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Development of a high-performance cake-less continuous filtration system

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ABSTRACT

A new cake-less continuous filtration system with a rotating disk filter and slurry prepared in a well-dispersed state is discussed in this paper. It is expected that the new system can concentrate a feed suspension much more than traditional filtration systems and that the concentrate can be discharged by the filtration pressure without a scraping device. We tried to filter some difficult to filter materials such as sericite, hydrolyzed cellulose, pulp wastewater and algal suspension. Concentrated slurries of sericite and hydrolyzed cellulose were discharged at the 35 vol% and 12 mass%, respectively. The algal suspension and the pulp wastewater were concentrated up to 8 times more than the concentration of feed suspensions. The concentrates of every sample retained fluidity and flowed out of the new system by way of the filtration pressure.

In this system, it was shown that the filtration flux increased with the rotation speed. At lower rotation speeds, the filtration flux was independent of pressure. Conversely at higher rotation speeds, the filtration flux increased along with the pressure. This dependency was clearer in the case of the large disk than when the small disk was used. We also proposed a model for a sweeping mechanism in this system which is explained in the above results.

1. Introduction

The filtration technique known as cake filtration is widely used in industry to separate solid particles from liquids. In cake filtration, the filter cake grows continuously on the filter media and the filtration flux gradually decreases because of increasing cake resistance. In order to reduce this resistance, flocculants are usually added. By adding flocculants, the flow rate of liquid through the cake is made to increase (Nguyen and Ripperger, 2002; Fuchs et al., 2006; Manttari et al., 1996). However, the packing fraction of the cake is also reduced. The cake contains a lot of water, and therefore, more time and money are spent on drying it after filtration. Another weak point is that the system needs to scrape the cake from the filter media, which has to be done by a batch process.

In order to operate the filtration continuously, dynamic filtration with a high-shear-rate filtration system, such as rotating disk filtration, has been studied in several recent papers (Koch et al., 2002; Jaffrin et al., 2004; Tanida, 2003; Shirato et al., 1987; Ding et al., 2006; Bott et al., 2000; Bouzerar et al., 2003; Pessoa Jr and Vitolo, 1998). In rotating disk filtration, the concentrate is continuously swept by high-shear fluid flow between the rotating filter disks and baffles or scraping devices. This fluid flow created by the relative motion between the filter and its housing, as well as high-shear rates, are necessary to sweep the cake continuously from the filter media, and these systems therefore require much more energy.

However, it seems that if the concentrate retains fluidity, then filtration can be continued using less energy because the concentrate can be discharged without a scraping device. We have developed two evaluation techniques for slurry characterization: hydrostatic pressure measurement (Tsubaki et al., 2003a; Mori et al., 2004, 2006) and constant pressure filtration (Tsubaki et al., 2003b; Kim et al., 2005; Mori et al., 2006). Using the hydrostatic pressure type, it was shown that the particles in well-dispersed alumina slurry had fluidity even if the slurry concentration reached approximately 40 vol%. Thus, we developed a new filtration technique using the addition of dispersants instead of flocculants (Tsubaki et al., 2006). In this paper, we compared the filtration behavior of flocculated and dispersed slurries of alumina particles in gravity filtration. In gravity filtration of the dispersed slurry, we were able to collect a high-concentration slurry without a scraping device; however, the filtration flux was not high. Thus, we tried to increase the filtration flux by pressure filtration. Although the filtration flux increased in the early stages,

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the particles clogged the filter and filtration ultimately stopped because the discharge rate of the concentrate was not balanced with the filtration rate.

From these results, we have been developing a new rotating disk filtration, in which the filtration rate and the discharge rate are independently controlled by the filtration pressure and rotation speed of the disk filter. The slurry is concentrated on the rotating filter disk and discharged by filtration pressure alone, without a scraping device.

In this study, we tried to filter some difficult to filter materials using this new filtration system. Difficult to filter materials such as sericite, hydrolyzed cellulose suspensions, pulp wastewater and algal suspension are investigated in the presented paper.

Furthermore we investigated the effects of the filter diameter, filtration pressure and rotation speed on the filtration flux. In addition we also propose a model to explain the filtration mechanism in this system. Moreover, it is also important to investigate the effect of the slurry concentration on the filtration behavior; therefore, filtration tests at both low and high-concentration levels were carried out.

2. Experiments

2.1. Filtration units

A schematic diagram of the filtration system is given in Fig. 1. The sample slurry was fed into the vessel using a pump. The slurry was concentrated on the filter media and the concentrate was swept by the centrifugal force of the rotating disk. The rotating disk was 300 mm in outer diameter and 120 mm in inner diameter. The total filtering area was 0.1 m^2. The rotating disk filter consisted of filter papers and sintered polyethylene plates as shown in Fig. 2. Filter paper made by Advantec Japan Co., Ltd., was sandwiched between sintered polyethylene plates manufactured by Mitsubishi Jyushi Co., Ltd., Japan. The pore sizes of the filter paper, the outer and inner plate were 1, 9 and 135 μm, respectively. The disk and shaft assembly were rotated by an electric motor mounted at the bottom of the vessel. Filtrate permeated the rotating filter disk and was collected through the bottom of the hollow shaft. The concentrate and filtrate flowed from each valve, respectively. In this system, the discharge rate of the concentrate and filtration rate can be individually controlled by the rotation speed and pressure.

In addition, the dead-end filtration test was carried out to compare the efficiency of filtration using a dead-end filtration instrument made by Chuokakohki Co., Ltd. Japan, model IKABUST JT-F.

2.2. Experimental procedures

2.2.1. Concentrating of sericite slurry

Sericite powder (10 μm) distributed by Sanshin Mining Ind. Co., Ltd., Japan, and water glass distributed by Kanto Kagaku Co., Ltd., Japan, were used as a sample and dispersant. The sample powder was dispersed in tap water. The additive amount of the dispersant was 0.03 g per 100 g-sericite powder.

