# High Efficiency Recycling of Newsprint

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***ABSTRACT***

*Given the increasing use of recycled fiber in wide variety of paper applications, the deinked pulp must meet always higher market requirements. To achieve this, mechanical processes such as deinking, cleaning and screening must be carefully optimized and controlled. In the pulping processes, the optimized chemicals used here to produce high brightness are sodium hydroxide (2%), surfactant ionic-non ionic (2%), sodium silicate (2%), consistency (10%) at 50°C for 20 minutes. The brightness achieved was 50% ISO. Bleaching of recycled fiber can be done with oxidative bleaching agent e.g. peroxy acetic acid. The brightness of this bleaching step was achieved at temperature of 60-63°C. The effect of recycling on the mechanical properties of the fibre and on paper made from those fibres is also discussed here. Loss of the mechanical properties in a recycled pulp can be recovered by blending these recycled fibres with mechanical virgin pulp fibres.*

## INTRODUCTION

The use of secondary fibers in paper industry has been growing over the past few years because of current environmental awareness. The ability to utilize these lower quality wastepaper packs is very important to reduce the operating cost for the deinking plant. The processes for deinking plant are becoming very complex with multiple stages of screening, cleaning, floatation, dispersion and kneading (1).

Various approaches can be used to remove the ink from wastepaper. The major process for ink removal is floatation process. Almost all of the increase of deinking capacity in the past decade is related to high consistency (10-14%) with chemicals. Pulped stock is screened and fed at about 1% consistency into the flotation cell. Air is introduced for stirring and hold the ink particles and carry them to the surface where they will be sucked or skimmed off (2). Deinking of wastepaper has been developed by empirical means for many decades. Many combinations of chemicals have been proposed. In deinking process, pulp is first disintegrated at low alkalinity (3) in the pulper where the combination of physical and chemical actions separates the ink particles which are then carried away by the foaming action of air bubbles and surfactants so that clean fiber steam remains (4).

Hydrogen peroxide is used in this system in the pulper to protect the brightness of the fiber and enhance ink removal and if necessary, again in a separate bleaching stage to increase the fiber brightness.

## EXPERIMENTAL

The newsprint which was used in this study is from Al-Ahram newspaper, Cairo, Egypt. About 20 g of the newspaper was used in every deinking process.

1. Pulping : Pulping was carried out in PVC bags. Pulping conditions were, old newspaper, sodium hydroxide (1-3%), sodium silicate (2%) or magnesium sulphate (2%), surfactant, Egyptol, Espacone and Toximol (0.5-3.0%) and hydrogen peroxide (2.0%) with consistency of 10% at temperature of 40-60°C for 10-20 minutes.

2. Floatation: 20 gm O.D. pulp at 0.5% consistency at 55°C for 15 min. was taken. No chemicals were added at this stage, only fresh water was used.

3. Bleaching: The bleaching of the deinked newspaper was carried out via two stages. First stage was carried out by using 2% peroxyacetic acid stage at 70°C for 60 minutes and 10% consistency. Second stage was carried out by using 2% hydrogen peroxide at pH 11 for 60 min at 70°C and 10% consistency.

## RESULTS AND DISCUSSION

The type of equipment and deinking chemicals used in any deinking process are driven by the varieties of ink found in wastepaper. The type of equipment used to remove ink is based on the particle size to be removed. Screening and cleaning are employed to remove particles of the ink. Floatation removes particles which can not be removed by screening. Washing is the most efficient step for removing the smallest particles of ink. However, both washing and floatation require chemicals to aid them to perform efficiently.

## *Factors controlling the Recycle Potential of the Pulp*

### *1- The alkalinity in the repulping stage:*

Alkalinity in the repulping stage of the deinking process is important to facilitate ink removal by swelling the fibers and by saponfication of the ink binder (5).

Table-1 shows the effect of alkalinity in the repulping process on the yield and brightness of the pulp produced for newsprint. From the table, it is clear that on increase of the alkalinity of the pulping liquor, the brightness of the pulp produced increases till 2% NaOH. By increasing the alkalinity to 3% NaOH, the brightness began to decrease. The addition of sodium hydroxide could be used in a moderate concentration to make balancing action for sufficient alkalinity to achieve good saponfication and hydrolysis of resin of the ink, fiber flexibility and hydrogen peroxide performance while minimizing the formation of chromophores and softening of any contrary materials. On the other hand, pulp brightness slowly increases as the pH is increased from 8.6 to nearly about 11.5. Above this pH, the brightness starts to decrease (6). The added sodium hydroxide in the pulper is the amount required to reach a given pH, not to a given dose on the fibers. The problem with alkali deinking is concerned only with wood containing furnishes. Higher pH of 11 can be used with wood-free furnishes with no alkali darkening (7).

