Concentration of Bleach Plant Effluent

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This paper sumarizes the results of a combined reverse osmosis (RO) and freeze concentration (FC) process for the treatment of bleach plant effluents. RO removed about 90% of the water from a stream containing 5 g/l of total solids to give a concentrated stream with 50 g/l solids. FC further concentrated the RO concentrate to about 200 g/l. Thus, the combined process yielded about 98 volumes of clear water and two volumes of concentrate for each 100 volumes of bleach plant effluent. Cost of the treatment was found to be inversely related to the volume of water usage in the bleach plant. At 10,000, gal/ton water usage the cost ranged between $20–30/t and at 5000 gal/t, $10–20/t. Additional increase in membrane life, reduction in effluent volume and consideration of related side benefits could drop the cost to $4–10/t and make the process more attractive.

Introduction

The bleaching of cellulose pulp has traditionally used large volume of water to dissolve and wash away the residual lignin and other components remaining in the washed brown stock from pulping processes. Generally, this requirement could be as high as 50% of mill's total water requirement per ton of product. Some scattered examples of higher water usage also exist.

Bleach plant effluents, although dilute, produce high BOD[5], color and other organic and inorganic residues. Typical effluent loadings from bleach plants of a kraft and a sulfite mill are given in Table 1.[1] Calculations show that 94-95% of the total colour generated in the pulp mill comes from the bleach plant, of which 95% is in the alkali extractions stage stream[2]. Data in Table 2[2] and 3[3] show that the organics present in the E-stage of a kraft bleach plant are highly chromophoric in nature. Table 3 further shows that the chromophoric character increases during treatment in holding basin (ratio increased from

Table 1
Typical Effluent Loadings From Bleach Plant[1]

	Kraft	Sulfite
Volume (gal/t)	6–14,000	12,000
Total solids (lb/t)	—	200
Suspended solids (lb/t)	20–30	15
BOD_5 (lb/t)	40–60	30
Color (mg/l)	4–6,000	2,000
pH	3–4	5.0–5.8

Table 2
Survey of kraft Bleach Plant Effluent[a]

Parameter	Bleaching Stage			
	C	E	H	DED
Color, %	1*	95	3	1
COD, %	14	69	8	9
BOD, %	34	50	8	8

Values based on [C+E+H+DED=100]
For 300 tpd mill

Table 3
Color and TOC Ratios of Kraft Effluent[3]

Effluent Source	Ratio (Color/TOC)
Pulping + recovery	6.9
Bleach plant	
Cl_2–stage	3.9
E–stage	14.9
Paper mill	3.3
Combined mill sewer	7.6
Stabilization basin[a]	10.0

[a]Combined mill sewer in holding basin for four months.

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7.6 to 10.0). Although this could be due to decrease in total organic carbon (TOC), actual color increases in holding ponds have witnessed[4].

Because of stricter environmental quality standards, various ways of treating these dilute bleaching effluents have been under development in recent years. Complete counter current recycle approach developed by Rapson[5] is one such way the industry is looking at with great interest.

Although The Institute of Paper Chemistry is involved in many corrective procedures for pollution abatement, I would like to highlight for you, our activity in one very interesting approach This involves the concentration, and separation of dissolved materials through the combined use of Reverse Osmosis (RO) and Freeze Concentration (FC) process. The Institute, with the cooperation of some member companies, has just completed on-site pilot trials and an economic evaluation of combined RO-FC process. This work has been partially funded by the U. S. Environmental Protection Agency. The details of the equipment used will be discussed in our extensive report to be issued by the U. S. EPA under the authorship of Wiley, et al. However, for your information, experimental setups for RO and FC are schematically shown in Fig. 1 and 2.

