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Optimization of Repulping Process of Unsorted ONP for Pulp Mold (II)

- Pilot trial -

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ABSTRACT

In order to utilize unsorted ONP, which contains leaflets (printed coated papers), as a raw material to produce pulp mold, optimum conditions for repulping were investigated with the pilot Helico pulper at Centre Technique du Paper (CTP), France. Two major process factors were focused: repulping concentration and rotor speed. Repulping at a higher concentration showed more rapid defibering kinetics. Increasing the rotational speed of rotor at the optimum repulping concentration accelerated the defibering kinetics while it also led to higher fines generation and faster decrease in drainage property of the produced pulp. Hence, an alternative way was suggested: starting repulping at a conventional rotor speed and then accelerating the rotor speed for the last minute(s) of repulping.

Keywords *: pulp mold, slushing, repulping concentration, rotor speed, defibering kinetics*

1. Introduction

Pulp mold is a packaging material, typically made of virgin pulp or recovered papers such as old corrugated container (OCC) and old newsprint (ONP), which lead to a minimal impact on environment (1). Pulp mold can be a direct replacement and perfect alternative for expanded polystyrene (EPS) in the new era of environmental awareness.

Currently, most of egg trays are produced with 100% sorted ONP, which has uniform quality. However, the use of unsorted ONP which contains leaflets (printed coated papers) has becomenecessary to reduce the production cost. The difficulties in utilizing unsorted ONP as a raw material to produce pulp mold are due to the fact that, different from ONP, leaflets are characterized by higher resistance against wetting and defibering. As a consequence, quite a lot of flakes are remained in repulped stock after slushing. In a previous research performed with a laboratory

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Helico pulper, it was concluded that repulping at a high concentration shall be utilized to accelerate defibering kinetics of unsorted ONP (2). The optimum repulping concentration of the laboratory Helico pulper was 11%, considering the fast deflaking kinetics and small generation of fines.

The objective of this study was to check the possibility of using unsorted ONP containing leaflets at a pilot scale and to determine the optimal repulping conditions. The variables of interests were repulping concentration and the rotational speed of rotor.

2. Experimental

Blend of 90% ONP (blend of French old newsprints) and 10% Korean leaflet was slushed with the pilot Helico pulper at Centre Technique du Paper (CTP), France. For the repulping, water was first added into the pulper and then the recovered papers were uniformly loaded (no agitation during this sequence). 50 kg of the recovered papers (o.d. weight) were used for each test. When all the recovered papers were loaded into the pulper, the rotor was started. For all the experiments, the repulping temperature was adjusted to 30°C.

To investigate the influences of repulping concentration on slushing characteristics, the concentration of recovered paper was varied from 11.2% to 13.6% by varying the added amount of water. Repulping was conducted at the fixed rotational speed of rotor (500 rpm). Samples of suspension were taken at 1, 2, 3 and 5 minutes. Defibering kinetics was evaluated by measuring flake content with a Somerville screen (slot width = 80 μm). Flakes are the fraction retained on the Somerville screen. Material passing 150 mesh wire was considered as fines. Dewatering property of produced pulps was measured with the Canadian Standard Freeness (CSF) tester. Higher value of CSF means that the pulp produced has a good drainage property.

To test the effects of rotor speed on repulping characteristics, the rotational speed of rotor was increased from 500 rpm to 620 rpm at repulping concentrations of 13% and 13.6%. In addition, the influences of the different rotor speed sequences on repulping characteristics were tested. First, the recovered papers had slushed at 620 rpm for 1 min followed by slushing at 500 rpm for 2 min. The second option was to repulp at 500 rpm for 2 min followed by slushing at 620 rpm for 1 min.