At first the vessel was completely filled with the prepared slurry and then filtration test was started by feeding the slurry at an applied pressure of 0.2 MPa. In the concentration test, the outlet valve of the concentrate was closed and the filtrate valve was open in order to concentrate the slurry in the vessel. The concentrate was circulated in the vessel by the centrifugal force of the rotating disk. The filtrate volume was measured as a function of time. The concentration of the concentrate in the vessel was calculated using a mass balance from the filtrate volume, feed concentration and hold-up volume of the vessel. The calculated value was compared with the experimental data measured at the determined filtration time. The initial solid concentration was 1 vol%. The rotation speed was 400 rpm.

For the dead-end filtration, the initial concentration of the prepared slurry was also 1 vol%. The initial slurry volume was 80 mL and the slurry was filtered at a constant pressure of 0.2 MPa. The rate of filtrate expression was measured as a function of time and after filtration the cake thickness was measured in order to calculate the packing fraction of the cake.

In the semi-continuous filtration test, a feed slurry prepared at 20 vol% was concentrated up to 30 vol% by closing the outlet valve of the concentrate and then the valve was opened for the continuous filtration test. In this test, filtration was performed pseudo-continuously because the flow rate of the discharged concentrate was smaller and difficult to keep constant. Since the concentration in the vessel would decrease after discharge, the outlet valve of the

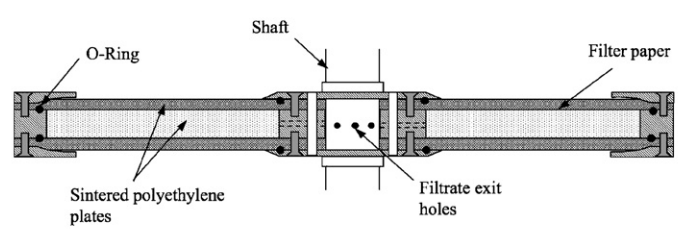

Fig. 2. Detail drawing of rotating disk filter.

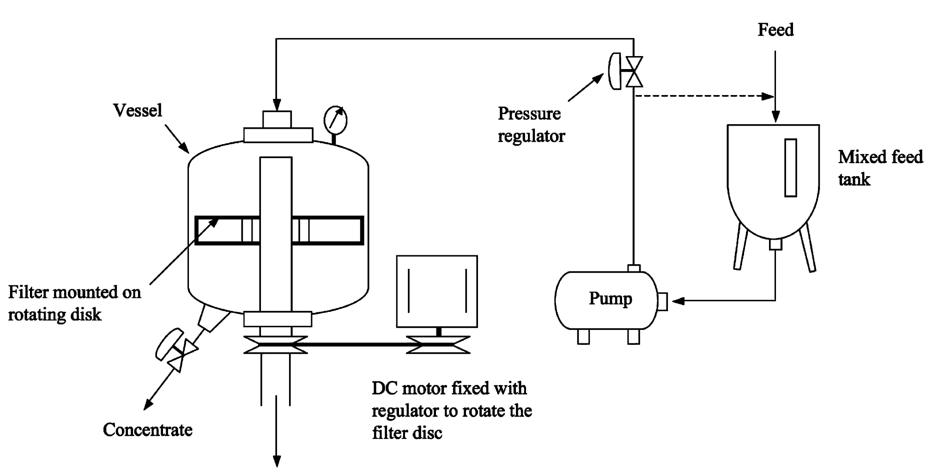

Fig. 1. Schematic diagram of cake-less continuous filtration system.

concentrate had to be closed to concentrate the slurry again up to 30 vol%. The concentrating time was calculated by the following equation:

$$F_{\mathrm{conc.}}(\psi_{\mathrm{conc.}} - \psi_{\mathrm{fd.}}) = t \cdot q \cdot \psi_{\mathrm{fd.}}$$

where $F_{\mathrm{conc.}}$ (kg) is the mass of the discharged concentrate, $\psi_{\mathrm{conc.}}$ (dimensionless) and $\psi_{\mathrm{fd.}}$ (dimensionless) are the mass concentrations of the concentrate and feed slurry, q (kg min^{-1}) is the filtrate flow rate and t (min) is the concentrating time. This procedure (discharge and concentrating) was repeated every 3–4 min. In this test, the filtrate volume was continuously measured with time and the concentration of the concentrate was measured at a given time using a gravimetric method. The calculated concentrate concentration data were compared with the experimental data. The continuous filtration test was carried out at the same pressure and rotation speed as the concentrating test (0.2 MPa, 400 rpm).

2.2.2. Purification of pulp wastewater

In this test, the concentrating limit of pulp wastewater was investigated. The pulp wastewater sample was taken from a river in Kochi prefecture in Japan. Purification was examined at a constant pressure of 0.2 MPa and a rotation speed of 300 rpm. The outlet valve of the concentrate was closed and the pulp wastewater was concentrated in the vessel. The change in the filtrate mass over time was measured and the concentration of the concentrate was calculated from the filtrate volume.

2.2.3. Filtration test of algal suspension

An algal suspension sample was collected from a pond in Osaka prefecture in Japan. The filtration test was carried out at a constant pressure of 0.2 MPa and a rotation speed of 400 rpm. The experimental procedure for this test was the same as that for the purification of pulp wastewater, and filtrate volume was also measured with time. The concentration of the concentrated algae was calculated from the filtrate volume. Additionally, dead-end filtration of the algal suspension was performed in order to compare the filtration efficiencies. The filtration pressure was 0.2 MPa and the initial sample volume was 180 mL.