**Table-1 Effect of alkalinity in the repulping stage**

| NaOH conc., % | Yield % | Brightness ISO% | Strength property | |
|---|---|---|---|---|
| | | | Breaking length, km | Tear factor |
| 1 | 88.40 | 42.10 | 3.85 | 62.75 |
| 2 | 86.50 | 48.30 | 3.85 | 62.50 |
| 3 | 82.30 | 40.30 | 3.45 | 58.70 |

The repulping of newsprint with alkali was only insufficient for hot melt additives. Therefore, to increase the removal of hot melt adhesives, some additives must be added.

### *(i) Surface active agents (surfactants):*

In this study, three surfactants were used, Egyptol, which was delivered from Misr petroleum company, aspecone 1030 which was delivered from starch and yeast company, Egypt and the third one was Toximol (Stepan, R.C.S., Grenoble).

The best one used in this study is Toxmiol which produced the best brightness (Table-2). Surfactants used for deinking, will have principal components, hydrophobic and hydrophilic. When it is introduced in the pulper or just prior to the floatation, the hydrophobic end will associate with the ink or dirt while the hydrophilic end will remain in the water. The most frequently used surfactants are nonionic as they function independent of water hardness. It aids in the penetration of the alkali into the fiber for better fiber swelling and ink separation. From Table-2 it is clear that the surfactant (Toximol) gives the best results for deinking by helping to disperse the ink particles into the water so that they do not redeposite on the fiber. It also produces stable foams in the floatation step which carry away the ink particle (5). On the other hand, surfactant is very important in the deinking process because it increases the connections between ink particles (mostly hydrophobic) and the air bubbles (in the floatation process). This connection is partially reduced by the surfactant molecules.

**Table-2 Effect of surfactant kind**

| Kind of surfactant | Yield % | Brightness ISO% | Strength property | |
|---|---|---|---|---|
| | | | Breaking length, km | Tear factor |
| Aspecone 1030 | 83.70 | 59.20 | 3.25 | 60.00 |
| Egyptol | 88.50 | 48.70 | 3.65 | 58.33 |
| Toximol | 82.60 | 60.80 | 3.83 | 62.50 |

From Table-3, it is seen that, brightness of the deinked pulp produced decreases by increasing the amount of surfactant more than 2%. In this case, it is conceived that the excess of surfactant begins to form double layer and that hydrophiles are associated together causing in ink-hydrophobe, hydrophile-water and hydrophile-hydrophobe complexes to be deposited onto fiber or formed into large agglomerates of ink and surfactant (9).

| Table-3 : Effect of surfactant concentration | | | | |
|---|---|---|---|---|
| Surfactant Conc., % | Yield % | Brightness ISO% | Strength property | |
| | | | Breaking length, km | Tear factor |
| 0.5 | 83.25 | 52.40 | 3.70 | 63.50 |
| 1.00 | 83.35 | 55.35 | 3.75 | 62.85 |
| 2.00 | 82.60 | 60.80 | 3.83 | 62.50 |
| 3.00 | 80.25 | 61.51 | 3.54 | 62.35 |

### *(ii) Additives:*

Table-4 shows the results on the effect of additives e.g. sodium silicate, magnesium sulfate and EDTA (ethylenediaminetetraacetic acid) in the repulping process. From the table, it is seen that addition of sodium silicate produces pulp with good quality more than other two additives since the amount of sodium hydroxide necessary to balance the pH may be lowered. This is attributed to the fact that sodium silicate helps in the stabilization of hydrogen peroxide during repulping process and gives the alkalinity which is equivalent to pH 11 with sodium hydroxide, because it contains equal portion of silica and sodium oxide.

$$Na_2SiO_2 \leftrightarrow 2Na^+ + OH^- + SiO_3^-$$

On the other hand silicate aids deinking through the dispersion action which prevents ink particles from redepositing on the deinked fibers. The use of sodium silicate in the pulp bleaching relates to the stabilization of hydrogen peroxide. In the pulper, sodium silicate has an important role as an ink collector. The brightness gain due to the application of sodium silicate is independent of the brightness gain due to the use of peroxide (10).

