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Neutral Deinking of Old Newsprints Contaminated with Flexo Ink

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ABSTRACT

Presence of small amount of old newspapers printed with waterbased flexographic inks leads to a significant loss of brightness of the deinked pulp by flotation process. Recently there has been an increased interests in employing neutral deinking processes to solve the problems associated with waterbased flexo ink.

A comparative experimental study was performed to evaluate the efficiency of neutral deinking and conventional alkaline deinking for ONP furnishes contaminated with flexo ink. Effects of the deinking processes on pulp quality and white water characteristics were examined. It was shown that neutral deinking would provide significant improvement in brightness, yield, and freeness as compared with conventional alkaline deinking. There was no increase in brightness when OMG was added in the furnish up to 20 %, and it was attributed to the redeposition of flexo inks on chemical pulp fibers.

1. Introduction

Deinked pulps are useful raw materials in the manufacture of newsprints and tissue products. During the period of 20 years from 1970 to 1990, worldwide demand of recycled fiber increased about 5 % a year, while the demand of virgin fibers increased only 2.5 % a year (1). It is almost certain that this trend of utilizing increased amount of recycled fibers will continue in the future not only to save the manufacturing cost but also to meet the environmental regulations.

Diverse printing processes are being used today for printing newspapers, and this causes difficulties in recycling ONP. Especially difficulties deriving from the waterbased flexo printed newspapers are well recognized. Flexography has several advantages for printing newspapers. It is a low cost method of printing newspapers at top industry standard speed. It is simple to control color and produces lower waste during printing. Furthermore, flexographic inks are entirely solvent free and are considered to be environmentally friendly (2, 3). Thus the use of flexography for printing newspapers has increased substantially, especially in Europe and North America.

Flexo printed ONP, however, leads to deinking difficulties in the conventional flotation process. Thus many consider flexography is not environmentally friendly. The deinking difficulties of flexo printed papers are associated with the acidic resins, mainly acrylic resins, which become water

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soluble or dispersible when neutralized with organic bases such as amines (4). In conventional alkaline deinking conditions the flexo ink binders are solubilized to form very small particles with hydrophilic character, which tend to remain dispersed in the pulp slurry (4-6).

These extremely dispersive waterbased flexographic inks are not collectable at all under alkaline conditions and will result in a dark water phase and poor final brightness in a conventional alkaline flotation deinking system. In order to solve the difficulties associated with waterbased flexo ink various deinking processes have been proposed. For instance, it has been pointed out washing deinking is effective in removing waterbased flexographic inks (6, 7). Washing deinking, however, is not widely accepted in many countries mainly because it requires considerable amount of process water. It has also been proposed that a two stage flotation deinking process would be very effective for deinking ONP's containing flexo printed materials. Deinking in neutral conditions is carried out in the first loop of the two stage process for the removal of waterbased flexographic inks, and alkaline deinking is performed in the second loop to remove conventional offset inks (10, 11). The success of this two stage process relies on the fact that waterbased flexo inks are not dispersed into small particles in neutral or acidic conditions. This suggests neutral deinking could be a logical alternative for deinking ONP contaminated with flexo printed papers. Furthermore, neutral deinking is an environmentally benign and highly cost effective process since it reduces the use of chemicals and effluent discharge (8-10).

Since more equipment and steps are required in the most of the new processes proposed to solve the deinking difficulties, it is uneconomical for many mills to adopt these luxurious processes. It is worthwhile, therefore, to investigate the possibility of using a single stage deinking process for removing both offset and flexo inks which have very different character.

The immediate purpose of this study was to evaluate the effectiveness of a single stage neutral deinking process for the furnishes containing both flexo printed and conventional offset printed papers. The influence of different types of surfactants and OMG contents on deinking efficiency was examined.