2.2.4. Concentrating of hydrolyzed cellulose

The hydrolyzed cellulose sample supplied by the Dai-Ichi Kogyo Seiyaku Co., Ltd., Japan, is used in cosmetic products. The initial concentration of the prepared sample slurry was 2.6 mass%. The rotation speed and filtrate pressure were also 400 rpm and 0.2 MPa, respectively. First, the hydrolyzed cellulose was concentrated in the vessel, and we then investigated whether or not the concentrate could be discharged. The filtrate volume was also measured as a function of time and the concentration of the concentrated hydrolyzed cellulose was calculated from the filtrate volume. Usually, the hydrolyzed cellulose slurry contains sulfuric acid because of its synthesis, therefore, we should wash it in order to remove sulfuric acid. Thus the hydrolyzed cellulose is washed with added water and then the water containing the sulfuric acid is eliminated by filtration. This procedure is repeated until the sulfuric acid content has decreased to a sufficiently low level. Therefore, washing of the concentrated cellulose was attempted using this system instead of the conventional process. The cellulose samples were concentrated up to 5.4 vol%, and then the feed was replaced by water and the washing process was initiated. Washing was performed under the same conditions as the concentrating test (0.2 MPa, 400 rpm) and the change in the filtrate over time was measured.

2.2.5. Effects of experimental conditions on filtration flux

The raw material was sericite powder (with an average particle size of 10 μm, Sanshin Mining Ind. Co., Ltd., Japan) and water glass (Kanto Kagaku Co., Ltd., Japan) was used as a dispersant. The sericite powder was added to tap water. The additive amount of dispersant was 0.03 g per 100 g-sericite powder.

The prepared sericite slurries were filtered using small and large disk filters. The solid concentration of the feed slurry was 3 vol% and filtration fluxes were measured under constant concentration conditions. At first, the vessel was filled with sample slurry and then the disk filter was rotated. Filtration was started by applying pressure and feeding water instead of the sample slurry. The concentration in the vessel could be kept constant during filtration because solely water was fed to the vessel and the outlet valve of concentrate was closed for this test. The filtrate volume was measured as a function of time. The rotation speeds and filtration pressures were 100–400 rpm and 0.2–0.4 MPa, respectively.

In addition, the effects of rotation speed and pressure on the filtration flux at a high-concentration level were also investigated. The concentration of the sample slurry was 30 vol%. In this test, it was difficult to prepare a slurry with a concentration of 30 vol% manually; therefore, a feed slurry prepared at 20 vol% was concentrated up to 30 vol% using this filtration system. Then the feed slurry was replaced by water and the filtration experiment was started. The filtrate volume was measured as a function of time at a constant concentration. The filtration tests at a high-concentration level were conducted in the same operating conditions as those at a low concentration level (rotation speeds of 100–400 rpm and filtration pressures of 0.2–0.4 MPa).

3. Results and discussions

3.1. Concentrating of sericite slurry

3.1.1. Concentrating test

The relationship between the filtration flux and volumetric concentration of a concentrate is shown in Fig. 3. The concentrate of 35 vol% had fluidity as shown in Fig. 4 and the filtrate was transparent. The filtration flux decreased gradually while the slurry was being concentrated up to 20 vol%, however, it became almost constant thereafter. At the end of the experiment, no cake was observed on the surface of the filter media, and the concentrate was discharged at a concentration as high as 35 vol%. In this test, we concentrated the slurry up to 35 vol%. However, in the case of dead-end filtration,

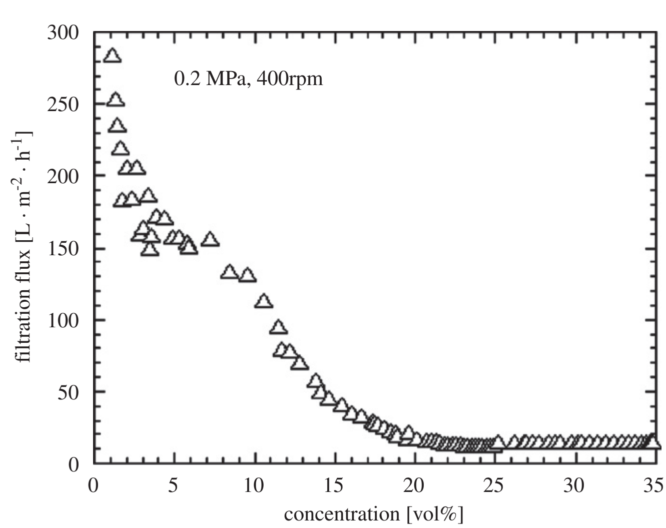

Fig. 3. Relation between filtration flux and volumetric concentration of concentrate of sericite slurry.

Fig. 4. Discharge of the sericite concentrate at the concentration as high as 35 vol%.

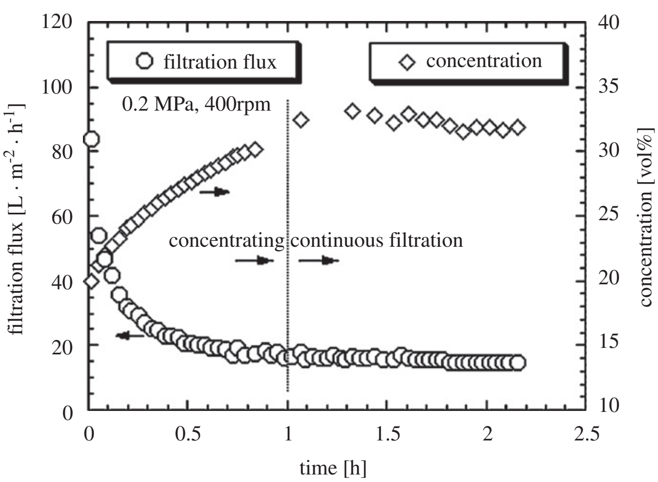

Fig. 5. Continuous filtration test at thehigh-concentration condition.

the packing fraction of the cake was 23 vol%, much lower than that of the concentrated slurry.

3.1.2. Continuous filtration test

Fig. 5 shows the experimental data from the continuous filtration test. Although filtration flux decreased during concentrating, it was almost constant during the continuous filtration test. No cake was observed on the filter surface and filtration resistance was constant during continuous filtration. The concentrate was able to be discharged continuously at concentrations as high as 30 vol%. It is thus confirmed that continuous filtration can be performed under high-concentration conditions using this new filtration system.

