INTERACTION of FLOTATION CELL OPERATING VARIABLES

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ABSTRACT

A laboratory experiment was designed to investigate the relationships between flotation cell operating consistency and specific air volume. For a flotation cell with fixed air input, optimal ink removal can be achieved at 0.8% operating consistency, at the expense of higher yield losses. Where specific air volume can be manipulated, an equivalent ink removal can be achieved through increased air application at higher operating consistencies, and reduced yield losses. The loss of filler particles was found to be independent of operating consistency. The work has implications for the design of flotation cells to improve process profitability.

INTRODUCTION

Abitibi-Consolidated operates six (6) waste paper deinking plants for the production of newsprint, using a variety of process designs and flotation cells. A study comparing the results of each plant's deinking system performance identified differences in flotation cell operating conditions [1], the effects of which were not well understood.

In many plants studied, the operating consistency of flotation cells had been elevated above design levels to increase production rates. At several other plants, air input to flotation cells was below design levels due to either an effort to reduce yield losses, or reduced mechanical condition of the equipment. In both cases efforts had been made to reduce overall operating costs by displacing expensive mechanical pulps, or by reducing system losses.

The interaction between operating consistency and flotation cell air input was studied to understand their effect on pulp quality and yield losses, allowing for informed decisions on cost reduction efforts. Laboratory work was carried out at the National Silicates Technical Centre in Toronto, Ontario, Canada.

TEST METHODS

Design of Experiment software was used to develop experimental conditions over a range in consistency from 0.5 to 1.5%, and specific air volume from 150 to 700 l/kg. Nine (9) experiments were run.

In each experiment, the same pages from the same publications were pulped and floated, to eliminate ink and base fibre properties as variables. Pulping was carried out in a H-600T (68L) Hobart mixer at a specific energy approximately equivalent to that applied at the Thorold mill deinking plant's drum pulper. A conventional alkaline pulper chemistry was used, that consisted of 1.1% peroxide, 0.77% caustic, 0.02% surfactant, and 2.0% sodium silicate. Flotation was carried out in a Voith Sulzer E-18 laboratory cell. A dose of 0.56% fatty acid soap was added prior to flotation along with sufficient calcium chloride to provide 150ppm hardness as calcium carbonate.

Experiments were evaluated according to ash content of flotation cell feed, accepts, and rejects streams, as well as total ERIC and hyper-washed ERIC on flotation cell accepts pulp. Ash content was determined using an ashing temperature of 525°C, to preserve carbonate components of the pulp mineral content. Brightness pads were made with the use of a cationic polyacrylamide. [1]

Flotation cell accepts pulp was hyperwashed in a Britt jar using a 157 µm perforated screen plate (equivalent to 100 mesh).

ASSESSMENT METHODOLOGY

Samples of flotation cell feed, accepts, and rejects were taken on each run. Samples were analyzed for ash content, and evaluated for the removal efficiency of pulp components. The ash test separates the pulp into two components; combustible materials, and inorganic ash. Combustible materials include ink, other hydrophobic organics collected by flotation chemistry, and fibre. Ash test results report the inorganic content, and reflect filler content of the pulp.

Previous literature describes the use of ash tests in determining yield losses from a flotation cell (2,3). Expressed as a percentage of solids in cell feed, losses can be calculated from ash tests as follows;

% Combustible Losses

$$= (1-(1-X_A)(X_R-X_F)/(1-X_F)(X_R-X_A)) *100$$

% ASH Losses

$$= (1-(X_A(X_R-X_F))/(X_F(X_R-X_A)))*100$$

where X_A, X_F, and X_R, are the fractions of ash by weight in the flotation cell accepts, feed, and rejects samples, respectively.

Flotation cell accepts samples were also measured for residual ink concentration (ERIC). Total ERIC measures the sum of free and bound ink particles. Hyperwashing the sample allows measurement of only bound ink. The difference between these two measurements is accepted to be free ink that was not removed during flotation.

Air input was measured with a rotameter, and along with flotation time, used to calculate the specific air volume applied during the run.

Data was evaluated using the “Multiple Property Optimizer” program supplied by Harold Haller & Company. This multiple correlation program permits predictions of dependent variables from the functional relationships identified in the data set.

SPECIFIC AIR VOLUME

The Specific Air Volume (SAV) is defined as the litres of air applied over the course of flotation in a cell or line, per kilogram solids in the cell feed (L air/kg solids). Changes in the flotation cell operating consistency, or air input, change the SAV and resulting flotation efficiency.

