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Deinking of White Ledger with Ultrasonic Wave : Laboratory Scale Trial

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ABSTRACT : Ultrasonic deinkings of white ledger were carried out to confirm whether the ink removal efficiency and pulp qualities can be improved by the ultrasonic deinking. The effects of conventional pulping and ultrasonic treatment of white ledger on the ink particle size distribution and ink removal coefficient were compared. The physical properties of paper, energy consumption and effluent qualities were measured. The ultrasonic treatment of white ledger resulted in the ink particle size distribution suitable for flotation. The ink removal efficiency, brightness, breaking length and effluent quality were improved by the ultrasonic deinking. It is expected that the competitiveness of ultrasonic deinking system can be improved by the optimization of treatment condition.

Keywords : White ledger, Conventional, Ultrasonic, Dekinking, Ink removal efficiency, Paper properties, Energy consumption, Effluent quality

INTRODUCTION

The members of the United Nations Framework Convention on Climate Change (UNFCCC) met in Kyoto, Japan to develop an international accord that would help mitigate the effects of climate change through the reduction of greenhouse gas emission in December, 1997. Tokyo global warming pact went into force on February, 2005, seven years after it was negotiated, imposing limits on emissions of carbon dioxide and other gases scientists blame for rising world temperatures, melting glaciers and rising oceans. Although, the United States, the world's largest emitter of such gases, has refused to ratify the agreement, most manufacturing companies of many countries including Korea are trying to develop the environmentally friendly technologies and raw materials that can reduce the emission of greenhouse gases.

There is strong and growing pressure from public interest groups and governments to increase the recycling of wastepaper, and there have been great increases in the amounts of paper being recycled, driven by a combination of environmental and economic factors. Environmental organizations emphasize the conservation of natural resources; governments and local authorities are more concerned with finding alternative outlets for various components of solid waste, including wastepaper. These concerns have resulted in a number of legal and financial incentives for wastepaper recovery.

Although many advantages are well known in the use of recycled secondary fiber as papermaking raw material, there is the limitation in the amount of recycled fiber that can be used because there are some serious problems. The strength and printing properties of recycled fiber are inferior to those of virgin fiber. There are also many troubles including the contamination of the equipments, complication of wet end chemistry, slow drainage by the increase of fines content, load for the waste water treatment and solid wastes, etc. Most of problems listed above can be resolved by the optimization of stock preparation and retention system, but the development of novel deinking technology is required in order to remove and/or minimize the environmental problems.

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Many research works were carried out in order to develop the environmentally friendly deinking technologies recently. One of representative research is the trial of neutral pH deinking which was carried out to reduce the contamination of waste water in France (Galland et al., 1995), Finland (Heimonen and Stenius, 1995) and United States (Jobbins and Heise, 1996). However the improvement in the qualities of recycled fiber should be solved for the commercialization. Reductive deinking (Haché et al., 1995) was tried to reduce the use of chemicals in ONP (old news print) deinking process. Short sequence recycling system was also developed for ONP (Blain et al, 1993; Grant and Blain, 1995). The principle of this method is that the ink particles are flocculate and remove by the use of special formula in pulper. Another interesting research was the enzymatic deinking (Jeffries et al., 1994; Sykes et al., 1995; Rutledge-Cropsey et al, 1995; Heise et al, 1995). However the additional equipment and process are required, and the cost effectiveness in the improvement of pulp quality was not so good.

In the ultrasonic deinking, only few research works (Turai and Teng, 1978; Naimpally, 1982; Norman et al., 1994; Scott and Gerber, 1995; Offill and Venditti, 1995) were reported because there was a prejudice that the new equipment and higher energy cost will be required. It was also found that the ultrasonic wave treatment can improve the pulp qualities by the refining effect (Simpson and Mason, 1951; Willems, 1962; Begin, 1963; Iwasaki et al, 1967; Won and Lee, 1996). Thus, the effects of ultrasonic treatment condition on the deinking efficiency of white ledger and pulp qualities were investigated by the use of ultrasonicator in order to obtain the fundamental informations.

