show the experimental results of the relation between $(i/v)_{20}$ corrected at 20°C and v with the strength of electric field as parameter for calcium carbonate, white clay and bentonite slurries, respectively. The relations between $(i/v)_{20}$ and v are approximately linear for these slurries and each strength of electric field, and it is confirmed that Eq. (5) is practically usable except for the later period of filtration for each slurry and the case at $E=0$ for bentonite slurry, as shown in these figures. The values of k_R and v_0 obtained at 20°C for each slurry are listed in Tables 1, 2 and 3 together with the observed values of v and other important factors. It is considered that the deviation from the straight line occurred in the later period of filtration because some amount of cake formed on the filter medium was washed off while the

Table 1 Characteristics of electrokinetic filtration for calcium carbonate slurry

E [V/cm]	k_R [m ² /s]	$(s_{av}=0.0529, \Delta P_H=1.33 \times 10^4 \text{ N/m}^2, F=0.25)$				
		v_0 [m]	ν [g-dry cake] [cm ³ -filtrate]	m [g-wet cake] [g-dry cake]	$(\Delta P_H + \Delta P_E)/\alpha$ [(N/m ²)/(m/kg)]	α [m/kg]
0	1.53×10^{-5}	6.75×10^{-5}	0.0278	1.44	2.14×10^{-7}	6.37×10^{10}
0	1.36×10^{-5}	6.31×10^{-5}	0.0242	1.45	1.65×10^{-7}	8.23×10^{10}
10	1.58×10^{-5}	9.37×10^{-5}	0.0236	1.44	1.88×10^{-7}	
20	1.64×10^{-5}	14.5×10^{-5}	0.0232	1.43	1.92×10^{-7}	
20	1.76×10^{-5}	11.3×10^{-5}	0.0222	1.44	1.96×10^{-7}	
30	2.01×10^{-5}	13.9×10^{-5}	0.0230	1.43	2.32×10^{-7}	
40	2.21×10^{-5}	14.2×10^{-5}	0.0205	1.43	2.28×10^{-7}	

Table 2 Characteristics of electrokinetic filtration for white clay slurry

E [V/cm]	k_R [m ² /s]	v_0 [m]	$(s_{av}=0.0544, \Delta P_H=1.33 \times 10^4 \text{ N/m}^2, F=0.25)$					$\kappa \times 10^8$ [1/ $\Omega \cdot \text{cm}$]	
			ν [g-dry cake] [cm ³ -filtrate]	m [g-wet cake] [g-dry cake]	$(\Delta P_H + \Delta P_E)/\alpha$ [(N/m ²)] [(m/kg)]	α [m/kg]		values at $V=0 \text{ cm}^3$	values at $V=3000 \text{ cm}^3$
0	0.425×10^{-6}	0.11×10^{-5}	0.0402	2.08	0.859×10^{-8}	1.55×10^{12}		1.51×10^2	2.98×10^2
2.5	0.638×10^{-6}	0.31×10^{-5}	0.0312	1.98	1.00×10^{-8}			1.72×10^2	6.80×10^2
5	0.960×10^{-6}	0.50×10^{-5}	0.0224	2.56	1.08×10^{-8}			1.55×10^2	1.27×10^3
7.5	1.88×10^{-6}	1.2×10^{-5}	0.0171	2.13	1.62×10^{-8}			1.12×10^2	1.63×10^3
10	1.69×10^{-6}	0.75×10^{-5}	0.0103	2.14	0.952×10^{-8}			1.90×10^2	1.63×10^3
12.5	2.36×10^{-6}	1.2×10^{-5}	0.0101	2.11	1.20×10^{-8}			1.47×10^2	1.83×10^3

