Deinking of Recycled Pulps Using Column Flotation: Energy and Environmental Benefits

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ABSTRACT

Deinking of recycled pulps is an important operation intended to provide pulps appropriate for making paper and paperboard products from recycled wastepaper. Conventionally, deinking of recycled pulp is conducted in a flotation cell equipped with an agitator. We have investigated the applicability of a new flotation cell based on a column without an agitator present to accomplish the deinking of typical wastepaper feedstocks and also a feedstock consisting of rejects from a conventional deinking cell.

Experimental results on the deinking operation indicate that it is possible to achieve deinking of a mixture of photocopier and laserprinted paper in the column flotation cell. The performance of the column as measured by the resultant pulp's brightness and ink particle size distributions is comparable to that of a conventional laboratory cell which incorporates severe agitation regimens. Thus, it is found that the agitator can be eliminated by using the column flotation design which could yield significant electrical energy savings in addition to savings in capital costs and other operational and maintenance costs. A series of deinking experiments were also performed on a feedstock consisting of rejected waste obtained from a conventional cell in a pilot plant. We found that de-inking of the rejected waste could yield significant usable fiber. This indicates the potential of the column flotation technique in enhancing the reuse of a waste component thus reducing the volume of deinking waste rejected into the environment.

Introduction

Deinking of wastepaper in the paper industry is accomplished primarily by the flotation process. Some conventional mechanical flotation devices that are in use in the deinking of wastepaper are simple stirred tank reactors with air bubbles sparged continuously into the recycled pulp slurry. The air bubbles collect ink particles which are usually hydrophobic and rise to the surface of the slurry in a foam or froth. This is drawn off at the top and after the foam is collapsed, it is rejected. The clean pulp sinks to the bottom of the cell where it is withdrawn. The Denver cell and the Degussa cell are typical examples of agitated flotation cells used in the laboratory as models of mill deinking cells (Dusserault et al. 1995). In addition, the Pressurized De-Inking Module of Beloit achieves deinking by dissolving air under pressure in the recycled pulp suspension. When this pressure is released, air bubbles come out of the slurry and remove ink particles again by flotation. In the recent past, the use of column flotation as an effective technology for the deinking of wastepaper has been suggested (Gomez et al., 1994). Column flotation is a novel technology being introduced into the mineral processing industry since it offers significant cost and process advantages over conventional flotation cells. Among the benefits of column flotation are a higher selectivity, less floor space requirement, reduced capital cost and reduced operating and maintenance costs (Finch and Dobby, 1990). The vertical construction results in considerable floor space savings and the absence of moving parts results in lower manufacturing costs. It has been reported that the operating cost can be reduced by up to 80% compared to conventional cells (Dusserault et al., 1995). Furthermore, power savings result since agitator requirements are eliminated and savings in reagent consumption of up to 30% have also been reported (Gomez et al., 1994). However, in many applications of column flotation technology, inadequate mixing or excessive backmixing and non-uniform dispersion of gas bubbles has limited the capacity and efficiency of several column flotation devices (He et al, 1997). As described in (He et al., 1995, Walmsley, 1994), collection kinetics and axial mixing need to be enhanced in conventional column flotation devices. It appears from literature reports (Dusserault et al., 1995) that when pulp fibers are present in a suspension, bubble coalescence is enhanced. Increased gas holdup can be achieved only at the expense of transiting to a regime of slug-flow. This reduces the collision frequency with ink particles since the bubbles tend to be much larger in this flow regime. Thus, methods of obtaining higher gas holdup at small bubble sizes are important in achieving higher separation efficiencies and better throughputs in flotation columns.

Experimental Apparatus

Figure 1 shows a schematic of a bench scale flotation column set up in our laboratory. The flotation column can be used to accomplish deinking in both continuous and batch modes. The column is 1.946 m tall and 92.075 mm in diameter. It is provided at the top with a collection trough which leads to an overflow tank. An air sparger is provided at the bottom of the column to supply air bubbles. Two pressure transducers are provided in the column to measure the pressure differential between two locations. The pressure differential can be used to obtain the air holdup within the column at any chosen time. A thermocouple is also provided to record the temperature of the slurry in the column.