For a cell that has injectors designed to deliver a fixed volumetric air input, SAV will change with operating consistency as in Figure 1. Flotation cells which allow adjustment to air input with pressurized injectors, or by restriction of air flow to naturally aspirated injectors, allow the adjustment of SAV by varying either the consistency or air volume.

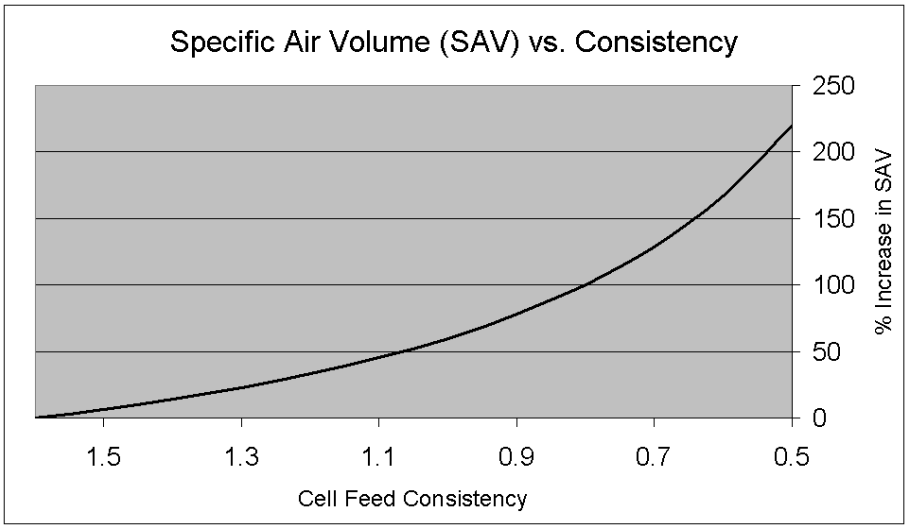

FIGURE 1. Increase in SAV in a cell with fixed volumetric air input, as cell consistency drops

Bubble size in the cell vat is determined by cell injector design and surface chemistry of a particular system, therefore changes in SAV will be approximately proportional to the bubble surface area available for attachment of hydrophobic materials. Changes in bubble size and air hold-up in a cell, that is operated at constant liquid level and stable consistency, are seen in the daily fluctuations of indicated level (pressure transmitter) in the Thorold, ON deinking plant. Implied by this trend is the dynamic condition of air hold-up (bubble size) resulting from the variable contribution of surfactants from waste paper feed, and changes in system closure. (Figure 2)

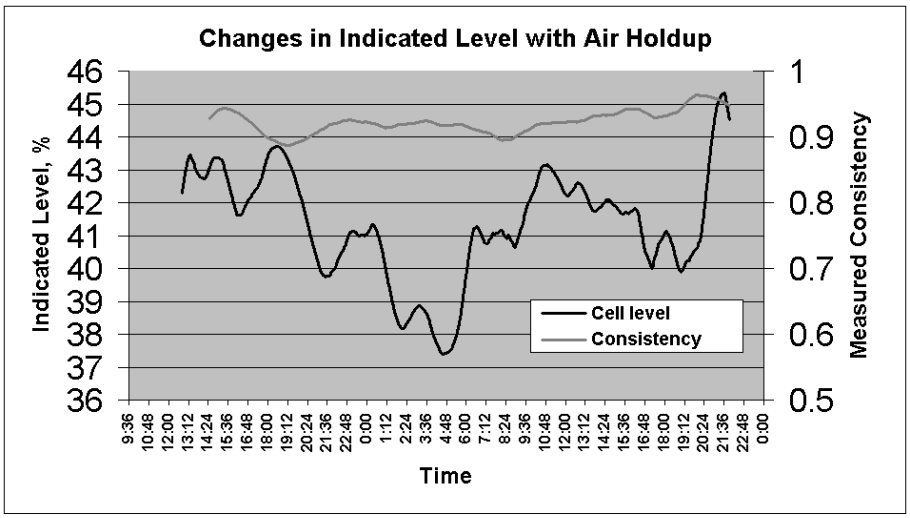

Figure 2. Changes in indicated level of a flotation cell due to air holdup.

At any given consistency, SAV determines the relative rejects rate of the cell. This study focuses on the interaction between SAV and consistency, and the effect on the selectivity of flotation, or the losses necessary to achieve a given pulp quality.