3. Results and Discussion

3.1 Effect of repulping concentration

Fig. 1 shows the effect of repulping concentration on defibering kinetics in terms of flake content. Test results confirm that repulping at a higher suspension concentration is more energy efficient and hence that deflaking rate was slowed down as the suspension concentration was decreased. When repulping concentration was raised from 11.2% to 13.6%, flake content was reduced from 31.2% to 12.4% for the first one minute. The difference between repulping concentrations 13% and 13.6% was low. The flake content at 13.6% was 10.8%. After 2 min of slushing, flake contents among three repulping concentrations were almost the same.Somerville reject was 4.1% at

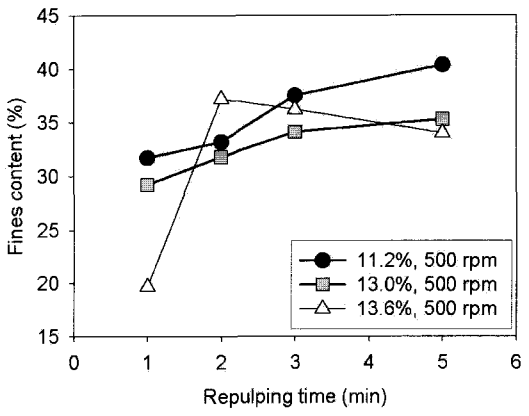

Fig. 1. Effect of repulping concentration on defibering kinetics.

11.2% of repulping concentration, 4.5% at 13% and 4.4% at 13.6% (repulping time = 2 min). After 5 min of repulping, Somerville rejects for three repulping concentrations were decreased to 1%. One of the main forces responsible for defibering recovered papers is the overall friction forces (fiber/rotor, fiber/fiber and fiber/liquid) (3). Fabry et al. used a shear factor to characterize the overall friction imposed on fiber during repulping (4). When the suspension concentration is increased, the friction forces become higher and then the higher friction will help the defibering of recovered papers. Also, according to Bennington et al., raising suspension concentration in a repulper increases the contact between fiber and rotor, resulting in faster defibering of recovered paper (5).

Effect of repulping concentration on fines generation is illustrated in Fig. 2. Fines content was increased with repulping time. At the repulping concentration 13%, fines content was 29.2% at 1 min and it was increased to 35.3% at 5 min. This trend agrees with a previous research (6). Fines in produced pulps generally consist of fillers such as $CaCO_3$ and talc, pigments such as $CaCO_3$ and clay in a coating layer and fiber fines and are generated by mechanical force during slushing. As slushing of ONP and leaflet proceeds, the recovered papers are broken down into individual fibers, the fines components are liberated from the recovered papers at the same time, and counted as fines. Comparing at 5 min in which most of flakes are considered to be broke down, the lower the repulping concentration, the higher the fines content. At the repulping concentration 11.2%, the highest fines content was observed (40.4% at 5 min). At 13%, the fines content was 35.3% and, at 13.6%, it was 34%.

Effect of repulping concentration on drainage property of produced pulps is illustrated in term of Canadian Standard Freeness in Fig. 3. Higher CSF value indicates good dewatering property of pulp while lower CSF means poor dewatering. CSF decreased with time that can be related to a decrease of coarse elements (lower flake content) and higher fines content (6). Between 11.2% and 13%, the two curves are almost identical. Repulping at 13.6% induces an increase in CSF, whichcould be related to a lower hydration of fibers at this high concentration level. Also in a previous research, it was shown that repulping at a high concentration caused fibers to deform, increasing in the amount of curled or kinked fibers (2). The curled or kinked fibers provide spaces for water to escape through the forming web (fiber network). However, the differencesin CSF among three repulping concentrations were reduced when sufficient repulping time is applied (i.e., at 5 min).

