Deinking of Indian Newspaper by Agglomerate Floatation

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Recycling of newspapers is done after deinking. One of the most important methods of deinking is floatation. As the ink particles are fine in nature, the agglomerate floatation has been tried and found to be efficient in separating ink particles with only 2.2%-3.5% loss of brightness and the paper recovery is more than 95%.

Keywords: Deinking; Newspaper; Agglomeration; Floatation

INTRODUCTION

Increased recycling of waste paper is being emphasized everywhere. Now-a-days, waste paper is being used extensively in manufacturing box board, tissue papers, newsprint, etc[1]. Around 30% of global fibre consumption is met from waste paper. Japan uses about 70% of the deinked stock in the production of newsprint. The commercial practice of deinking includes a number of processes in succession depending on the particle size of the ink particles liberated from the newsprint. For example, to remove coarse ink particles, hydrocyclone is used. Floatation is then used to remove finer particles (around 40 μm) and washing is done to remove ultra fines. However, floatation technique is generally used for removal of ink particles and more than 65% of the industrial practices for deinking use floatation process.

Prior to floatation, the newspapers are pulped and further processing is generally done by (i) heating at a temperature between 45°C and 65°C, (ii) adjustment of pulp density to 5%, and (iii) addition of sodium silicate of 2%-3%, sodium hydroxide of 1%, hydrogen peroxide of 0.7%-1.0% and surfactant of 0.4%-3%. Calcium ion is also used as activator for adsorption of anionic collectors, such as, oleic acid[1]. The chemicals used for deinking pose a number of problems in both deinking plant as well as in subsequent operations due to foam formation. While calcium chloride is added as an activator, calcium may deposit as carbonate whereas chloride ion may lead to corrosion problems.

It has, therefore, been considered necessary (i) to improve the floatation process by reducing the number of chemicals using cheaper alternatives, (ii) to avoid the adverse effect of chemicals in the down stream processes, and (iii) at room temperature to reduce energy consumption.

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EXPERIMENTATION

An Indian daily newspaper, was the source of pulp used in this study. Solutions of (1N) NaOH and (1:1) HCI were used for pH adjustment. Methyl isobutyl carbinol (MIBC) was used as a frother. Diesel and kerosene oils were used as collectors. Hydrogen peroxide was used for improvement in brightness.

Procedure

A 20-g sample of shredded paper was placed in a Denver floatation cell of 1-l capacity in which the concentration of solids was adjusted to 5% (weight basis) for pulping pH was adjusted by using sodium hydroxide solution. Addition of floatation reagent was done in two steps: one during pulping and the other during floatation. In pulping step, a part of the floatation reagent as mentioned in the Table 1 to Table 4, was added while mixing at 500 rpm for 15-min. The mixture was kept for soaking for 16-h. This mixture was further pulped in two stages: one at 300 rpm for 30-min and the other at 500 rpm for 15-min. Pulping was done in two stages for better separation of ink particles and also to avoid breakage of ink particles. The pulp was transferred to the floatation cell and the speed of the impeller was set at about 800 rpm. The pulp was then diluted to 0.4% by weight. The remaining part of the floatation reagent was added to the pulp and conditioned for 5-min. Methyl isobutyl carbinol (MIBC) at dosages of two to three drops, were used as frother. The air was then allowed to pass through the cell for 30-min and the floatation of the ink particles was found to be over within about 30-min. Samples were collected from the float (froth) and the non-float (sink) pulps.

For measurement of brightness of the non-float, the diluted pulp was filtered on a filter paper and the circular shaped filtered mass was transferred on circular disc and allowed to dry at 80°C for 8-h. The brightness of these samples was measured in a brightness tester at an Orissa–based organization[3].

The improvement in deinking was estimated with respect to the loss of brightness as compared to the original paper without print, that is, the white portion of the newspaper and the same can be represented as

$$\text{Loss of Brightness, (\%)} = \frac{\text{Brightness of the white portion} - \text{Brightness of the sample}}{\text{Brightness of the white portion}} \times 100$$

RESULTS AND DISCUSSION

The newspaper was taken as a sample for the present study. The top portion of the papers does not contain any print and brightness of this top portion is the same as the starting material for the press. Therefore, this brightness was taken as a reference point.

Pulping

As the newsprint contains a considerable amount of the fine particles, the concept of oil agglomeration has been thought to be of great use in the present study. It has been observed by researchers[4] that deinking of newsprint can be done effectively by floating ink particles using neutral oil. The process for removal of ink requires a step to make a pulp during which the ink particles are to be dislodged from the paper base. Therefore, in pulping step, sodium hydroxide is added to increase the pH to make highly alkaline for easy removal of ink particles from the paper base. Neutral oils have been chosen, as ink particles are mostly carbon particles. Pulping steps have two functions, namely, (i) to make the paper sheets into pulp, and (ii) liberation of ink particles from paper base. The oils chosen are diesel and kerosene. It has been found[4] that high alkalinity in pulping steps is required for better separation in floatation. The amount of oil added in the pulping step has been varied to optimize a condition such that the liberated ink particles during pulping can get adsorbed on the oil droplets. Thus, as expected, it has been observed that the black ink particles are associated with the oil droplets.

Floatation for Deinking

After pulping and conditioning with floatation reagents at a particular pH, the ink particles are subjected to floatation. It can be seen from Table 1 that while pulping at a pH of 12.1 and at a dosage of 1-ml of diesel oil during floatation, the brightness is 43.4, which is found to be the highest but the paper recovery is only 76.7%. However, higher dosage of diesel oil has become less effective, though the paper recoveries are high. The brightness of the white portion of the paper is 46.3 units. Therefore, the loss of brightness as compared to the feed paper is only about 6.26%.