Figure 2 shows a schematic of the gas supply system to the column. A compressed air bottle is connected via a two stage regulator to a rotameter. An electronic flow meter was also connected in series to provide a calibration of the flow rate indicated by the rotameter. The compressed air is passed through a metering valve and a barometric leg after which it is led to the sparger. Pressure gauges are provided on either side of the metering valve to aid setting of the air flow conditions in a reproducible manner.

Materials and Methods

The wastepaper feedstock chosen for our experiments consisted of 50% laserprinted paper and 50% photocopier waste. The laserprinted paper was obtained by printing a standardized page in a HP LaserPrinter operated at a speed of 11 pages per minute. The same page was photocopied in a standard photocopier. Equal quantities of the two were then pulped in a disintegrator for 1 hour at a pH of 10. The temperature of the pulp was maintained at 40 C. After dispersing the wastepaper and producing the required quantity of pulp, it was diluted to a consistency of between 0.7 and 1.1%. The pH was measured and NaOH was added to make it up to the designated value. The pulp was charged into the column (for the case of batch experiments) and the air flow was initiated at a chosen air flow rate. The appropriate deinking chemicals (surfactant) were added and deinking was carried out. The froth was collected at the top and after chosen intervals of time, the air supply was stopped and the drain was opened and the clean pulp was collected at the bottom. For the case of continuous operation experiments, the recycled pulp was charged into a feed tank. A pump was used to feed the pulp continuously into the column and the drain was opened to allow the clean pulp to be drawn out. The froth was also collected from the overflow into a tank. The clean deinked pulp drawn from the at the bottom as well as the overhead deinking rejects were sampled at various times.

Handsheets were prepared and the brightness was measured according to Tappi standards. The handsheets were also scanned using a 600 dpi flatbed scanner and digital images of the handsheets were obtained. Six locations on each side of the handsheet were chosen and analyzed for ink particle distributions using Global Image software. Yield measurements were accomplished by weighing the total solids content of the clean pulp sample and the overflow. Ash contents were obtained by incinerating the pulps in a furnace according to Tappi standards.

A summary of the experimental conditions is provided in Table 1.

Results

Table 2 shows the brightness of handsheets made from pulps deinked in the batch mode in the column for time intervals of up to 15 minutes. A comparison of deinking accomplished in the column cell with the conventional agitated cell is also shown. We note first that the brightness improvement is from 76.55 of the feedstocks to 82, an improvement of approximately 5.3 points. In addition, the yield of the deinking operation in the conventional cell (labeled Degussa) and the column cell is shown in Table 2. Results for the continuous mode of operation are also shown in this table. These results lead us to conclude that it is possible to achieve typical deinking performance using the flotation column in a similar manner to conventional agitated cells. Table 3 shows the results of deinking operation in the flotation column at different consistencies. It is seen that the deinking is best achieved at low consistencies. At high consistencies near and above 1.2%[1], a drop in deinking is observed. Table 4 shows the results of performing a two stage batch deinking operation using a similar wastepaper feedstock. In this case, the recycled pulp was first deinked, the rejects were collected and deinked again in the same column. It is demonstrated that the rejects contain a significant amount of usable fiber which can be further deinked. This points out the possibility of column flotation being used as a secondary stage to a primary deinking cell.

[1] Pulp consistency is defined as the ratio of the dry weight of pulp fibers to the weight of the suspension. It is often expressed as a percentage.

Table 5 shows the brightness results obtained by deinking the rejects obtained from an existing pilot deinking plant. Both the batch and continuous modes of operation were tested. Large increases in brightness were observed and high yields of around 64% were obtained indicating that at least 64% of the solid that would have been rejected could be recovered. Since the brightness of these fibers it higher than the rejects themselves, they could be effectively utilized either in a recycle loop or by mixing them into another feed stream.

Conclusions

We have shown some preliminary results indicating the effectiveness of deinking using column flotation in both batch and continuous modes. In addition, deinking was achieved with rejects from a typical pulp deinking operation. These results demonstrate that significant energy and environmental pollution abatement benefits can be achieved by using the column flotation operation.

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Table 1. Summary of experimental conditions

Pulps chosen:

Laserprint and photocopier waste paper. 90% - 10% or 50% - 50%.