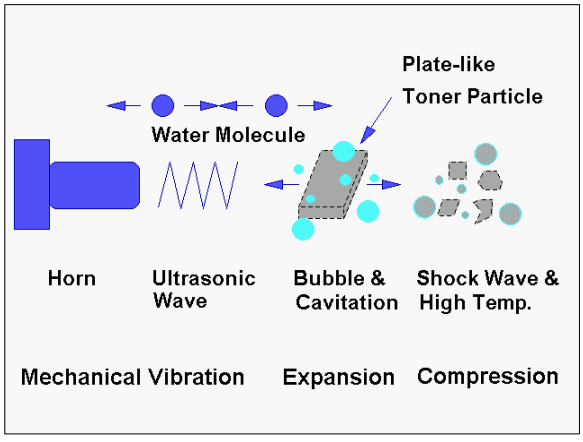

Fig. 1. Principle of toner ink particle degradation by ultrasonic treatment.

MATERIALS AND METHODS

The ink removal efficiency is strongly affected by the ink particle size distribution. The toner ink is not easy to remove because the particle size is too large to be removed by flotation or washing and too small to be removed by the screen and cleaner. It is very important to reduce the ink particle size in order to remove efficiently by the conventional washing and flotation process. It is expected that ultrasonic treatment could reduce the toner ink particle size by the principle illustrated in Fig. 1. Thus the conventional pulping and ultrasonic treatment were carried out to investigate the change of ink particle size distribution with the conditions as summarized in Table 1. Ultrasonic deinking was also carried out to know whether the ink removal efficiency and the properties of pulp recovered from white ledger can be improved by the

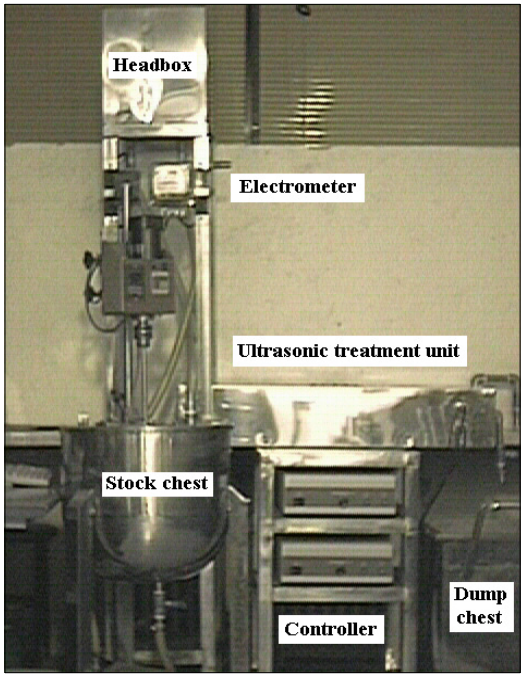

Fig. 2. Small scale pilot ultrasonic deinking system.

Table 1. Conventional pulping and ultrasonic treatment conditions

Methods	Conditions
Conventional 1	NaOH 2%, surfactant 1%, hydrogen peroxide 1%, sodium silicate 2%, DTPA 0.2%, consistency 5%, 50℃, 20 min.
Conventional 2	NaOH 3%, surfactant 1%, hydrogen peroxide 1%, sodium silicate 2%, DTPA 0.2%, consistency 5%, 50℃, 20 min.
Ultrasonic 1	pH 7, Surfactant 1%, consistency 1%, 50℃, 10 min.
Ultrasonic 2	pH 9, Surfactant 1%, consistency 1%, 50℃, 10 min.

ultrasonic deinking method. Ultrasonic treatments were carried out by the probe type laboratory ultrasonicator (Sonic dismembrator, Model 550, 20 kHz, 550 W) immersed in stainless beaker filled with white ledger slurry. The energy consumption and the contamination of waste water by the ultrasonic method were compared with the conventional deinking method. The small scale pilot ultrasonic deinking system designed by author was used to measure the electrical energy consumption.

RESULTS AND DISCUSSIONS

Ink Particle Size Distribution

The effects of conventional pulping and ultrasonic treatment of white ledger on the ink size distribution were compared (Fig. 3). The surfactant was only added to prevent the agglomeration ink particles broken down during ultrasonic treatment. The ink particles larger than 200 ㎛ were not observed in the case of ultrasonic treatment, but there were not significant difference between pH 7 and 9. These phenomena mean that ultrasonic treatment was better means to reduce the ink particle size than pH control and other chemicals used in conventional pulping in the pulping of white ledger. It was found that the ultrasonic treatment of white ledger gave the proper ink particle size distribution suitable for the flotation deinking, although the surfactant was only added in this experiment.