3.2. Purification of pulp wastewater

As it was difficult to measure pulp concentration, we evaluated the progress of filtration by the degree of concentration, defined as the concentration ratio of the concentrate to the feed slurry. Filtration flux and concentration degree are plotted in Fig. 6. Filtration flux decreased drastically in the beginning of filtration; however, after about 10 min, the rate of decrease became smaller. The pulp wastewater was concentrated up to 8 times more than was the raw suspension, as shown in Fig. 7a. Fig. 7c shows the discharge.

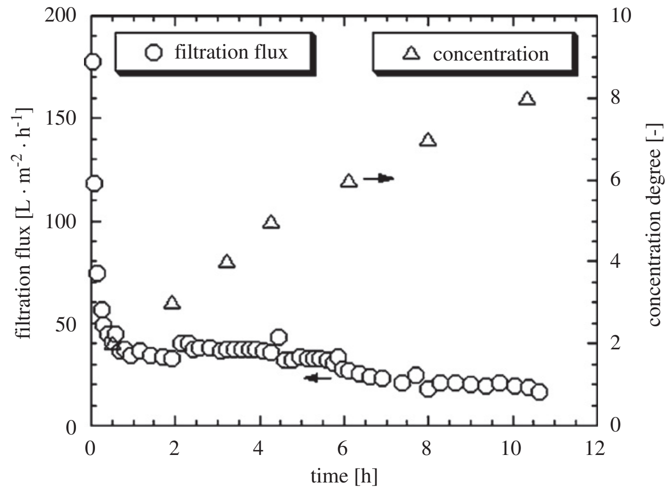

Fig. 6. Filtration flux and concentration degree of pulp wastewater.

Additionally, the filtrate was transparent, as shown in Fig. 7b and no cake was observed on the surface of the filter media after filtration.

3.3. Filtration test of algal suspension

Fig. 8 shows the experimental results of the algal suspension. The algae were concentrated up to 6 times from the feed suspension and the final concentrate was 0.12 mass%. Six times concentration was not the upper limit. If we had had enough volume of algal suspension, the feed suspension might have been much more concentrated. The filtration flux of algal suspension in the new system and that of dead-end filtration are compared in Fig. 9 The new system shows higher filtration flux than the dead-end during filtration. In addition, in the case of dead-end filtration, filtration stopped after about 5 h because of the permeation of particles into the filter and cake formation. The filtration flux of the new system decreased rapidly in the beginning due to particle permeation into the filter media; however, the filtration flux was almost constant thereafter as shown in Fig. 8 because of the lack of cake formation. The important fact is that the permeated particles can be eliminated by an ultrasonic washer and the filtration flux can be recovered completely.

3.4. Concentrating of hydrolyzed cellulose

The changes in the filtration flux over time and the mass concentration of the concentrate are shown in Fig. 10. A feed slurry of 2.6 mass% was concentrated to 12 mass% and discharged. The discharged concentrate shown in Fig. 11b had fluidity and the filtrate was transparent as shown in Fig. 11a. After filtration, no cake was observed on the filter media. As shown in Fig. 12, filtration flux did not decrease during washing and no cake was observed on the filter media after washing. Usually, the sulfuric acid is eliminated by a batch process as explained in Section 2.2.4; therefore, manpower is needed and the product might become contaminated. On the contrary the new filtration system can rinse the sulfuric acid continuously through a single path. It can be said that the new filtration system has the potential to shorten the washing process, reduce energy consumption and prevent contamination.

3.5. Comparison of the filtration performance of hardly filterable materials

The initial concentrations of the sample slurries other than sericite and hydrolyzed cellulose were not determined in this study,

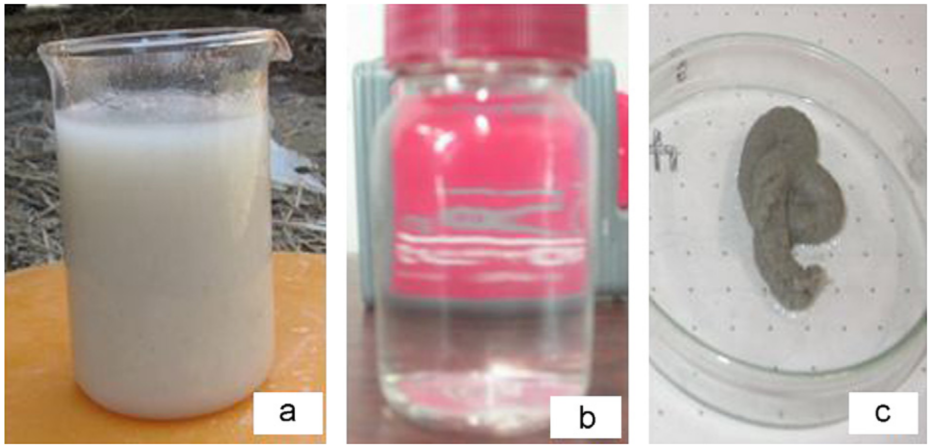

Fig. 7. Raw suspension (a), filtrate (b) and concentrate (c) of pulp wastewater purification.

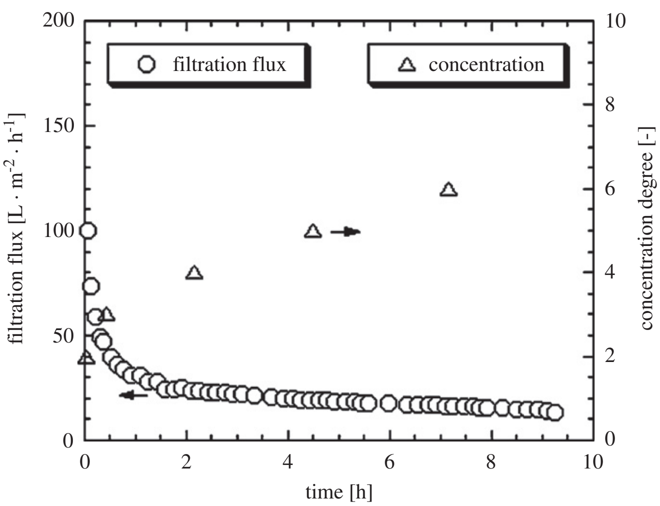

Fig. 8. Filtration flux and concentration degree of algal suspension.