Pulping conditions:

Slurry volume	10 l
Consistency	6 %
Time	40 min
pH	10.5 to 11.0
Temperature	50 C.
Surfactant dosage	0.5 % (Based on oven dry weight of wastepaper)

Flotation conditions

Degussa cell volume	10 l
Flotation column volume	10 l
Consistency	0.8 %
Time	Upto 15 min
Temperature	40 C (approx.)
Air flow rate	6 - 8 lpm (variable)

Table 2. Brightness of deinked pulp handsheets showing performance of column flotation compared to conventional deinking cell. Delta B is the difference in brightness between undeinked and deinked handsheets

Time, min	Brightness (ISO)	Delta B	Yield, %
1. Deinking in Degussa cell (Agitated flotation cell).			
0	76.5	-	-
6	80.9	4.4	79.6
9	82.0	5.4	75.6
12	81.8	5.3	74.0
15	81.7	5.2	71.8
2. Batch deinking in flotation column.			
0	76.5		
6	80.1	3.6	82.3
3. Continuous deinking in column.			
0	77.6		
6	80.8	3.2	80.8

Table 3. Effect of consistency of pulp on flotation in column. Feed was 50% Laserprint waste and 50% photocopier waste. Total pulp processed was 10 l

Consistency, %	Delta B
0.5	3.7
1.0	5.4
1.5	4.85

Table 4. Column flotation in two stages

Pulp	Consistency %	Brightness	Delta B	Yield, %
Un-deinked		75.48		
A	1.5	80.0	4.8	84.23
B	0.5	79	3.7	35 (Based on rejects)

Pulp B is the overflow obtained from column flotation - the rejects of A.

Table 5. Deinking of mill rejects from a pilot de-inking plant

Pulp	Consistency, %	Brightness	Delta B	Yield, %
Un deinked		59.86		
Deinked	0.8	73.06	13.21	64.0
	1.2	72.85	12.99	65.2