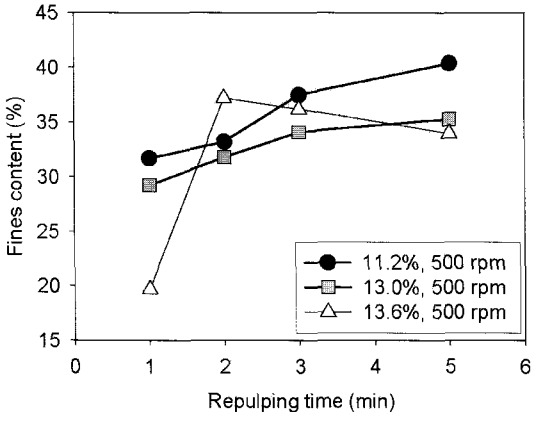

Fig. 2. Effect of repulping concentration on fines content.

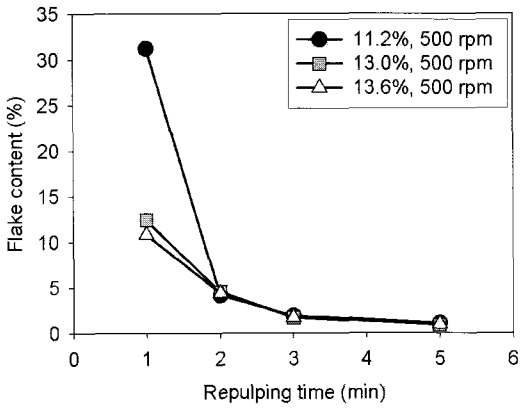

Fig. 3. Effect of repulping concentration on Canadian Standard Freeness.

3.2 Effect of rotor speed

In order to investigate the effect of rotor speed on slushing characteristics, rotor speed was raised from 500 to 620 rpm at repulping concentrations 13% and 13.6%. Different defibering kinetics was observed for different repulping concentrations (Fig. 4). At 13%, the defibering was improved at a higher rotor speed (620 rpm) for the first 3 minutes. After the recovered papers had slushed for 1 min, flake content was 12.4% at 500 rpm and was reduced to 9.9% at 620 rpm. After 3 min, no significant differences were observed between 500 rpm and 620 rpm: flake content was 1.7% at 500 rpm and 1.4% at 620 rpm. When the rotational speed of rotor is raised, the area swept by a rotor at a given time is increased and hence the contact between fiber and rotor is increased, resulting in increased deflaking rate.

At repulping concentrations 13.5% and 13.6%, defibering rate was similar between 500 rpm and 620 rpm. The rotor speed was increased in order to obtain uniform motion of the suspension in a repulper. However, even at the higher rotor speed (620 rpm), the repulping concentration was too high to induce a good pulp motion and the motion of the suspension in the repulper was not uniform. A kind of slipping occurredso that the pulp had stayed for a long period without being slushed. This phenomenon was responsible for non-homogeneous defibering. In addition, due to poor pulp motion, the frequency of application of mechanical force was relatively low in comparison to lower concentrations (13% and 12.8%).

Fig. 5 shows the effect of the rotational speed of rotor on fines generation. At the repulping concentrations 13% and 12.8%, an increase in rotor speed during repulping was responsible for higher fines generation. This can be due to more frequent application of mechanical forceson fiber as the suspension flows at a faster rotor speed. At 13.5% and 13.6%, an increase in rotor speed during slushing caused lower fines content. Two phenomena should explain this: nonuniform suspension flow in the repulper and lower defibering (i.e. higher flake content that is the source of fine elements that have not been liberated).

Effects of the rotational speed of rotor on drainage property of produced pulps are illustrated in Fig. 6. In all repulping conditions, CSF values were over 205 mL, which can provide enough drainage rates to produce molded pulp. When rotor speed was raised, CSF was decreased, i.e., drainage became slower. Combined effects of lower flake contents and higher fines content were responsible for slower dewatering.