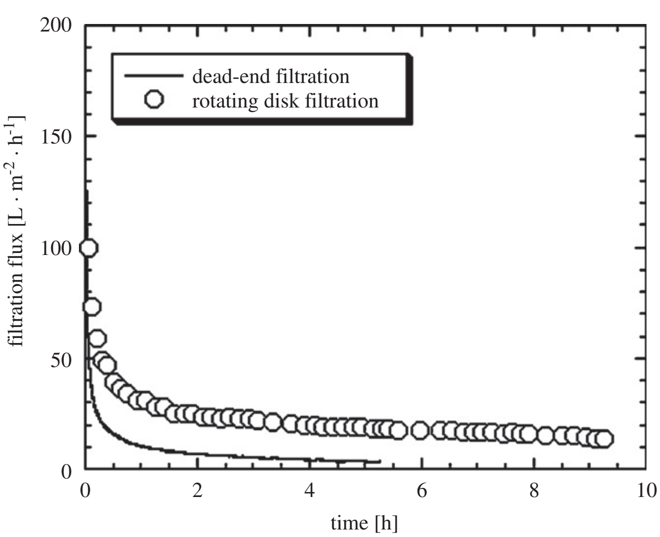

Fig. 9. Comparison between rotating disk filtration and dead-end filtration test of algal suspension.

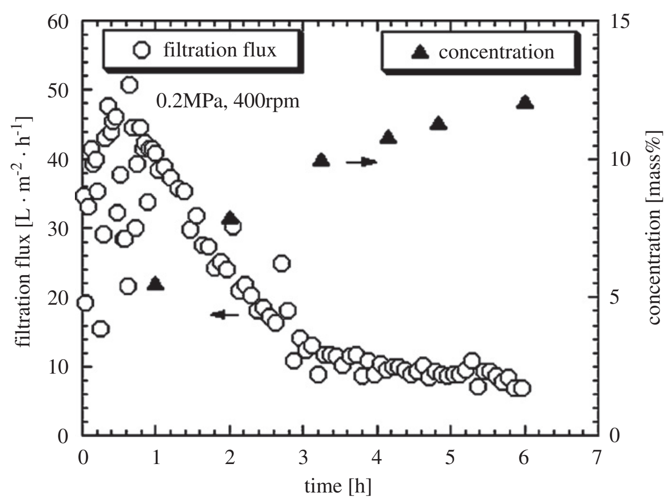

Fig. 10. Filtration flux and concentrate concentration of hydrolyzed cellulose.

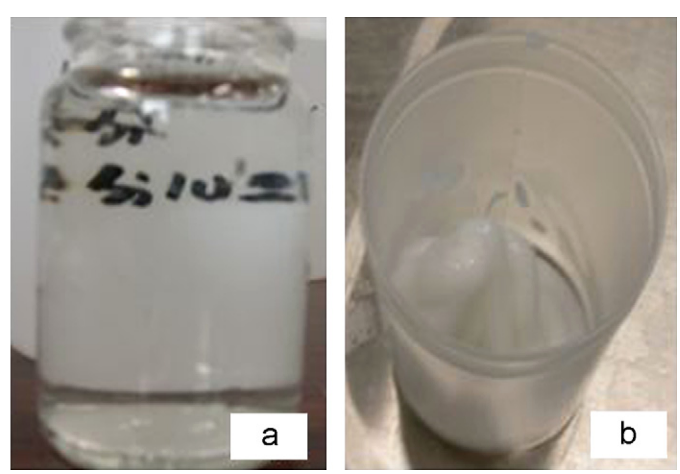

Fig. 11. Filtrate (a) and concentrate (b) of hydrolyzed cellulose filtration.

so it is difficult to compare the filtration results in detail. Here, we took the relationship between the degree of concentration and filtration flux shown in Fig. 13 The sericite slurry was filtered better than the other samples, and filtration flux hardly decreased with

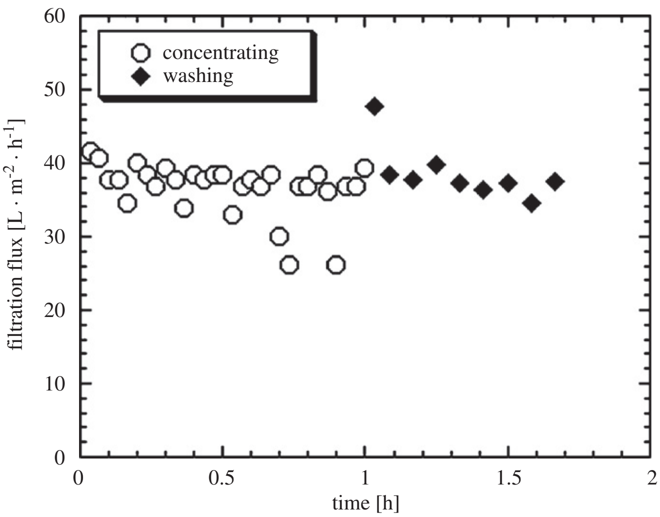

Fig. 12. Time changes of the filtration flux during washing of hydrolyzed cellulose.

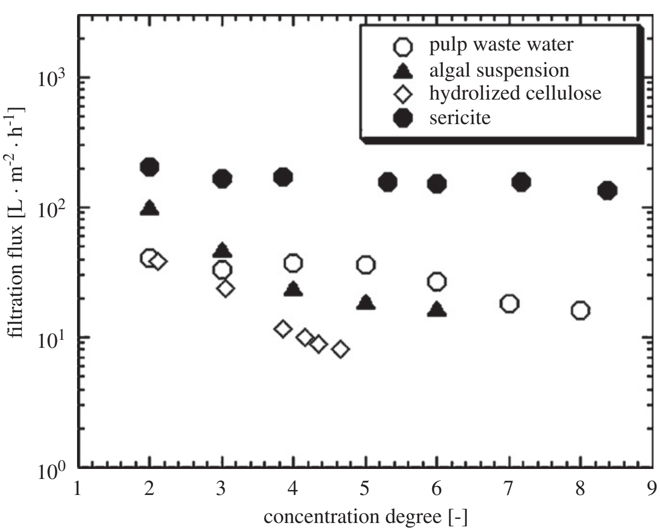

Fig. 13. Relation between filtration flux and concentration degree of hardly filterable materials.