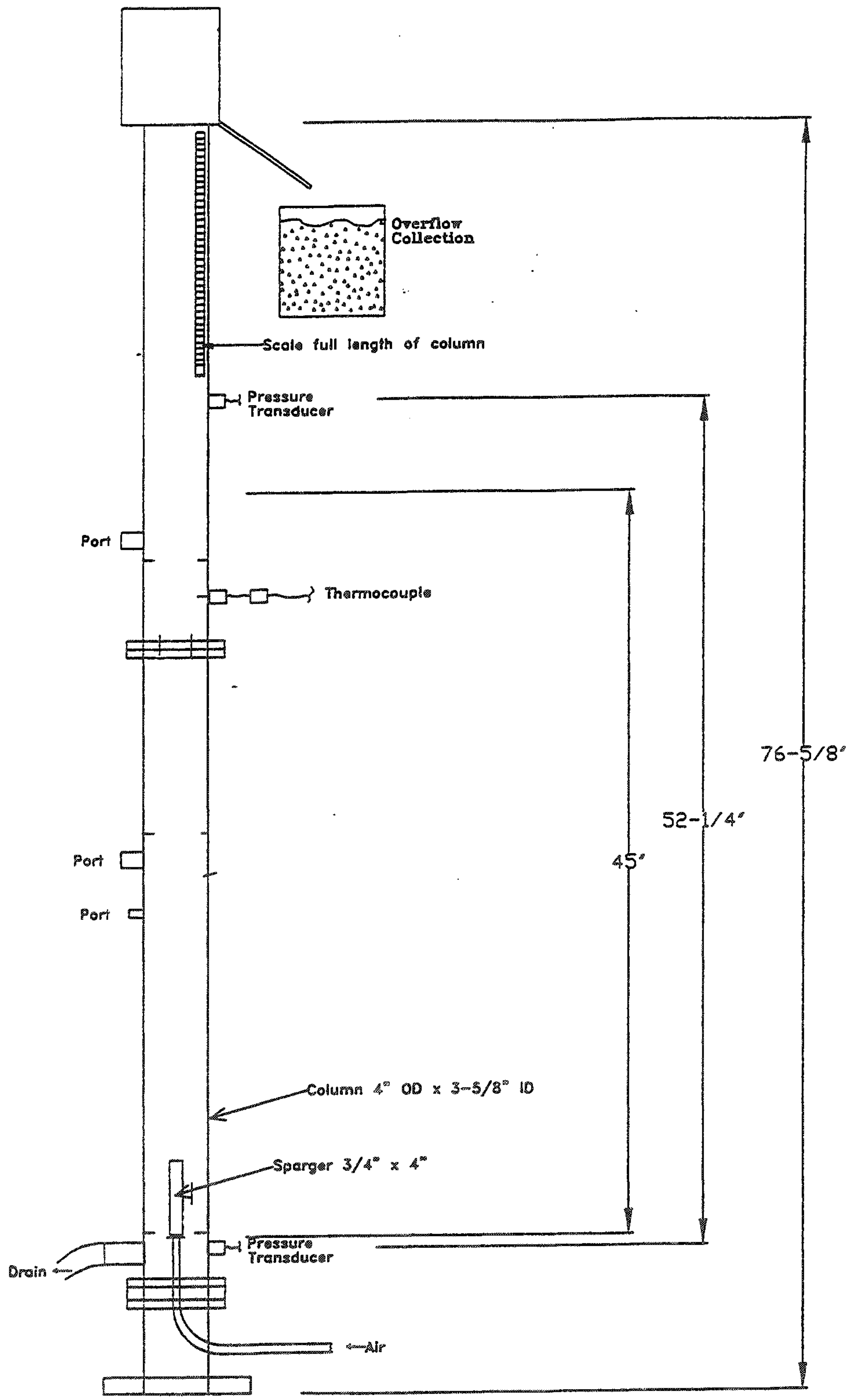

Figure 1. Schematic of flotation column with instrumentation for pressure and temperature measurements.

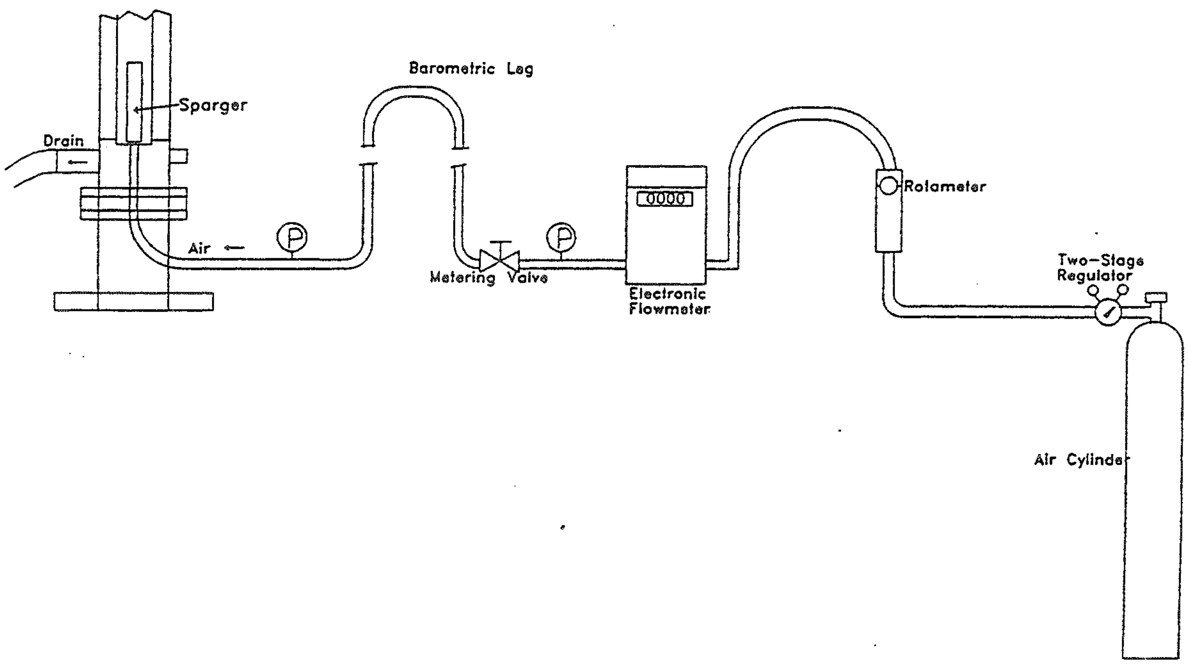

Figure 2. Schematic of the gas flow supply to the flotation column.