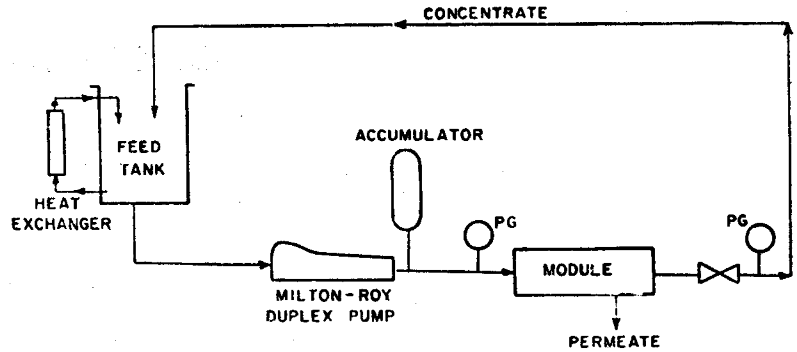

Fig. 1–Schematic Diagram of Experimental Setup

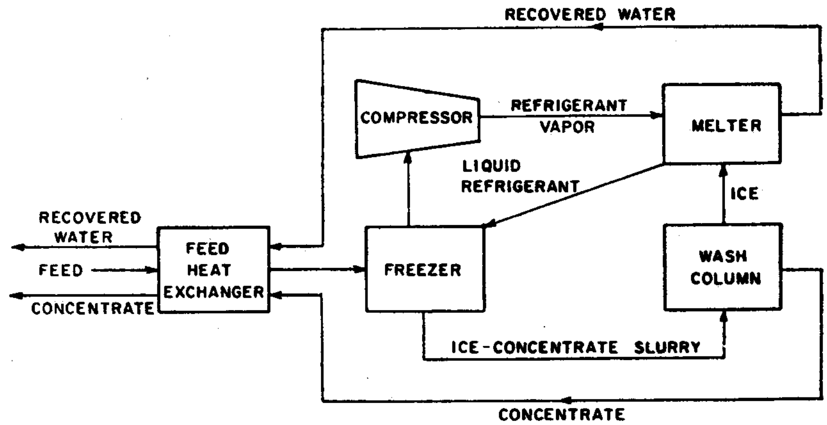

Fig. 2–Simplified Freezing Process

Results and Discussion

The basic concept of the RO-FC approach is shown in Fig 3. Bleach effluents having approximately 0.5% solids are concentrated by RO to 5% solids (10 fold) which become feed to a two stage FC unit. The first FC stage concentrates the RO effluent from 5% to 15% which in turn is concentrated to 25% by the second stage. The concentrated BPL can either be further concentrated by evaporation and sent to recovery, or disposed of as such or utilized. High quality recovered water (permeate) is reused in the mill We expect that such an approach would lead to :

* Concentration of dissolved solids for recovery and disposal

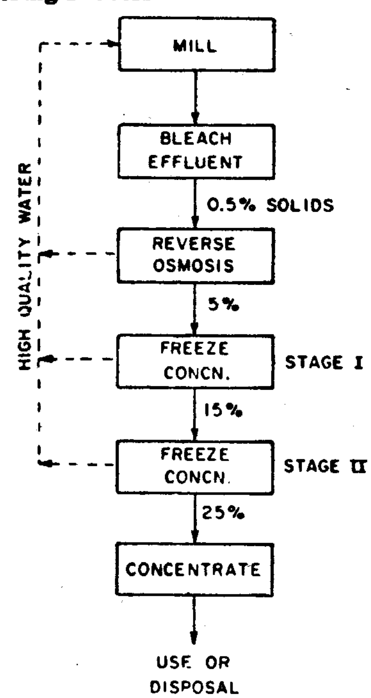

Fig. 3

* Reclamation of clean process water for reuse
* Possible reduction in overall energy requirements

A preliminary RO concentration run on sulfite bleach liquors (2–hypochlorite stages) showed good membrane performance (Table 4). Except for sodium and BOD_5 rejections of over 75% were obtained (color was rejected by 100%). Table 5 presents average data on performance of four successive membrane concentration stage for sulfite bleach (2 hypochlorite stages) and kraft bleach (chlorine-extraction-hypochlorite stages) liquors. The differences between % rejection of sulfite and kraft bleach liquors are due to some basic differences in effluent characteristics.

Table 6 presents data on freeze concentration of sulfite and kraft bleach liquors which have been concentrated by RO. Because FC involves formation and separation (by washing) of ice crystals at freezing temperatures and that the ice crystals formed are of sure water, excellent removals are seen. The data indicate general removal of over 98%.

Process Economics

The following factors were found to be significant in determining process costs :

* RO membrane life
* RO high pressure equipment
* FC power consumption
* FC maintenance (labor supplies and refrigerant).

Table 4
RO Concentration of Sulfite Bleach Liquors

	% Rejection
Total solids	80
Calcium (soluble)	78
Sodium	50
Chlorine (inorganic)	75
Oxalate (soluble)	82
COD	81
Color	100
BOD_5	48

Table 5
Average Percent Rejection of Four Successive Membrane Concentration Stages

	% Rejection	
	Sulfite Bleach Liquor	Kraft Bleach Liquor
Total solids	83	72
Sodium	64	84
Calcium (soluble)	82	94
Chloride (inorganic)	80	66
COD	85	92
Color	100	99
BOD_5	56	75

Table 6
Freeze-Concentration of Bleach Liquors

	% in Concentrate	
	Sulfite Bleach Liqour	Kraft Bleach Liquor
Total solids	99.3	98.7
Calcium (soluble)	99.3	100
Sodium	∾100	∾99.5
Chloride (inorganic)	99.6	99 3
COD	98.1	95.5
Color	99.0	∾99

A simple computer program was used for calculating proces economics. The total installed costs were computed by multiplying the membrane costs by a Lang factor. Operating costs were computed from the power consumption, estimated maintenance and estimated membrane replacement costs. FC costs were computed by Avco Corporation, a subcontractor in this project.

Based on data collected during the on-site pilot trials of RO-FC system, estimates of the process economics were made. At current levels of water usage for bleaching, costs ranged from $20 to $30 per ton of bleached pulp (approximately $ 3.50/1000 gal of bleach plant effluent). This study further indicated that at water usage of about 5000 gal/t (instead of 10–20,000 gal/t) operating costs would drop to $10-20/t range. Reduction in water usage would also reduce capital requirements. The above $10—20/t figure could further drop to say $4—10/t if the life of membranes were to be doubled to 4 years, effluent volume further reduced, and also if one were to take into account the side benefits/color removal & that no sludges would have to be handled. In addition the recovered water would be of high quality and, therefore, comparable or better than treated raw water for mill usage.

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