3.3 Comparison after 3 min repulping

In order to search an optimum repulping condition, the experimental data were compared at 3 min. Fig. 7

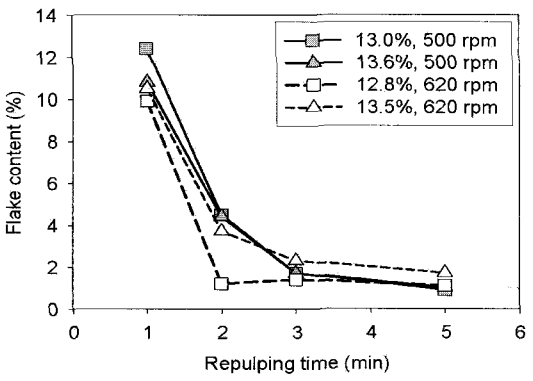

Fig. 4. Effect of rotor speed on defibering kinetics.

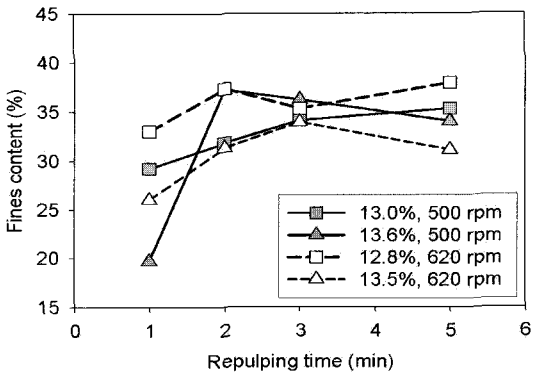

Fig. 5. Effect of rotor speed on fines content.

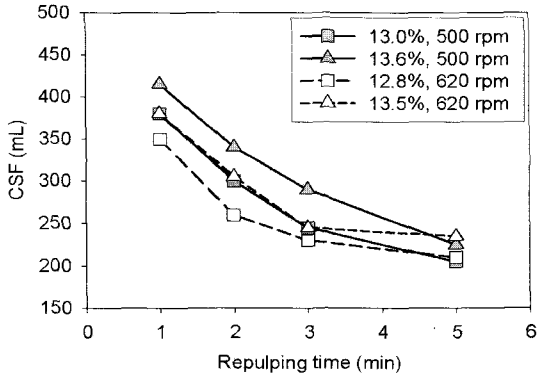

Fig. 6. Effect of rotor speed on Canadian Standard Freeness.

shows the effect of repulping concentration on flake content at various sequences of rotor speed. At the rotor speed of 500 rpm, defibering was initially improved when the repulping concentration was increased from 11.2% to 13% and then levelled off when moving from 13 to 13.6%. On the other hand,at 620 rpm, an increase in repulping concentration was resulted in worse defibering that can be related to poor suspension flow in the repulper.

Application of different rotor speed sequences led to interesting results. Repulping at 620 rpm for 1 min followed by slushing at 500 rpm for the last 2 min resulted in similar flake content with the case of repulping at 500 rpm for 3 min. When the recovered papers had slushed for 2 min at 500 rpm followed by 1 min repulping at 620 rpm, the lowest flake content was observed. These results imply that the most efficient way to slush recovered paper is to start repulping at a lower rotor speed, breaking down the recovered paper into smaller pieces, and then to increase the rotor speed at the end of the repulping sequence. An increase in the rotational speed of rotor at the end of repulping sequence allows a faster pulp motion and application of more frequent mechanical forces that finalize defibering.

When the recovered paper was slushed for 3 min at 500 rpm, fines content passed through a minimum value (34%) at a repulping concentration of 13% (Fig. 8). At the rotor speed of 620 rpm, when the repulping concentration was increased from 12.8% to 13.5%, fines content was reduced from 35.9% to 33.9%. This is due to the poor defibering at the higher concentration caused by nonuniform motion of suspension in the repulper. Repulping for 1 min at 620 rpm followed by slushing 2 min at 500 rpm resulted in the lowest fines content (30.5%). When the higher rotor speed was applied at the end of pulping sequence (i.e., 500 rpm (2 min) + 620 pm (1 min)), the fines content was somewhat high (35.6%).