2. Experimental

Three months old offset printed domestic newspapers, and 8 months old flexo printed newspapers imported from the U.S were used in this experiment. Newspaper inserts with an ash content around 35 % was also used to investigate the effects of coated OMG on deinking efficiency for the mixed ONP furnishes. When evaluating the influence of the amount of flexo printed papers, 10 or 20 % of the offset printed papers were substituted with the flexo printed papers. 0.2-0.6 % of surfactants were added to water prior to charging the furnish for pulping. During the entire course of the deinking experiments the temperature of slurries was maintained constant at 45 ℃.

In neutral deinking experiments, two high alcohol type nonionic surfactants, oleyl ether and oleyl ester, were used. In alkaline deinking, oleic acid and 1.0 % of caustic soda were used. Pulping was carried out for 15 minutes at 5 % consistency. After pulping, the furnish was kept in a water bath for 30 minutes, and diluted to 1 % with tap water, then flotation deinking was carried out in a Voith flotation cell for 10 minutes.

To investigate the effect of OMG contents on neutral deinking, 10 or 20 % of OMG was used along with 20 % of flexo printed ONP. Changes in brightness, yield, freeness and ash removal percentage in neutral or alkaline conditions were examined. The characteristics of white water of accept furnish including turbidity, COD, TDS and cationic demand were also determined.

3. Results and discussion

3.1 Neutral Deinking vs. Alkaline Deinking

Deinking difficulties of flexo printed ONP that make the conventional flotation deinking plant inefficient is well-recognized. These difficulties are due to the tendency of flexo inks to form small size ink particles that are highly hydrophilic in character. These particles tend to stay dispersed in pulp slurry and are apt to redeposit on the fiber surface.

To evaluate the possibility of employing a single stage neutral deinking process as a method to eliminate the difficulties associated with flexo ink, the deinking efficiency of neutral and alkaline processes was examined using ONP furnishes that contains 0-20 % of flexo printed papers. In alkaline deinking, oleic acid, which is considered to be the most effective deinking chemical in alkaline conditions, was used as a surfactant along with sodium hydroxide. On the other hand, in neutral deinking two different types of surfactants, oleyl ester and oleyl ether, were used.

As shown in Fig. 1, flexo printed ONP caused a substantial brightness reduction for deinked pulps. Significant improvement in brightness, however, was obtained when deinking was carried out in neutral conditions. Especially, when oleyl ether was used, deinked pulps with high brightness were obtained. Surprisingly the brightness readings were higher than that obtained with offset printed paper only in alkaline conditions irrespective of the amount of flexo printed papers. This is because lower alkali darkening as well as greater ink removal arise in neutral deinking.

The amount of ink particles larger than 80 μm in diameter decreased as the amount of flexo printed ONP in the furnish increased as illustrated in Fig. 2. This indicates that flexo inks disperse to particles small enough not to be detected as discrete particles in this measurement. As seen here, oleyl ether was most effective in reducing the amount of large ink particles.

Yield is one of the most important criteria determining the economy of the deinking processes. Neutral deinking was superior in yield to alkaline deinking as depicted in Fig. 3. This is because the calcium ions present in alkaline deinking process tend to collect not

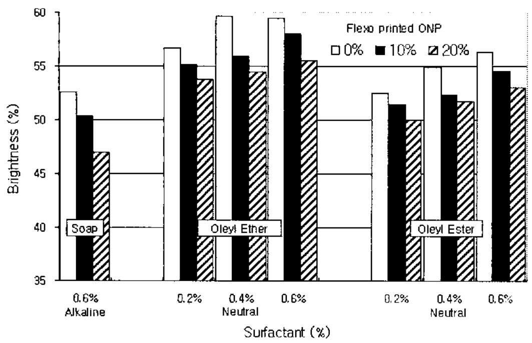

Fig. 1. Effect of the amount of flexo printed papers and surfactant on brightness.