Ink Removal Efficiency

Flotation method was applied to removed the ink particle from the slurries prepared by the conventional pulping and ultrasonic treatment. The conventional pulping gave the ink removal efficiency of ca. 81-85%, but the higher ink removal efficiency (ca. 89-95%) was obtained from the slurries prepared by the ultrasonic treatment (Fig. 4). Although any obvious difference was not observed in the ink size distribution (Fig. 3), the ultrasonic treatment at the higher alkaline condition seems to be beneficial in the removal of ink particles by the flotation.

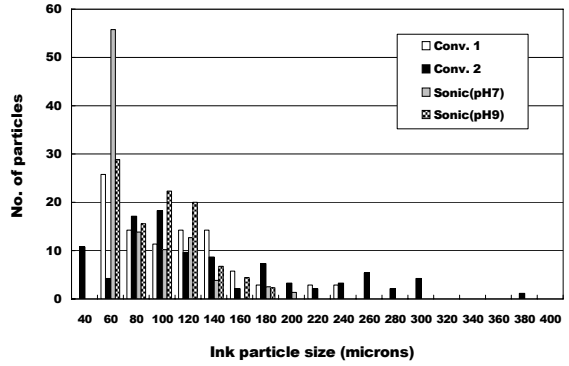

Fig. 3. Effect of pulping method on the ink size distribution of white ledger.

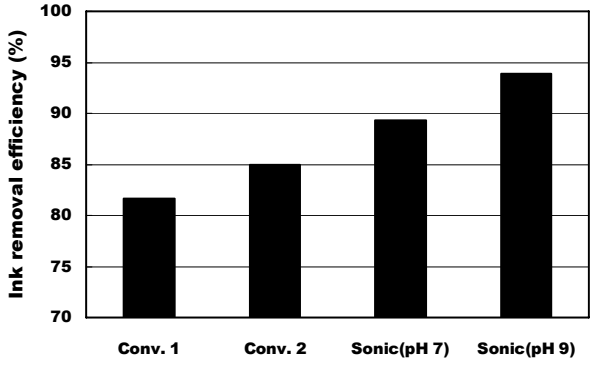

Fig. 4. Effect of pulping methods on the ink removal efficiency of white ledger.

Physical Properties of Paper

The earlier research result shown that the effect of ultrasonic treatment on pulp was similar to the refining (Won and Lee, 1996). If the same effect can be obtained from the ultrasonic deinking of white ledger, it might be possible to obtain the improved physical properties of paper. The air permeability of paper obtained from conventional deinking was 4.34-4.48 seconds and 2.46-3.82 seconds for the ultrasonic deinking (Fig. 5). These results mean that the paper obtained from the conventional deinking was denser than those of paper obtained from the ultrasonic deinking. The higher brightness (78.8-80.6%, Erlepho) was obtained by the ultrasonic deinking than those by the conventional deinking (78.2-79.6%, Erlepho). This result means that the ultrasonic deinking might be superior to the conventional deinking, although the difference was not so much. The breaking length (2.8-3.8 km) of paper obtained for the ultrasonic deinked pulp was also little bit higher than those (2.7-3.3 km) obtained from the conventional deinking (Fig. 6). It was confirmed that the ultrasonic treatment is beneficial in the improvement of paper properties.

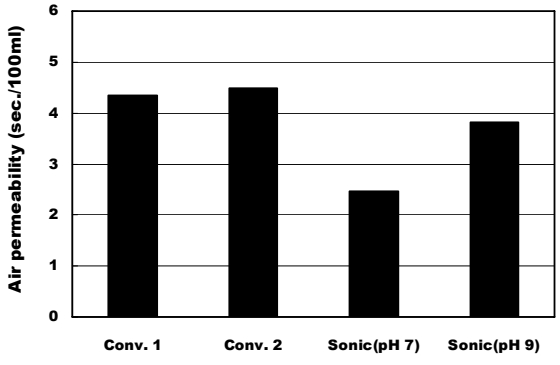

Fig. 5. Effect of deinking methods on the air permeability of paper.