Fig. 9 shows the effect of repulping concentration on CSF at various sequences of rotor speed. After 3

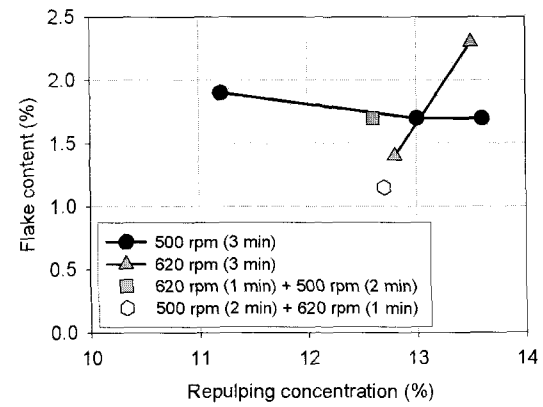

Fig. 7. Effect of repulping concentration on flake content at various rotor speed sequences.

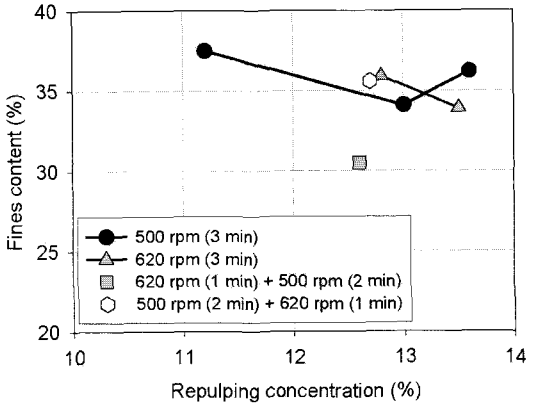

Fig. 8. Effect of repulping concentration on fines content at various rotor speed sequences.

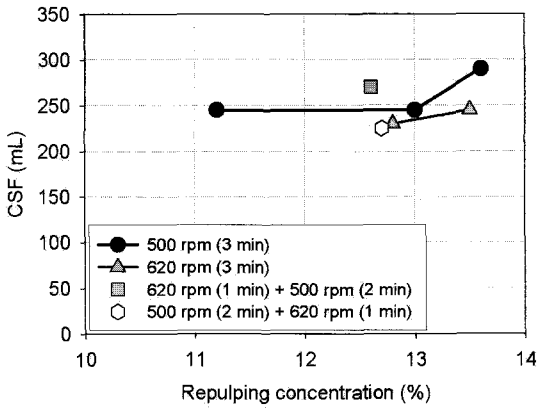

Fig. 9. Effect of repulping concentration on Canadian Standard Freeness at various rotor speed sequences.

min of slushing, the value of CSF ranged between 225 mL and 290 mL for all the repulping conditions investigated. These pulps can provide enough drainage rates to produce molded pulp in a mill. At 500 rpm, an increase in repulping concentration from 11.2% to 13% did not change the freeness (245 mL CSF), whereas an increase to 13.6% improved drainage (290 mL CSF). At 620 rpm, CSF slightly increased at the higher repulping concentration due to higher flake content and lower fines content.

4. Conclusions

Optimum conditions for repulping to produce molded pulp with unsorted ONP were investigated with a pilot Helico pulper, focusing on two major process factors: repulping concentration and rotor speed. Repulping at a higher concentration showed more rapid deflaking and the optimal repulping concentration of the CTP pilot repulper could be suggested around 13%. Increasing rotor speed at the optimum concentration (13%) accelerates the defibering rates while it also lead to higher fines generation and faster decrease in dewatering property of the produced pulp. Hence, an alternative way is recommended: starting with a conventional rotor speed and then accelerating the rotational speed of rotor during the last minute(s) of slushing. Such a solution will raise defibering rates, saving energy and keeping decent drainage property of produced pulp.

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