Table 3 Characteristics of electrokinetic filtration for bentonite slurry

E [V/cm]	k_R [m ² /s]	v_0 [m]	$(s_{av}=0.0506, \Delta P_H=2.67 \times 10^4 \text{ N/m}^2, F=0.25)$			$\kappa \times 10^6$ [1/ $\Omega \cdot \text{cm}$]	
			ν [g-dry cake] [cm ³ -filtrate]	m [g-wet cake] [g-dry cake]		values at $V=0 \text{ cm}^3$	values at $V=1000 \text{ cm}^3$
0			0.0276	6.66		1.33×10^2	3.78×10^2
1	0.723×10^{-7}	3.2×10^{-5}	0.0180	6.27		1.49×10^2	5.73×10^2
2.5	1.15×10^{-7}	6.2×10^{-4}				1.41×10^2	1.45×10^3
5	2.43×10^{-7}	1.2×10^{-3}				1.38×10^2	1.72×10^3
7.5	3.70×10^{-7}	1.1×10^{-3}				1.45×10^2	1.80×10^3
10	7.22×10^{-7}	3.9×10^{-3}				1.42×10^2	2.09×10^3

filter surface was rotating in the slurry, since the structure of cake became loose owing to electric force acting on the particles.

At $E=0$ for bentonite slurry as shown in Fig. 5, Ruth's filtration coefficient k_R decreases as cake thickness increases, because the cake formed becomes gelatinous with time and the filtration resistance increases remarkably. It was found that cakes were scarcely deposited on the filter surface with increase of E , and the scraping of cake was impossible at more than $E=2.5$ V/cm. At more than $E=2.5$ V/cm, the electric charge of bentonite particles was discharged at the anode and the particles adhered to the slurry-side electrode (anode) and the thickness of adherent particles was 0.8 to 1.2 cm, but the slurry concentration almost never changed during the filtration.

According to Tables 1, 2 and 3, for example, the value of k_R at $E=40$ V/cm is 1.6 times as large as that of k_R at $E=0$ V/cm for CaCO_3 slurry, k_R at $E=12.5$ V/cm is 5.6 times as large as k_R at $E=0$ for white clay slurry, and k_R at $E=10$ V/cm is 10 times as large as k_R at $E=1$ V/cm for bentonite slurry. As described fully in **Appendix**, the estimated values of the dry

cake formation rate per unit filtration area, dw/dt , in continuous electrokinetic filtration in which the cake formed is scraped off every revolution are almost the same or are smaller by a maximum of 50% as compared with that at $E=0$. On the other hand the value of the filtration flow rate dv/dt is a maximum of 2.4 times as large as that at $E=0$ in these experiments. Therefore, it is found that the effect of the electric field on filtration flow rate is remarkable and that electrokinetic filtration is usable for slurries suspended with fine particles and for the slurry forming gelatinous cake. It was observed that the suspended particles of calcium carbonate were more coagulated with increase of E .

Figure 6 shows the relation between $(\Delta P_H + \Delta P_E)/\alpha$ and E and the relation between values of ν and E for CaCO_3 slurry, which are listed in Table 1. **Figure 7** shows the relation between values of ν and E for white clay slurry, which are listed in Table 2. According to Figs. 6 and 7, relations between ν and E for both CaCO_3 and white clay slurries are linear and can be represented by the equation $\nu = \nu_0(1 - E/E_{cr})^{\gamma}$. The linear equations obtained by the method of least

Fig. 6 Relations between $(\Delta P_H + \Delta P_E)/\alpha$ and E and between ν and E for CaCO_3 slurry

Fig. 7 Relation between ν and E for white clay slurry

Fig. 8 Experimental results of electrokinetic filtration and successive constant hydraulic pressure filtration for CaCO_3 slurry

square, shown as the lines in Figs. 6 and 7, are expressed by the following experimental formula:

$$\nu = 0.0244(1 - E/305), E_{cr} = 305 \text{ V/cm} \quad \text{for } \text{CaCO}_3 \text{ slurry}$$

$$\nu = 0.0375(1 - E/15.0), E_{cr} = 15.0 \text{ V/cm} \quad \text{for white clay slurry}$$

Figure 8 shows the relation between $(i/v)_{20}$ and v for the electrokinetic filtration and the successive constant hydraulic pressure filtration in order to evaluate the values of the electrokinetic filtration pressure ΔP_E and

Fig. 9 Relations between V and W_p with strength of electric field as parameter for white clay slurry

Fig. 10 Changes in a and n in empirical equation of $V = a \cdot W_p^n$ owing to E for white clay slurry

the average specific filtration resistance α in the electrokinetic filtration for the slurry of CaCO_3 . The obtained characteristics of electrokinetic filtration are listed in Table 4. In the relation between α and E for batch electrokinetic filtration, α decreases as E increases⁷⁾, but in this experiment the correlation between α and E is not clear. In the relation between ΔP_E and E for batch electrokinetic filtration, ΔP_E is proportional to E^2 . In this experiment ΔP_E increases as E increases, but ΔP_E is not directly proportional to E .