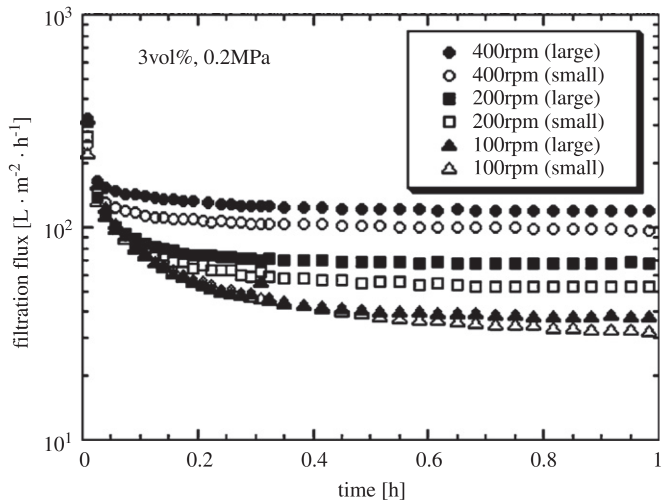

Fig. 14. Variation of filtration flux with time for two sizes of disks at various rotation speeds.

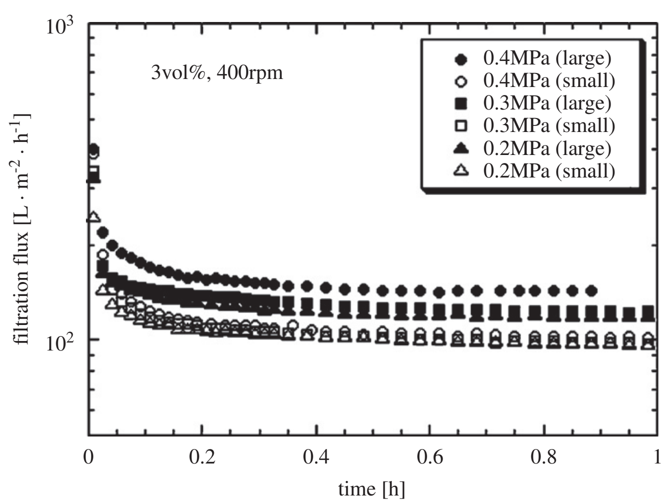

Fig. 15. Variation of filtration flux with time for two sizes of disks at various filtration pressures.

the degree of concentration. This may be because the morphology of the sericite particles is much simpler than that of the other samples. The particles in the pulp wastewater and the hydrolyzed cellulose are long fibrous particles. This may explain why its filtration flux is lower than that of the sericite. The algae, which were a plant, had a relatively low filtration flux, which decreased clearly with the degree of concentration; however, the filtrate flux was easily recovered using an ultrasonic washer.

3.6. Effects of experimental conditions on filtration flux

3.6.1. Effect of filter diameter on filtration flux in low slurry concentration (3 vol%)

Fig. 14 shows the time changes of the filtration flux at various rotation speeds (100, 200 and 400 rpm) at the pressure of 0.2 MPa for both the large and small disks. The filtration flux decreased at the initial stage of filtration due to the clogging of filter media; however, the flux reached a constant value and retained that value for all samples in this system. The filtration flux increased with the rotation speed in both the large and small disks. The filtration flux of the large disk was higher than that of the small one at the same rotation speed. After the filtration test, the surface of the rotating disk was observed. In the case of 400 rpm, no cake was observed on the filter surface in both the large and small disks. However, in the cases of 100 and 200 rpm, the cake was left on the filter surface and the cake thickness of the large disk was thinner than that of the small one at the same rotation speed. These results indicate that the concentrate could not be swept completely from the filter surface and finally a cake began to form at a lower rotation speed, because the centrifugal force was not strong enough to sweep the concentrate. This is why the filtration flux increased with the rotation speed. In addition, the centrifugal force of the large disk is higher than that of the small one at the same rotation speed; therefore, the cake should be difficult to form and the filtration flux should increase in the case of the large disk.

Fig. 15 shows the time changes of the filtration flux at various filtration pressures (0.2, 0.3 and 0.4 MPa) and a rotation speed of 400 rpm. The filtration flux of the large disk was higher than that of the small one at the same pressure. This is because the centrifugal force of the large disk is higher than that of the small one as mentioned above. In the case of the large disk, the filtration flux increased with the pressure, while the filtration flux was almost independent of the pressure in the case of the small one. Observing the filter surface after filtration test, the cake was observed at 0.3 and 0.4 MPa in the case of the small disk and the cake thickness at a pressure of 0.4 MPa was thicker than that of 0.3 MPa. On the contrary no cake was observed for all the pressures used in this study in the case of the large disk. From these results, for the small disk, the filtration resistance increased with the pressure because the thickness of the formed cake on the filter surface increased; therefore, the filtration flux was almost constant even if the pressure increased. For the large disk, however, the centrifugal force was large enough to sweep the concentrate completely and the filtration resistance might be almost constant at the all pressure used in this study, thus the filtration flux increased with the pressure.