The efficiency of ink particle floatation is a function of two important factors, namely (i) collision between the air bubbles and the ink particles, and (ii) attachment of the ink particles to the rising gas bubbles. The probability of the collision depends on the particle size[5]. As the fine ink particles are attached to the oil droplets, efficiency of separation becomes high.

The effect of pH on flotation of ink particles is given in Table 2. The best floatation of pH is found to be at about 10.1, where the loss of brightness is only 3.46%. It has been mentioned earlier that some amount of oil is also required during pulping with a view to retain the ink particles to be adsorbed on the oil droplets after being liberated from the newspaper. Thus, oil agglomeration causes concentration of ink particles in the oil droplets, which are subsequently removed by floatation.

It is seen that at pH above 10.1, brightness decreases to 40.7. And again the brightness is higher at pH 12.1. According to Mc Kinney[6], the brightness decreases as the average size of the dispersed ink particles becomes smaller. At a fixed quantity of ink, the distribution of the ink particles size determines brightness. The deviation may be the result of the variation in ink particle size distribution.

Kerosene oil has also been taken to study the deinking process. Table 3 gives the effect of kerosene oil concentration during pulping as well as floatation steps on brightness. It is clear from Table 3, that some amount of kerosene oil is required at floatation stage, though the pulp already contained kerosene oil. It is further found from Table 3, that the low dosage of kerosene oil does not make enough oil droplets to accommodate fine ink particles and the results do not show any uniform trend. With increasing concentration, brightness increases up to 45.3 units.

Table 1 Effect of diesel oil concentration at pH 12.1 (pulping at pH 12.15 without any oil, frother, MIBC-2 drops)

Serial Number	Diesel Oil at Floatation Stage, ml	Weight of Non-float Particles, g	Paper Recovery, %	Brightness Unit*	Loss of Brightness, %
1	1.0	15.24	76.2	43.4	6.26
2	2.5	19.80	99.0	40.2	13.17
3	5.0	19.80	99.0	39.0	15.77
4	7.5	18.00	90.0	39.1	15.55
5	10.0	19.00	95.0	38.0	17.92

* Brightness of the white portion of the paper (blank paper) : 46.3 units.

Table 2 Effect of pH on floatation of ink particles (pulping pH 12.15, diesel oil: nil in pulping stage and 1-ml in floatation stage)

Serial Number	pH	Brightness Unit*	Loss of Brightness, %
1	7.7	39.1	15.55
2	9.1	41.9	9.50
3	10.1	44.7	3.46
4	11.1	40.7	12.10
5	12.1	43.4	6.26

* Brightness of the white portion of the paper (blank paper) : 46.3 units.

Table 3 Effect of kerosene oil on deinking (pH ~ 10.3, MIBC: 2 drops)

Serial Number	During Pulping, ml	During Floatation, ml	Brightness Unit*	Loss of Brightness, %
1	1.0	Nil	35.60	27.43
2	2.5	Nil	33.20	28.29
3	5.0	Nil	36.40	21.38
4	5.0	2.5	40.80	11.89
5	5.0	5.0	42.61	7.99
6	5.0	7.5	42.40	8.42
7	5.0	10.0	45.30	2.15
8	10.0	10.0	41.80	10.80

* Brightness of the white portion of the paper (blank paper) : 46.3 units.

Table 4 Effect of hydrogen peroxide on brightness (pH ~ 10.3, pulping pH: 12.15, floatation pH : 10.3)

Serial Number	H_2O_2, ml	During Pulping, ml	During Floatation, ml	Brightness Unit*	Loss of Brightness, %
1	0	10	10	41.8	10.80
2	2	10	10	43.2	7.21
3	10	10	10	42.6	7.99

* Brightness of the white portion of the paper (blank paper) : 46.3 units.

Comparing the floatation results with diesel oil and kerosene oil, it is found that diesel oil requirement is considerably low but kerosene oil provides the highest brightness (45.3 units, that is, only 2.15% loss of brightness). In all the cases, the paper recovery is more than 95%. The highest brightness is found to be at a condition when pulping has been done at 5-ml of kerosene oil and floatation at 10-ml. Higher concentrations above this provide inferior results.

To improve the brightness, hydrogen peroxide (H_2O_2) has been used and the results are given in Table 4. It is found that there is some improvement in brightness when 2-ml of H_2O_2 (approximately) has been added but higher dosage does not have much significance in improving the brightness.

CONCLUSION

The following inferences are drawn based on the present study.

- Floatation of ink particles can be done with either diesel oil or kerosene oil.
- Ink particles are adsorbed on the oil droplets and these droplets are floated out by which the paper pulp is deinked.
- Paper recovery is more than 95%.
- Hydrogen peroxide improves marginally the brightness of the deinked pulp.
- A number of chemicals normally used in practice can be avoided. Only the chemical to adjust pH, oil for ink removal and a frother are required to deink newsprint.
- The whole process of deinking is done at room temperature instead of processing at higher temperature.
- As the chemicals used are less and cheap and processing is done at room temperature as compared to the processes in existing plants, the present method is considered to be economical.
- The optimum conditions for de-inking are (i) pulping to be done at high alkaline pH with one-third of the total oil in the pulping step and two-third in floatation step, (ii) pH in the floatation should be 10.3, and (iii) MIBC may be used as a frother.

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