A New Technology of Process Water Treatment Using Fluid-Jet Cavitation

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Abstract

A new technology using fluid-jet cavitation (CV-jet) has been developed in order to improve the quality of secondary fibers. CV-jet treatment was applied to process water in deinking. In this treatment, process water was injected into the reacting vessel by using a high-speed jet and cavitation bubbles were generated around the jet. The impact force produced by the collapse of the cavitation bubbles detached contaminants, such as ink and binder, from the surface of fines and ash particles. The effects of CV-jet treatments for process water in deinking were investigated in terms of the number of dirt speckles, the effective residual ink concentration (ERIC) and the brightness of the treated samples.

The results showed that CV-jet treatment decreased the average size of dirt speckles in the process water, and the treatment also facilitated ink detachment from the fines in the water. The number and average size of dirt speckles after CV-jet treatment were decreased by the subsequent flotation. And the degree of dirt reduction after CV-jet treatment was much higher than without the treatment. The brightness of the fines after CV-jet treatment was also improved by the subsequent flotation. Similarly, the brightness gain through the flotation after CV-jet treatment was much higher than without the treatment. These results indicated that CV-jet treatments improved the quality of the fines in the process water, which were difficult to be improved by conventional deinking devices. Therefore, the CV-jet technology has the potential to improve deinking process.

Keywords : cavitation, process water, dirt speckle, ink detachment, fines

1. Introduction

More and more amount of deinked pulp (DIP) is being used these days to save resources and reduce pulp production cost. DIP for printing and writing paper requires high brightness and low dirt speckle level. As demand of

paper labeled as recycled is growing in those markets, quality requested for reclaimed waste paper from which DIP is made, along with quality of resultant DIP itself, is getting severer. On the other hand, printing process is diversifying and unfavorable contaminants for DIP production are in greater use like tonner which is difficult to be removed and ink of special grade using hardening resin such as UV ink. This trend has been degrading quality of reclaimed waste paper year after year.

In DIP plant, process water (white water) is circulated and reused. As process water contains contaminants like

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ink, reusing it without any treatment will deteriorate quality of DIP like brightness and dirt speckle level. Therefore, process water is treated by flotation (F/T) and then fed back to the process in most cases. As most of contaminants adhere to fiber fines and ash particles suspended in process water¹⁻³⁾, removing them results in discharging fine fraction out of the process which causes low pulp yield in DIP production. Large amount of discharge is also unfriendly to environment. To detach substances attached on fiber surface, equipment like kneader and disperser is commonly used⁴⁾. They have to be operated at high pulp consistency more than 25% for good performance. Since solid content of process water is less than 3 % in most cases, they can't release contaminants from fine fraction. In other words, no method is available for removing contaminants like ink from process water at the moment.

We have developed a new deinking and refining process, using fluid-jet cavitations⁵⁻⁷⁾. In our process, fluid-jet cavitations (CV-jet) produce bubbles. When bubbles collapse, impact force generated detaches ink and brakes dirt speckles. Our CV-jet treatment unit was able to detach tonner and ink without help of deinking chemicals and heating, and could break down them efficiently so that fiber was less damaged during deinking⁸⁾⁹⁾. As CV-jet treatment took off contaminants effectively at a relatively low consistency range (less than 4 %), treating process water with it was promising. In this paper, we studied its possibility and evaluated the effect on ink and dirt speckles there. Then, process water was followed with flotation, and how pre-treatment by CV-jet affected removal efficiency of contaminants at flotation (F/T) was investigated.

2. Experiment

2.1 Samples

Test 1 : Effect on size reduction of dirt speckles and their removal by F/T with model process water

Coated paper was printed, shredded and disintegrated in low consistency pulper at 40°C for 10 minutes with sodium hydroxide (1 % per O. D. pulp) being added. Pulp slurry was squeezed through a Teflon bag of 80 mesh opening. The filtrate was model process water for test 1. Its solid content was 0.5 %.

Test 2 : Effect on ink removal with mill process water

Mill process water was obtained from an intermediate thickener in a DIP plant for newsprint in Mill A. Its solid content was 1.2 %.

Test 3 : Effect on removal at F/T with mill process water

Mill process water was obtained from washer in a DIP plant for newsprint in Mill B. Its solid content was 1.7 %.