Energy Consumption

It was found that the ultrasonic deinking of white ledger was superior to the conventional deinking in the ink removal efficiency and physical properties of paper. However the cost vs. performance improvement should be considered in order to confirm the ultrasonic deinking can be an alternative for the conventional deinking method. The electric energy consumption by the ultrasonic treatment for 10 min. at 1% consistency was 30.85 kWh per oven dry ton of white ledger (Fig. 7). If the ink removal efficiency of ultrasonic deinking is increased to more than 90% by the optimization of deinking condition, and the ultrasonic treatment time is decreased to 5 min., the competitiveness of ultrasonic deinking could be improved by the reduction of energy consumption.

Effluent Qualities

The premise for development of new process is the environmentally friendly process that the energy, chemicals and effluent contamination should be minimized. The

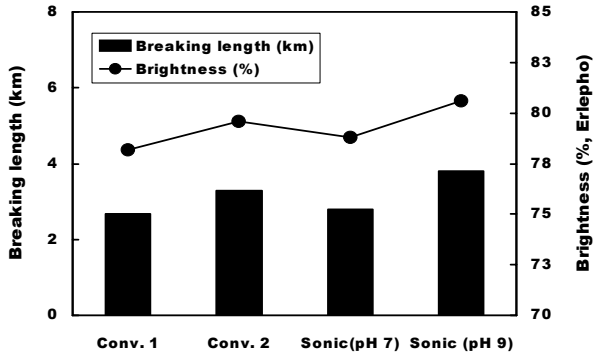

Fig. 6. Effect of deinking methods on the breaking length and brightness of paper.

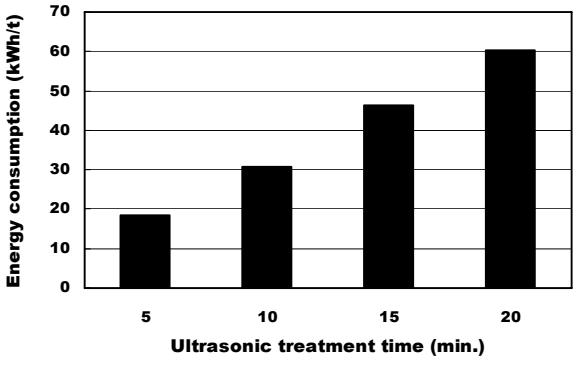

Fig. 7. Relationship between the ultrasonic treatment time and energy consumption.

Table 2. Characteristics of pulping effluents

Sample	pH	SS (mg/l)	COD (ppm)
Fresh water	6.8	66	0.8
Fresh water + surfactant		142	20
Conventional 1	11.3	658	530
Conventional 2	11.8	683	640
Ultrosinic, pH 7	7.0	376	290
Ultrasonic, pH 9	9.0	466	320

qualities of fresh water, the effluents of conventional pulping and ultrasonic treatment were compared as summarized in Table 2. As mentioned in materials and methods, the deinking chemicals were not added nearly during ultrasonic treatment. The excellent ink removal efficiency and physical properties of paper were obtained with only small amount of surfactant. Although the effluent qualities can be expected by the calculation, the qualities of fresh water, the effluents of conventional pulping and ultrasonic treatment were compared as shown in Table 2. The suspended solid of the ultrasonic effluent (pH 9) was 466 ppm, which was 70.79% of conventional pulping 1 and 68.21% of conventional pulping 2. The COD of the ultrasonic effluent (pH 9) was 320 ppm, which was 60.38% of conventional pulping 1 and 50% of conventional pulping. Thus it was confirmed that the significant improvement of the effluent could be improved by the ultrasonic system.

CONCLUSION

This study was carried out to develop the environmentally friendly deinking system for white ledger. It was investigated whether the ink removal efficiency and pulp qualities can be improved by the ultrasonic deinking. The effects of conventional pulping and ultrasonic treatment of white ledger on the ink particle size distribution and ink removal efficiency were compared. The physical properties of paper, energy consumption and effluent qualities were measured. The ultrasonic treatment of white ledger resulted in the ink particle size distribution suitable for flotation. The ink removal efficiency, brightness, breaking length and effluent quality were improved by the ultrasonic deinking. It is expected that the competitiveness of ultrasonic deinking system could be improved by the optimization of treatment condition. The optimization and pilot trials will be required for the commercialization.