Figure 9 shows the relation between V and the electric power consumption W_p with E as parameter for white clay slurry. According to Fig. 9, the relationship between V and W_p for each value of E can be represented by the empirical equation $V = a \cdot W_p^n$, similarly to batch electrokinetic filtration⁷⁾, in which a and n are experimental constants. Similar empirical equations are obtained for CaCO_3 slurry and bentonite slurry. Table 5 shows the observed values of a and n for each slurry and for each value of E . Figure 10 shows, as an example, plots of a and n against E for

Table 4 Characteristics of electrokinetic filtration for calcium carbonate slurry

$(s_{av}=0.0537, \Delta P_H=1.33 \times 10^4 \text{ N/m}^2, F=0.25)$								
E	k_R	v_0	k_{R0}	ν^*	$(\Delta P_H + \Delta P_E)/\alpha$	$\Delta P_H/\alpha$	α	ΔP_E
[V/cm]	[m ² /s]	[m]	[m ² /s]	[g-dry cake cm ³ -filtrate]	[$\frac{\text{N}}{\text{m}^2}$] [m/kg]	[$\frac{\text{N}}{\text{m}^2}$] [m/kg]	[m/kg]	[N/m ²]
0	1.36×10^{-5}	6.31×10^{-5}	1.36×10^{-5}	0.0244	1.65×10^{-7}	1.65×10^{-7}	8.23×10^{10}	0
10	1.49×10^{-5}	11.2×10^{-5}	1.39×10^{-5}	0.0236	1.77×10^{-7}	1.70×10^{-7}	7.84×10^{10}	5.5×10^2
20	1.60×10^{-5}	10.6×10^{-5}	1.42×10^{-5}	0.0228	1.83×10^{-7}	1.74×10^{-7}	7.66×10^{10}	7.0×10^2
30	1.46×10^{-5}	9.84×10^{-5}	1.17×10^{-5}	0.0220	1.61×10^{-7}	1.44×10^{-7}	9.28×10^{10}	16.3×10^2
40	1.76×10^{-5}	7.70×10^{-5}	1.17×10^{-5}	0.0212	1.88×10^{-7}	1.43×10^{-7}	9.29×10^{10}	41.2×10^2

Table 5 Values of a and n in $V=a \cdot W_p^n$

$\text{CaCO}_3 (s_{av}=0.0529)$			$(V \text{ expressed in cm}^3 \text{ and } W_p \text{ in watt-hr})$			$\text{Bentonite } (s_{av}=0.0506)$		
E	a	n	E	a	n	E	a	n
[V/cm]	[cm ³]	[—]	[V/cm]	[cm ³]	[—]	[V/cm]	[cm ³]	[—]
10	1710	0.675	2.5	1650	0.598	1	1270	0.512
20	636	0.734	5	689	0.644	2.5	397	0.563
20	513	0.767	7.5	393	0.706	5	222	0.606
30	310	0.814	10	278	0.734	7.5	162	0.610
40	153	0.873	12.5	183	0.762	10	89.7	0.697

white clay slurry. According to Fig. 10, n increases linearly and a decreases like a hyperbolic curve as E increases. The correlation between n and E and the correlation between a and E for other slurries are similar to those for white clay slurry.