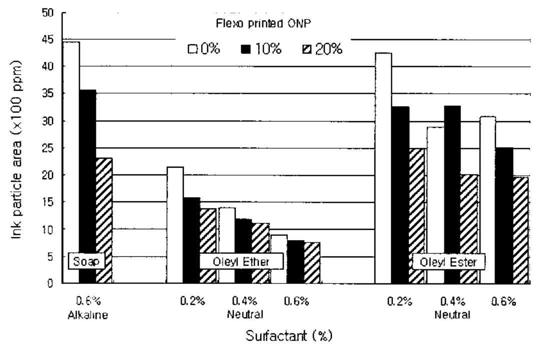

Fig. 2. Effect of the amount of flexo printed papers and sufractant on ink particle area.

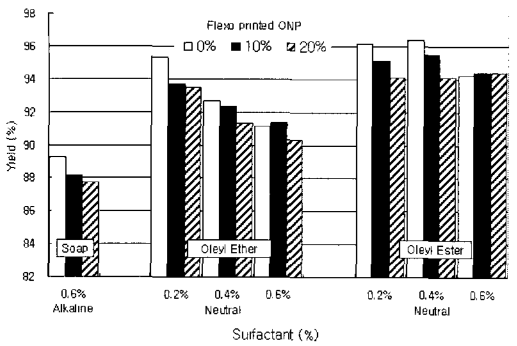

Fig. 3. Yield of deinked pulps.

only ink particles but also pulp fibers and make them rejected. As the amount of flexo printed ONP increased, yield decreased. Dispersants contained in the flexo inks and higher fines content of flexo printed papers were appeared responsible for the loss in yield. The amount of flexo printed ONP in the furnish did not affect the freeness of deinked pulps. Neutral deinked pulps showed higher freeness than alkaline deinked ones.

3.2 Effects of OMG

3.2.1 Brightness, yield, freeness and ash removal efficiency

It has been known that addition of OMG, which contains fillers and chemical pulps, improves the optical and strength properties of deinked pulps (12). To evaluate the influence of OMG on the optical and strength properties of deinked pulps, deinking experiments were carried out with the ONP furnish containing 10 or 20 % of OMG. The amount of flexo printed ONP in the furnish was maintained constant at 20 %. In other words, deinking experiments were performed with the furnishes consisted of offset printed ONP:flexo printed ONP:OMG at a ratio of 80:20:0, 70:20:10, and 60:20:20.

OMG did not influence the brightness after flotation as shown in Fig. 4. This indicates OMG is not effective for improving the brightness of ONP if it is contaminated with flexo inks. This is contradictory to an early finding (12). Redeposition of small flexo inks onto chemical pulps appeared responsible for this (13). Redeposition of ink particles onto fibers occurs when ink particles enter the fiber lumens through the fiber ends, pits or similar openings, or when they deposit in the cracks of fibers (14). Chemical pulps, especially refined chemical fibers, have many sites available for ink deposition. This phenomenon of ink redeposition will be described in detail later. Even though no significant improvement of brightness was observed with OMG, a substantial increase in opacity and tensile strength was achieved.

The effect of the amount of OMG on yield is illustrated in Fig. 5. Increasing the amount of OMG with 35 % of ash in the furnish decreased yield. When the furnish contains OMG substantially great amount of foam was observed during flotation, most probably because of the generation of carbon dioxide from carbonate pigments. Furthermore, the foam showed great stability when OMG was used. These two facts appeared to cause yield reduction when OMG was contained in the furnish. Higher yield was obtained in alkaline condition than in neutral condition

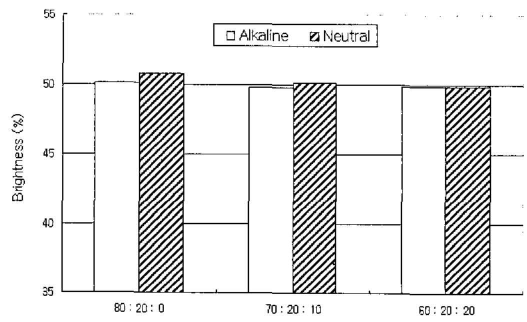

Fig. 4. Effect of OMG on brightness.