LITERATURE CITED

Begin, R. M. 1963. The effects of high frequency on secondary fibres, Proceedings of Technical Section, CPPA, pp. T330-T336.

Blain, T., J. Grant and D. Oldroyd. 1993. Short sequence recycling: The mechanism, 2nd Research Forum on Recycling, CPPA, pp. 101-110.

Galland, G., Y. Vernac and B. Carré. 1995. The advantages of combining neutral and alkaline deinking, 3rd Research Forum on Recycling, CPPA, pp. 235-245.

Grant, J. and T. Blain. 1995. Short sequence recycling : The factors affecting ink agglomeration and stability, 3rd Research Forum on Recycling, CPPA, pp. 247-255.

Haché, M. J. A., L. Hubley and D. Munroe. 1995. Reductive deinking - An innovative approach for the deinking and bleaching of wood-based paper, Proceedings of 4th Pira International Wastepaper Technology Conference, pp. 139-146.

Heimonen, J. and P. Stenius. 1955. The comparison of different types of deinking chemicals in alkaline and neutral deinking of coated and non-coated papers, Proceedings of 4th Pira International Wastepaper Technology Conference, pp. 109-136.

Heise, O. U., W. G. Fineran, Jr., J. P. Unwin, M. Sykes, J. J. Klungness and S. Abubakr. 1995. Industrial scale-up of enzyme enhanced deinking of non-impact printed toners, Proceedings of 1995 TAPPI Pulping Conference, pp. 349-354.

Iwasaki, T., J. Nakano, M. Usuda and N. Migita. 1967. Studies on beating of pulp (II). Effect of ultrasonic treatment on chemical pulp, Japan Tappi 21(10): 557.

Jeffries, T. W., J. H. Klungness, M. S. Sykes and K. R. Rutledge-Cropsey. 1994. Comparison of enzyme-enhanced with conventional deinking of xerographic and laser-printed paper, Tappi Journal 77(4): 173.

Jobbins, J. M. and O. U. Heise. 1996. Neutral deinking of mixed office waste in a closed-loop process, Proceedings of 1996 TAPPI Recycling Symposium, pp. 27-32.

Naimpally, A. V. 1982. Note on use of ultrasonics for deinking paper, Appita 35(3): 242.

Norman, J. C., N. J. Sell and M. Danelski. 1994. Deinking laser-print paper using ultrasound, Tappi Journal 77(3): 151.

Offill, L. G. and R. A. Venditti. 1995. Effect of ultrasonic treatment on the size distribution of toner particles in wastepaper, Proceedings of 1995 TAPPI Recycling Symposium, pp. 53-60.

Rutledge-Cropsey, K., S.M. Abubakr and J.H. Klungness. 1995. Performance of enzymatically deinked wastepaper on paper machine runnability, Proceedings of 1995 TAPPI Pulping Conference, pp. 639-643.

Scott, W. E. and P. Gerber. 1995 Using ultrasound to deink xerographic waste, Tappi Journal 78(12): 125.

Simpson, F. W. and S. G. Mason. 1951. Note on the treatment of

cellulose fibres with ultrasonic waves, Proceedings of Technical Section, CPPA, pp. 249-251.

Sykes, M., J. H. Klungness, F. Tan and S. Abubakr. 1995. Environmentally sound alternatives for upgrading mixed office waste, Proceedings of 1995 TAPPI International Environmental Conference, pp. 445-448.

Turai, L. L. and C. H. Teng. 1978. Ultrasonic deinking of waste paper, Tappi 61(2): 31.

Willems, P. 1962. Kinematic high-frequency and ultrasonic treatment of pulp, Proceedings of Technical Section, CPPA, pp. T455-T462.

Won, J. M. and M. K. Lee. 1996. Effect of ultrasonic treatment on the pulp properties, Journal of Korea TAPPI 28(2): 46.