The specific electric conductivity κ of filtrate of CaCO_3 slurry increased by 20% compared with that of city water used in this experiment, but κ of filtrate of white clay and bentonite slurries increased by 2–15 times that of city water with increase of E as shown in Tables 2 and 3. These results correspond with the fact that electrokinetic filtration of slurry having higher specific electric conductivity consumes more electric power. For example, the values of W_p required to obtain a filtrate volume of 1000 cm³ at $E=10$ V/cm were 0.46 watt-hour for CaCO_3 , 5.8 for white clay and 32 for bentonite, respectively.

Conclusion

In this study on continuous electrokinetic filtration with a modified rotary drum vacuum filter of the Oliver type, the following results have been confirmed.

1) The fundamental equation for electrokinetic filtration with the rotary vacuum filter, taking account of electrophoresis and electroosmosis, is represented by Eq. (3) and is of the same form as Ruth's equation for constant-pressure filtration. But Ruth's coefficient k_R of electrokinetic filtration is not only a function of ΔP_H but also a function of the electric field. The equation for electrokinetic filtration using a rotary drum vacuum filter is given by Eq. (5).

2) Electrokinetic filtration is usable to increase the filtration flow rate for slurries such as bentonite, which is difficult to filter mechanically because of gelatinous cake formation and an electrokinetic filter made by modifying a filter of the Oliver type is one type of

practical equipment.

3) The relation between filtrate volume V and electric power consumption W_p in continuous electrokinetic filtration is represented by the empirical equation $V=a \cdot W_p^n$, similar to that of batch electrokinetic filtration, in which a and n are experimental constants depending on the kind of slurry and are functions of E .

Appendix: Estimated values of dv/dt and dw/dt in continuous electrokinetic filtration

The filtration flow rate dv/dt and the dry cake formation rate dw/dt per unit filtration area in continuous electrokinetic filtration in which the cake formed is scraped off every revolution are shown in Table A-1. These values in Table A-1 were calculated by Eq. (6) in the case of $i=1$, $F=0.25$ and $N=1.04$ rpm. According to Table A-1, in the case of calcium carbonate slurry, the values of dw/dt are almost the same or are smaller by 14% (maximum) as compared with that at $E=0$. On the other hand the value of dv/dt at $E=40$ V/cm is larger than that at $E=0$ by 27% (maximum). In the case of white clay slurry, the values of dw/dt in the range of $E=2.5$ – 7.5 V/cm are almost the same as that at $E=0$, or dw/dt at $E=10$ V/cm is smaller than that at $E=0$ by 50% (maximum), but the value of dv/dt at $E=12.5$ V/cm is 2.4 times that at $E=0$. For bentonite slurry, the values of dw/dt cannot be compared because of small cake formation, but the value of dv/dt at $E=10$ V/cm is about twice that at $E=0$.

$dw/dt=\nu(dv/dt)$ is calculated by Eq. (A-1), substituting Eq. (4) into Eq. (6) and neglecting the filter medium resistance.

$$\frac{dw}{dt} = \sqrt{\frac{(\Delta P_H + \Delta P_E)\nu \cdot N}{2\mu\alpha} \cdot F} \quad (\text{A-1})$$

According to the authors' investigation⁷⁾, Tables 1 and 4 and Fig. 6, ΔP_E increases nearly in proportion to E , ν decreases linearly and α decreases hyperbolically with increasing E . Therefore, it does not necessarily follow that the value of dw/dt diminishes theoretically by applying an electric field to constant-pressure filtration.

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Table A-1 Values of dv/dt and dw/dt calculated by Eq. (6) as $i=1$, $F=0.25$ and $N=1.04$ r.p.m.