2.2 CV-jet treatment

The CV-jet device used in this study was based on the

Fig. 1 Mechanism of cavitating jet device.

PI : pressure gage, TI : temperature sensor.

apparatus for washing metal surface^{10), 11)} which was designed to deink and refine pulp fiber. It is shown in Fig. 1.

The specification of CV-jet was as follows

Output pressure of plunger pump : 7 Mpa

Pressure inside reactor : 0.3 MPa

Mode of treatment : Test 1 and 3 : circulated Test 2 : one-pass only

Time of treatment : Test 1 : 15 minutes Test 3 : 10 minutes

Chemicals : not charged

2.3 Flotation (F/T) treatment

Test 1

F/T volume : 5 L

Time for flotation : 3 minutes

Temperature : 15°C

Air flow rate : 5 L/min.

Deinking agent : 0.2% (v/v) (poly-alcoholic type)

Test 3

F/T volume : 2 L

Time for flotation :

Untreated : 2, 3, 4 minutes, respectively

CV treated : 3, 5, 7 minutes, respectively

Temperature : 40°C

Air flow rate : 1.3 L/min.

Deinking agent : not charged

2.4 Evaluation

Test 1 :

Samples were taken before and after CV-jet treatment. Then, they were processed with flotation. From every sample, volume equivalent to 2 g of solid was taken out and filtrate pads were made with Buchner funnel. The number of dirt speckles was measured by dirt analyzer of scanner type (Spec Scan 2000 by Apogee System Inc.).

Test 2 :

Samples were taken before and after CV-jet treatment. They were hyper-washed on a wire of 325 mesh of which opening was 44 μm . From every sample, volume equivalent to 2 g of solid was taken out and filtrate pads were made with Buchner funnel. The pad was evaluated its effective residual ink concentration (ERIC) and ISO brightness. ERIC was determined by Color Touch 2 by Technidyne Co. and ISO brightness by color-difference meter by Murakami Color Research Laboratory Co., Ltd.

Test 3 :

Samples were taken before and after CV-jet treatment. Then, they were processed with flotation. From every sample, volume equivalent to 2 g of solid was taken out and filtrate pads were made with Buchner funnel. Effective residual ink concentration (ERIC) and ISO brightness were measured.

3. Result and discussion

3.1 Effect on size reduction of dirt speckles and their removal by F/T

(Test 1 : Effect on size reduction of dirt speckles and their removal by F/T with model process water)

Model process water was treated by CV-jet for 15 minutes. Then, model process waters, original and one after treated, were processed with flotation. The result was in Table 1. Reject percentage at F/T was 6.3% in the blank (the original) and 10.5% in the CV-jet-treated. The result before F/T treatment was compared with each other. The CV-jet treatment significantly increased the number of dirt speckles larger than 100 microns. In contrast, the treatment reduced the number of dirt speckles over 250 microns. The average speckle diameter was also decreased. These suggested that dirt speckles of which size was larger than 250 microns were broken down to smaller size and the number of dirt speckles of which size was between 100 microns and 250 microns increased. Then, the effect of F/T was compared in both cases. F/T treatment reduced number of dirt in the blank as well as in the CV-jet treated. The degree of dirt reduction, however, was far greater in the CV-jet treated than the blank, and the CV-jet treated had less number of dirt speckles.

The reason would be :

- 1) CV-jet treatment broke down dirt speckles to size which could be more efficiently removed by F/T.
- 2) Ink which was colored and adhered to fine fraction in process water was detached and could be more easily removed by F/T.

Regarding item 2, process water used in test 1 was made from coated paper. As ink was supposed to be attached on ash particles, the CV-jet treatment might detach ink from them.

In a case where DIP was produced from coated paper, the CV-jet treatment broke down dirt speckles and improved the efficiency of dirt removal at F/T. Thus it was shown that the quality of fine fraction in process water after F/T was improved.