### *Effect of the repulping time:*

Table-5 shows the effect of repulping time at 50°C on the properties of deinked pulp produced . From the table, it is clear that, increasing of pulping time from 15 to 20 minutes leads to increasing the brightness of the pulp produced (after bleaching stage) from 47.5 to 60.8 percent. This can be attributed to the increase of contact between the old newsprint and the chemicals.

| Table-4 : Effect of Additives | | | | |
|---|---|---|---|---|
| No. | Additive | Conc., % | Yield, % | Brightness |
| 1 | $Na_2SiO_3$ | 1 | 84.50 | 62.15 |
| 2 | $MgSO_4$ | 1 | 81.25 | 58.5 |
| 3 | EDTA | 1 | 85.60 | 56.8 |

By increasing the pulping time from 20 to 30 minutes, the properties of the pulp produced is slightly affected especially the brightness which decreases from 60.8 to 60.15%. Further increase in the pulping time, the yield and brightness decrease from 88.5 to 78.4 and 60.8 to 57.25% respectively. This can be attributed to the longer period in pulping time and the redeposition of the ink on the fiber and increase of the degradation of the pulp produced .

### *Effect of the repulping temperature*

The repulping temperature has an important role in deinking process. Increasing the repulping temperature from 40 to 50°C, the brightness of the pulp produced (after the bleaching step) increases from 55.25 to 60.8% ISO. This can be attributed to the increase in the penetration of the chemicals through the old newsprint fiber and consequently the dissolution of the ink resin. This causes an increase in the separation of the ink particles which are then easy to float with surfactants.

By increasing the pulping temperature to more than 50°C, the brightness is not affected except that the yield of the pulp produced decreases. On the other hand, breaking length and tear factor decrease by increasing the pulping temperature. This can be attributed to the degradation of deinked pulp during the repulping processes.

| Table-5 : Effect of the repulping temperature | | | | |
|---|---|---|---|---|
| Surfactant Conc., % | Yield ISO% | Brightness, % | Strength property | |
| | | | Breaking length, km | Tear factor |
| 40 | 84.22 | 55.25 | 2.78 | 60.45 |
| 50 | 82.60 | 60.80 | 3.83 | 62.50 |
| 60 | 80.60 | 60.55 | 3.62 | 61.52 |

### *(iii) Hydrogen peroxide:*

To get the best use of peroxide, it is important to maximize the amount of $HOO^-$ anion

$$H_2O_2 + NaOH \rightarrow HOO^- + Na^+ + H_2O$$

The options available are raising the pH by increasing NaOH level, raising the temperature, reducing the competing side reaction e.g decomposition of hydrogen peroxide such as the presence of the heavy metal ions and raising the amount of hydrogen peroxide (8, 9). The optimum conditions for the use of hydrogen peroxide in our work were found to be 2% (based on newsprint fibers).

The decomposition of peroxide during repulping process can be lowered by the addition of stabilizing agent such as silicate which can improve the brightness also. Peroxide is not just the brightening agent for the fiber, it also helps in ink removal. By oxidizing the varnish or the oily substances in the ink it helps saponification. Peroxide can also penetrate the fibers and through the decomposition, it can help separation of the ink particles from the fibers.

### *Mechanical Properties of the Deinked pulps*

To optimize the deinking properties of the pulp produced, the mechanical properties of the sheet produced from these pulps were investigated. Table-6 shows the mechanical properties of the sheets produced from the optimum conditions of the deinked process. From the table, it is clear that the breaking length of the deinked pulp increases by increasing the amount of the blending virgin bleached thermomechanical pulp. This can be attributed to the

**Table-6 : Blending with chemimechanical pulp**

| Blended CMP, % | Brightness | Strength property | |
|---|---|---|---|
| | | Breaking length, km | Tear factor |
| 0 | 62.15 | 3.75 | 70.25 |
| 10 | 62.30 | 3.81 | 70.10 |
| 20 | 62.50 | 3.82 | 69.45 |
| 50 | 62.95 | 3.90 | 65.45 |
| 100 | 64.50 | 3.95 | 62.71 |

increase of the cross bonding between the virgin fiber (less degraded) with the deinked fibers (high degraded during the repulping and bleaching processes). On the other hand, the tear strength decreases by increasing the amount of the virgin pulp added. Moreover the brightness of the sheet produced from blended fiber increases by the amount of the virgin fiber added (Table-6).

## CONCLUSIONS

The study has demonstrated that the recycle of newsprint can be achieved with high efficiency. The paper sheets produced from the recycled pulp is of moderate brightness and good strength properties. As, the experimental work has been carried out with low technology equipment the experimental results are applicable to small - scale industry.

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