1) Calcium carbonate slurry						
E	k_R	v_0	ν	dv/dt	dw/dt	
[V/cm]	[m ² /s]	[m]	$\left[\frac{\text{g-dry cake}}{\text{cm}^3\text{-filtrate}}\right]$	[m ³ /m ² ·hr]	[kg/m ² ·hr]	
0	1.53×10^{-5}	6.75×10^{-5}	0.0278	1.85	51.5	
0	1.36×10^{-5}	6.31×10^{-5}	0.0242	1.75	42.3	
10	1.58×10^{-5}	9.37×10^{-5}	0.0236	1.88	44.5	
20	1.64×10^{-5}	14.5×10^{-5}	0.0232	1.92	44.5	
20	1.76×10^{-5}	11.3×10^{-5}	0.0222	1.99	44.1	
30	2.01×10^{-5}	13.9×10^{-5}	0.0230	2.12	48.9	
40	2.21×10^{-5}	14.2×10^{-5}	0.0205	2.23	45.7	
2) White clay slurry						
E	k_R	v_0	ν	dv/dt	dw/dt	
[V/cm]	[m ² /s]	[m]	$\left[\frac{\text{g-dry cake}}{\text{cm}^3\text{-filtrate}}\right]$	[m ³ /m ² ·hr]	[kg/m ² ·hr]	
0	0.425×10^{-6}	0.11×10^{-5}	0.0402	0.309	12.4	
2.5	0.638×10^{-6}	0.31×10^{-5}	0.0312	0.378	11.8	
5	0.960×10^{-6}	0.50×10^{-5}	0.0224	0.464	10.4	
7.5	1.88×10^{-6}	1.2×10^{-5}	0.0171	0.650	11.1	
10	1.69×10^{-6}	0.75×10^{-5}	0.0103	0.616	6.35	
12.5	2.36×10^{-6}	1.2×10^{-5}	0.0101	0.728	7.35	
3) Bentonite slurry						
E	k_R	v_0	ν	dv/dt	dw/dt	
[V/cm]	[m ² /s]	[m]	$\left[\frac{\text{g-dry cake}}{\text{cm}^3\text{-filtrate}}\right]$	[m ³ /m ² ·hr]	[kg/m ² ·hr]	
0			0.0276			
1	0.723×10^{-7}	3.2×10^{-5}	0.0180	0.127	2.29	
2.5	1.15×10^{-7}	6.2×10^{-4}		0.145		
5	2.43×10^{-7}	1.2×10^{-3}		0.197		
7.5	3.70×10^{-7}	1.1×10^{-3}		0.260		
10	7.22×10^{-7}	3.9×10^{-3}		0.257		

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Nomenclature

A	= filtration area	[cm ²]
a	= experimental constant	[cm ³]
d_{pm}	= median diameter of particles in slurry	[μm]
E	= strength of electric field	[V/cm]
E_{cr}	= critical strength of electric field	[V/cm]
F	= submergence ratio of drum filter	[—]
i	= number of revolution	[—]
K_R	= modified Ruth's filtration coefficient	[m ² /s]
k_R	= modified Ruth's filtration coefficient divided by square of filtration area	[m ² /s]
k_{R0}	= value of k_R after cutting off electric field in experiment made for evaluation of α and ΔP_E	[m ² /s]
L_E	= distance between electrodes	[cm]
m	= ratio of mass of wet to dry cake	[—]
N	= revolutions per unit time	[1/s] or [1/min]
n	= experimental constant	[—]
ΔP_E	= electroosmotic filtration pressure	[N/m ²]
ΔP_H	= hydraulic filtration pressure	[cm Hg] or [N/m ²]
R_m	= filter medium resistance	[1/m]
s_{av}	= average slurry concentration	[g-solid/g-slurry]
t	= filtration time	[s]
t_r	= real filtration time in continuous filtration	[s]
V	= filtrate volume	[m ³]
V_0	= fictitious filtrate volume	[m ³]
v	= filtrate volume per unit filtration area	[m]
v_0	= fictitious filtrate volume per unit filtration	

W_p	= area	[m]
w	= electric power consumption	[watt-hr]
	= dry cake mass per unit filtration area	[kg/m ²]
α	= average specific filtration resistance	[m/kg]
ζ	= ζ -potential of particles	[V]
κ	= specific electric conductivity	[1/Ω·cm]
μ	= viscosity of filtrate	[kg/m·s]
ν	= dry cake mass per unit volume of filtrate in electrokinetic filtration	[g-solid/cm ³ -filtrate]
ν_0	= ν in the absence of electric field	[g-solid/cm ³ -filtrate]
ν^*	= value of ν fitted by method of least square	[g-solid/cm ³ -filtrate]
ρ_p	= density of solid particles	[g/cm ³]

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