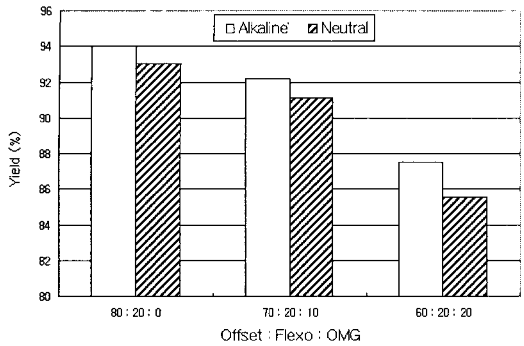

Fig. 5. Effect of OMG on yield.

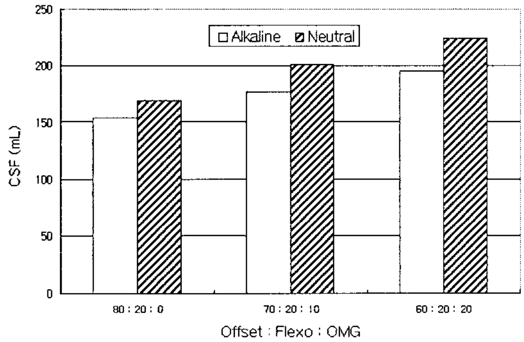

Fig. 6. Effect of OMG on freeness.

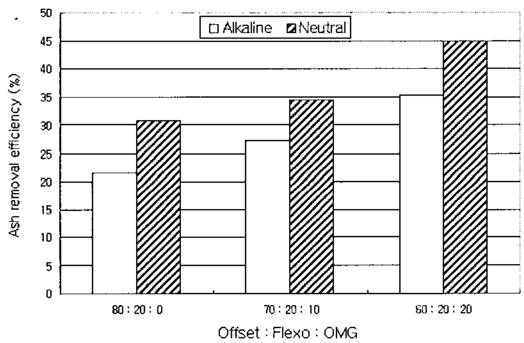

Fig. 7. Ash removal efficiency as a function of OMG content.

since more ashes and fines tend to be removed in neutral condition.

Freeness is an important variable in the papermaking process since it affects caliper, strength, and machine speed. The influence of OMG on freeness is depicted in Fig. 6. As seen here freeness increased with the increase of OMG content. Higher freeness was obtained with neutrally deinked pulps since it is more efficient in ash removal (Fig. 7).

3.2.2 White water analysis

Physico-chemical properties of white water vary depending on the amount of OMG in the furnish since not only pigments but also various chemicals such as latices, starch, dispersants, CMC, etc. are contained in OMG. The influence of the amount of OMG on the turbidity, COD, TDS (total dissolved and colloidal substances), and cationic demand of the white water separated from the accept furnish after flotation deinking was determined and shown in Table 1. Results showed that the properties of white water were aggravated with the increase of OMG contents irrespective of deinking processes employed. More severe contamination of white water occurred in alkaline condition. For instance, with the increase of OMG contents the turbidity of white water increased from 270 to 369 FTU in alkaline condition, while it increased from 195 to 236 FTU in neutral condition. Increased elution of lignin and hemicellulose from mechanical pulps and greater dissolution of dispersants and binders contained in OMG with the increase of pH elevated the levels of COD, TDS and cationic demands.

The cationic demand of white water is closely associated with the amount of anionic trash which impairs the product quality and paper machine runnability. Deinked pulps in alkaline condition showed greater cationic demand suggesting neutral deinking would provide better furnish for papermaking.

Table 1. White water characterisitcs

	Condition	Offset : Flexo : OMG		
		80:20:0	70:20:10	60:20:20
Turbidity	Alkaline	270	316	369
(FTU)	Neutral	195	210	236
COD	Alkaline	248	295	326
(ppm)	Neutral	166	195	216
TDS	Alkaline	345	376	434
(ppm)	Neutral	231	269	319
Cationic	0.863	0.912	1.117	'
demand(mL)	Neutral	0.376	0.482	0.504

3.3 Deposition of flexographic ink

As described earlier OMG showed no beneficial effect in brightness improvement when flexo printed ONP was contained in the furnish, and it was ascribed to the greater redeposition of flexo inks onto chemical pulp fibers. To elucidate this hypothesis brightness reduction of various pulps including TMP, softwood BKP and hardwood BKP were examined. The effect of refining was also investigated for bleached chemical pulps. Prior to using the pulps in this experiment they were aged for 24 hours at 105 ℃ to simulate the aging of OMG.