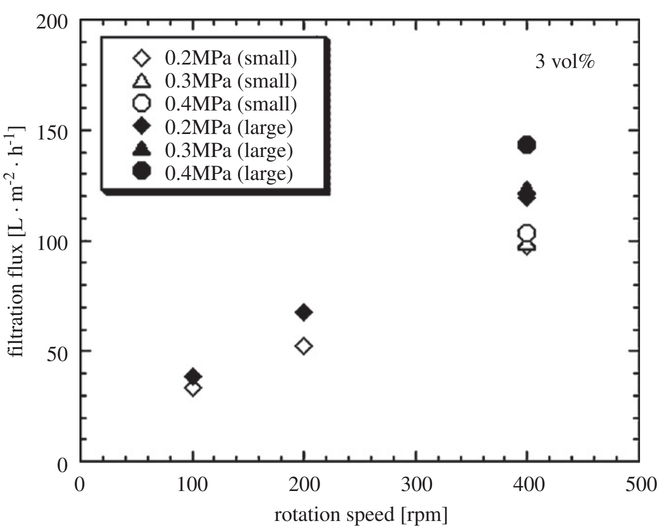

Fig. 16. Variation of filtration flux with rotation speed at various filtration pressures (3 vol%).

Fig. 16 summarizes the effects of the rotation speed and pressure on the filtrate flux at a low concentration level. The filtration fluxes plotted in this figure were the values obtained at a filtration time of 0.8 h in Figs. 3 and 5 after reaching an almost steady state. The filtration flux increased with the rotation speed for both the large and small disks. This is because the centrifugal force increased with the rotation speed as previously mentioned. In the case of the large disk, the filtration flux increased with the pressure at a rotation speed of 400 rpm, while the filtration flux was not dependent on the pressure at lower rotation speeds of 100 and 200 rpm. Furthermore the filtration flux was almost independent of the pressure in the case of the small disk. As mentioned above, no cake was observed for the large disk at 400 rpm, thus the filtration resistance was almost constant and the filtration flux increased with the pressure. Conversely, the cake was observed at lower rotation speeds of 100 and 200 rpm for the large disk and at all rotation speeds for the small disk. In these instances, the filtration resistance increased with the pressure because of the increase of the cake thickness, therefore, the filtration flux was almost constant even if the filtration pressure increased.

From the above results and discussion, we can demonstrate the cake-less filtration mechanism of this new filtration system as shown in Fig. 17(a). In this system, the concentrate is swept by the centrifugal force and the sweeping force increases with the diameter of the disk and the rotation speed. The sweeping resistance also acts on the concentrate and increases with the pressure. If the sweeping force is larger than the sweeping resistance, the concentrate can be swept from the filter media. On the contrary if the sweeping force is smaller than the sweeping resistance, the concentrate stays on the filter surface and finally becomes the cake.

In case of the constant rotation speed the sweeping mechanism is modeled as shown in Fig. 17(b). In this case the concentrate cannot be swept and will form a cake if the pressure exceeds the critical value, because the sweeping resistance becomes larger than the sweeping force. In addition, the sweeping force of the large disk is higher than that of the small one at the same rotation speed, therefore, the critical value of the pressure for the large disk is higher compared to that of the small one.

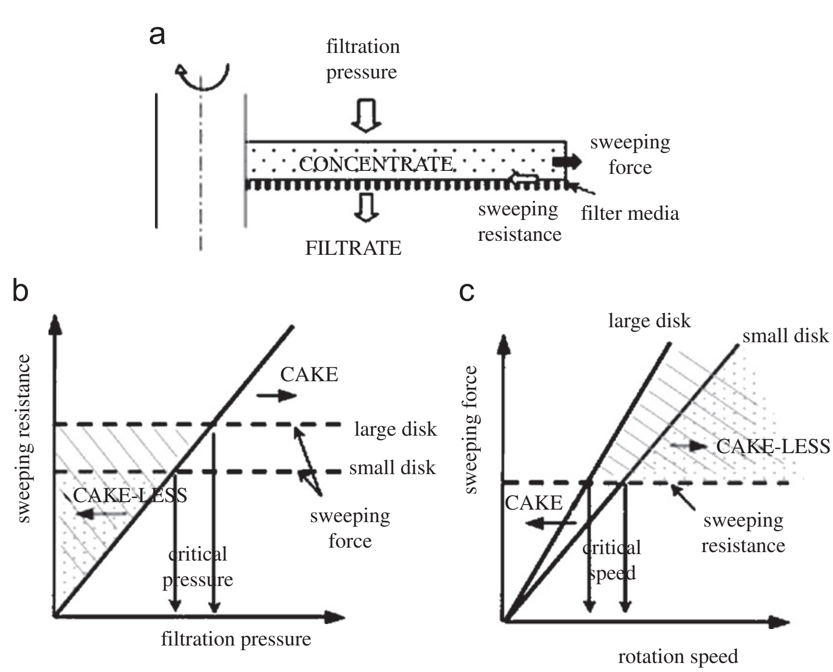

Fig. 17. Model for sweeping mechanism in this system: (a) force balance on the filter, (b) sweeping mechanism at constant rotation speed and (c) sweeping mechanism at constant filtration pressure.

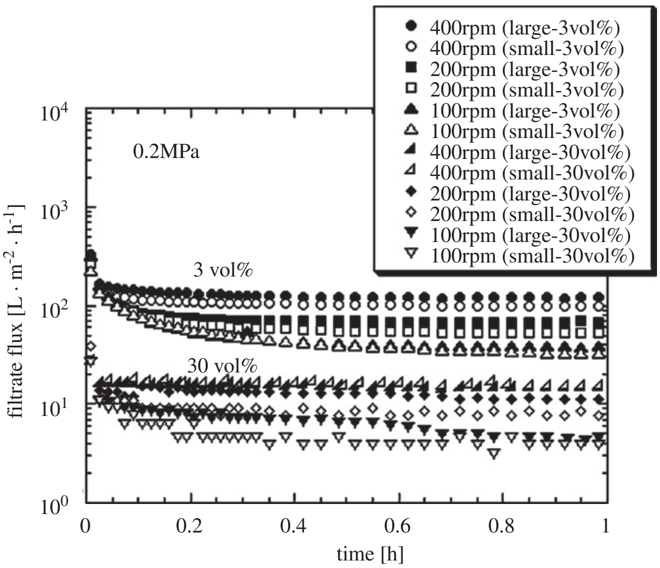

Fig. 18. Filtration test at the high-concentration condition with various rotation speeds.