3.2 The effect on ink detachment of the CV-jet treatment and ink removal at flotation.

(Test 2 : Ink detachment test with mill process water
Test 3 : Effect on ink removal at F/T)

How the CV-jet treatment worked on ink detachment was studied in Test 2, and its result was in Table 2. Before hyper-washing, there was little difference between the blank and the CV-jet treated as far as brightness and ERIC value were concerned. After hyper-washing, the CV-jet treated had higher brightness and lower ERIC value. The fact suggested that ink adhering to fine fraction in process water was detached by the CV-jet treatment and detached ink was removed by following washing. Because mill process water in Test 2 was sampled from DIP plant using newsprint as a resource, ink was supposed to be at-

Table 2 The results of the CV-jet treatment, Exp. #2. CV: CV-jet treatment. The samples were hyper-washed on a 325-mesh wire

	Before hyper-washing		After hyper-washing	
	Brightness %	ERIC ppm	Brightness %	ERIC ppm
Blank	51.0	814	60.8	119
CV	51.1	778	62.7	66

Table 1 The results of dirt measurement, Exp. #1. CV: CV-jet treatment for 15 minutes

	Before flotation			After flotation		
	Number of dirt speckles counts/m ²		Average speckle diameter μm	Number of dirt speckles counts/m ²		Average speckle diameter μm
	$>\phi$ 100 μm	$>\phi$ 250 μm		$>\phi$ 100 μm	$>\phi$ 250 μm	
Blank	260,000	97,000	238	140,000	10,000	105
CV	480,000	27,000	108	27,000	200	58

Table 3 The results of CV-jet treatment and flotation experiment, Exp. #3. CV: CV-jet treatment for 10 minutes

	Reject percentage %	Brightness %	ERIC ppm
Blank	—	57.9	601
	32.6	59.9	473
	44.9	61.1	393
	47.8	61.3	372
CV	—	57.8	615
	25.9	62.0	388
	35.0	64.3	277
	44.8	65.9	192

Fig. 2 The relationship between the reject percentage and the brightness of the filtrate pads from blank and CV-jet treated samples.

Fig. 3 The relationship between the reject percentage and the ERIC value of the filtrate pads from blank and CV-jet treated samples.

tached on fibers. So, the CV-jet treatment could detach ink from fiber fines.

Then Test 3 was conducted to evaluate how the CV-jet

Fig. 4 The scheme around the washer and process water treatments.

treatment of mill process water would affect the efficiency of dirt removal at F/T. The result was in **Table 3**. Same as in Test 2, the blank and the CV-jet treated had almost the same brightness and ERIC value before F/T treatment. After F/T, their brightness and ERIC value went up as their reject percentage increased. **Fig. 2** shows their brightness changes against reject percentage and **Fig. 3** is for ERIC changes as well. When compared at the same reject percentage, the CV-jet treated had significantly higher brightness and lower ERIC value than the blank. The CV-jet treatment clearly improved ink removal at F/T.

It was concluded that CV-jet treatment detached ink from fiber fines and improved ink removal at following F/T. Figures 2 and 3 showed that the CV-jet treatment increased brightness by 5 points and reduced the amount of ink by a half at the reject percentage of 45%. Therefore, it is expected that the CV-jet treatment will improve the quality of process water like higher brightness and lower ink content.

3.3 Estimation of probable improvement on pulp yield

Let us look at Figures 2 and 3 from another view point. They suggest that CV-jet treatment will give the same quality of process water with less reject percentage than one without the treatment. When compared at the same ink amount in **Fig. 3**, the CV-jet treated got it at a half of reject percentage which the blank could make it. So, a flow sheet is proposed in **Fig. 4**, using following conditions.

*Solid discharge percentage at washer : 10%

**Reject percentage at process water F/T

Blank : 30%

CV-jet treated : 15%

Washer discharges process water, which is followed by F/T. F/T will remove 30% of solid and return the rest to the washer. So, the total discharge percentage will be 3%. When CV-jet treatment is installed in the process, it will remove 15% of total solid and return 85% to washer. The total reject will be 1.5%. Installing CV-jet treatment before process water F/T will improve pulp yield by 1.5

points in DIP process.

4. Conclusion

By treating process water of DIP process by CV-jet, dirt speckles would be broken down and contaminants adhering to fine fraction like ink could be released. This effect of detachment was found not only on fiber fines but also on ash particles. When the treatment was followed by F/T, removal efficiency of ink and dirt there was improved. Therefore, the CV-jet treatment is promising as a new technology which is able to improve the quality of fine fraction of process water. It will also increase pulp yield, reduce the amount of waste discharge and refine technology of producing DIP.

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