To the flotation cell containing 0.5 mL of flexo inks disintegrated pulp slurry was added. And flotation was carried out as in flotation deinking. The pulp fibers would be contaminated by the flexo inks during the flotation process. Brightness readings of TMP, softwood BKP and hardwood BKP were 61.3, 79.7 and 81.0 %, respectively. Brightness of chemical pulps increased slightly after refining (Fig. 8). Although the brightness readings of chemical pulps were substantially higher than that of TMP, they were decreased abruptly to the level of TMP after deposition of flexo inks. This indicates that the chemical pulp fibers tend to be contaminated more severely than mechanical pulps with flexo ink particles. Furthermore, the ink partilces deposit rather strongly on the cheimcal pulp fibers, which is confirmed from the brightness of hyperwashed pulps. This verifies that the chemical pulp fibers contained in OMG would be preferentially contaminated by flexo inks through a redeposition phenomenon when the furnish contains flexo printed ONP.

The amount of flexo ink deposited onto the pulp fibers were determined by measuring the absorbance of white water and illustrated in Fig. 9. Again it is evident that the contamination level of TMP is a lot lower than that of BKP. Refined hardwood BKP, which is the most widely used in the manufacture of printing papers, showed the high-

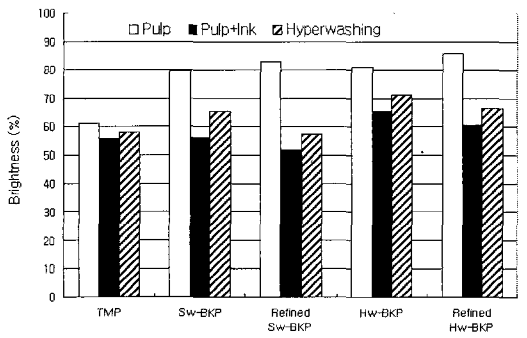

Fig. 8. Brightness of various pulps before and after deposition of flexo inks, and hyperwashing.

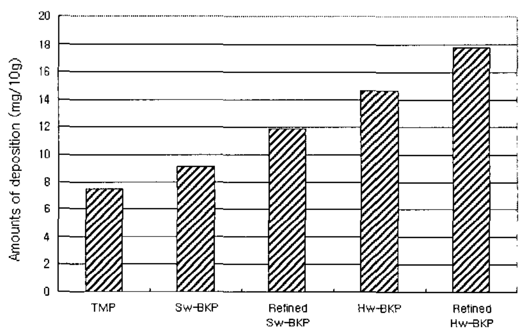

Fig. 9. Deposition of flexo ink onto various pulps.

est contamination tendency by redepositon of flexo inks.

4. Conclusions

The effectiveness of neutral deinking for the furnishes containing flexo printed papers along with conventional offset printed papers was investigated. Flexo printed ONP caused a substantial brightness reduction for deinked pulps. Significant improvement in brightness, however, was obtained when deinking was carried out in neutral conditions with oleyl ether as a surfactant. Significant loss of yield was observed in alkaline deinking because the calcium ions present in alkaline deinking process tend to collect not only ink particles but also pulp fibers and make them rejected. Deinking in neutral condition was found to provide better quality pulps in brightness and freeness at higher yield.

The properties of white water were aggravated with the increase of OMG contents irrespective of deinking processes employed. More severe contamination of white water was occurred in alkaline condition. OMG showed no beneficial effect in brightness improvement when flexo printed ONP was contained in the furnish, and it was ascribed to the greater redeposition of flexo inks onto chemical pulp fibers.

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