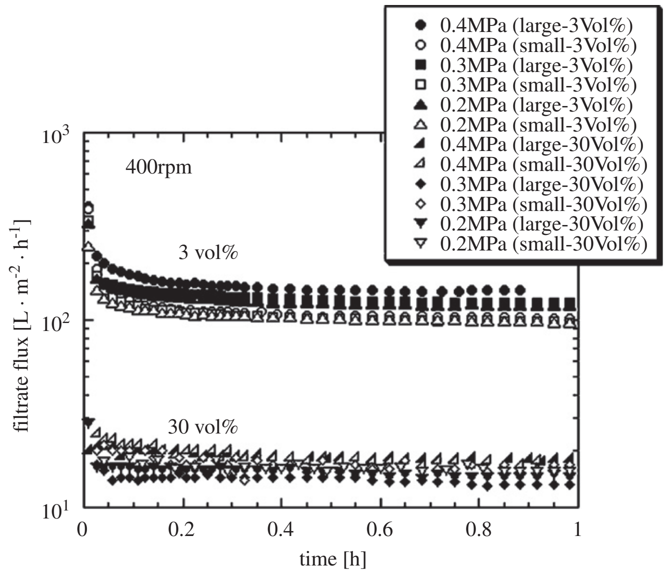

Fig. 19. Filtration test at the high-concentration condition with various filtration pressures.

In case of the constant pressure the sweeping mechanism is modeled as shown in Fig. 17(c). In this case the concentrate cannot be swept and will form a cake if the rotation speed is below the critical value, because the sweeping force becomes smaller than the sweeping resistance. Furthermore the sweeping force increases with the rotation speed more rapidly for the large disk, therefore, the critical value of the rotation speed for the large disk is smaller compared to that for the small one.

3.6.2. Effect of filter diameter on filtration flux in high-slurry concentration (30 vol%)

Fig. 18 shows the time changes of the filtration flux at various rotation speeds (100, 200 and 400 rpm) at a pressure of 0.2 MPa. At a high-concentration level, the filtration flux increased with rotation speed for both the large and small disks in the same way as filtration tests at a low concentration level. The filtration flux for the large disk filter was also higher compared to that of the small one. In the cases of 100 and 200 rpm, the cake was also observed on the filter media after filtration; however, the cake thickness was thinner compared to that obtained at a low concentration level in the same operating conditions. This suggests that a cake is difficult to form at a high-concentration level because the many more particles existing in the vessel help to sweep the concentrate on the filter surface in addition to the centrifugal force of the rotating disk.

Fig. 19 shows the time changes of the filtration flux at various filtration pressures (0.2, 0.3 and 0.4 MPa) at the rotation speed of 400 rpm. The filtration flux showed a tendency to increase with the pressure for the both the large and small disks. From the observations of the filter surface after the filtration test, there was no cake observed for all the pressures used in this study for both the large and small disks. This means that the centrifugal force was large enough to sweep the concentrate for all the pressures, thus the filtration flux increased with the pressure in the same way as the filtration tests at a low concentration level for the large disk.

Fig. 20 summarizes the effects of the rotation speed and pressure on the filtration flux at a high-concentration level. The filtration fluxes plotted in this figure were the values obtained at a filtration time of 0.8 h in Figs. 18 and 19. As mentioned in the results and discussion for the low concentration, the following tendencies were also obtained at a high-concentration level. First the filtration flux

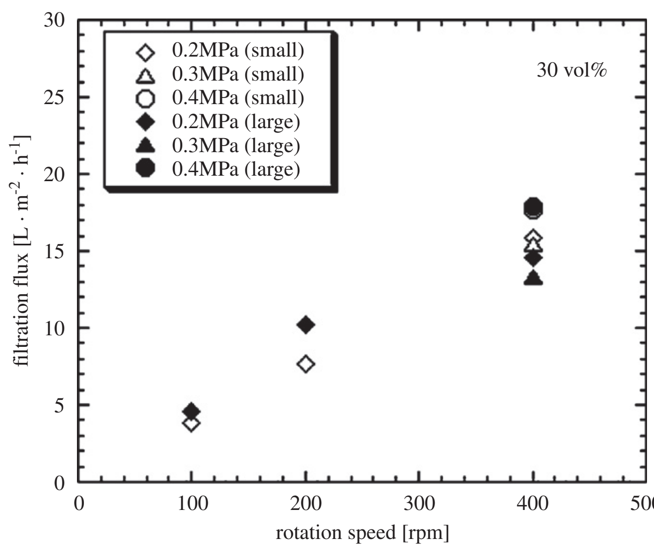

Fig. 20. Variation of filtration flux with rotation speed at various filtration pressures (30 vol%).

increased with the rotation speed for both the large and small disk. Second the filtration flux was independent of the pressure at lower rotation speeds of 100 and 200 rpm for both the large and small disk. At the higher rotation speed of 400 rpm, the filtration flux depended on the pressure for both the large and small disk and this dependency was clearer for the large disk. These results indicate that the filtration mechanism at a high-concentration level can be basically described as the same way at a low concentration level.

4. Conclusions

A new cake-less continuous filtration system with a rotating disk filter, in which slurry was prepared in a well-dispersed state was discussed in this paper. In this new system, it is expected that a concentrated material retains fluidity and can be discharged by filtration pressure alone without a scraping device.

We tried to filter some difficult to filter materials such as sericite, hydrolyzed cellulose, pulp wastewater and algal suspension, using the new system. In every sample, the concentrated material was discharged easily by the filtration pressure and no cake formed on the filter media. Furthermore, the concentrate materials retained fluidity and the filtration could be performed continuously under high-concentration conditions.

In this system, it was shown that the filtration flux increased with the rotation speed. At the lower rotation speed, the filtration flux was not dependent on the pressure. On the contrary at the higher rotation speed, the filtration flux increased with the pressure. This dependency was clearer in case of the large disk compared to the small one. We proposed a model for a sweeping mechanism in this system which can be explained in the above results.

We can verify the feasibility of our filtration concept, therefore, we ought to discuss the further improvement of the throughput for large-scale treatments.

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