ASH LOSSES

Losses of ash from a flotation cell are related to combustible losses, and influenced by system chemistry (4). Both ash losses and combustible losses increase as SAV increases. Results show that ash losses are independent of pulp consistency (Figure 3).

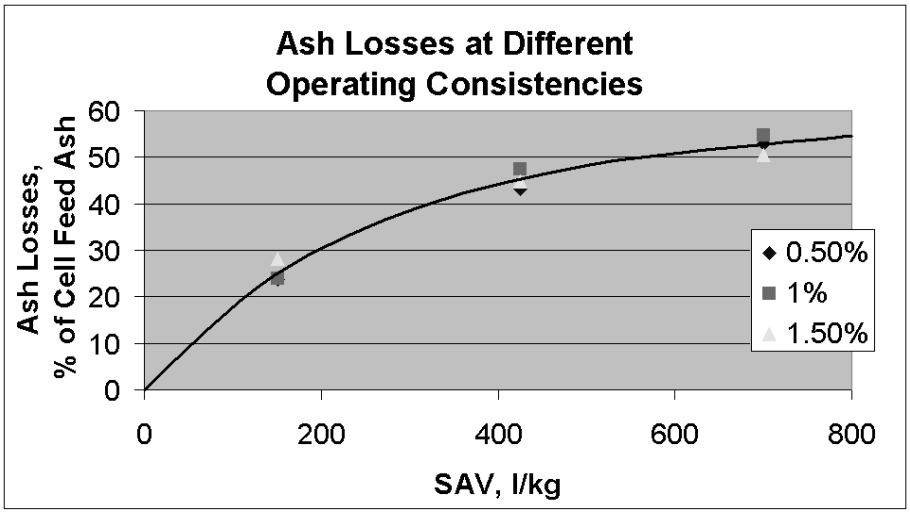

FIGURE 3. Ash losses are independent of pulp consistency.

Ash losses are a significant portion of the total yield losses incurred through a flotation cell, and an unnecessary expense if the paper grade being produced allows significant filler levels. Operating consistency of the flotation cell is not indicated as a control lever in the optimization of ash losses.

INK REMOVAL EFFICIENCY

Operators of deinking plants are constantly trying to improve operating costs by either reducing yield losses or increasing ink removal, but these goals seem to be diametrically opposed. The best conditions for a particular system have to be explored based on the variables available for control, including system chemistry, waste paper grades, pulper specific energy, flotation cell operating consistency, SAV, and rejects rate, and disperging conditions.

Ink removal efficiency is indicated by the free ink left after flotation. Analysis shows that the SAV required to achieve a given free ink value varies with the operating consistency, with the minimum SAV required at approximately 0.8% consistency (Figure 4).

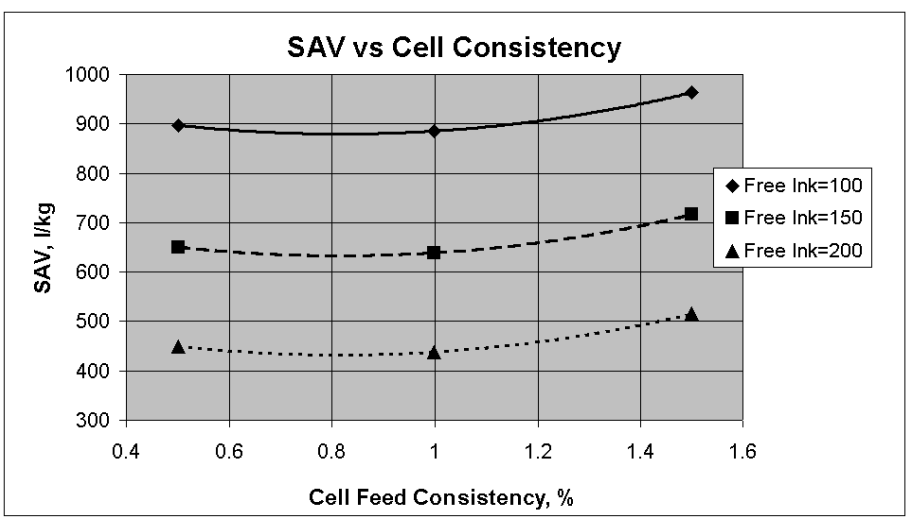

Figure 4. At a target ink removal, lowest SAV is required at 0.8% consistency.

This data indicates that for cells with fixed air input, best ink removal efficiency can be achieved at an operating consistency of 0.8% (Figure 5), however this operating consistency is not the optimal operating condition, due to yield losses incurred to achieve this ink removal efficiency.

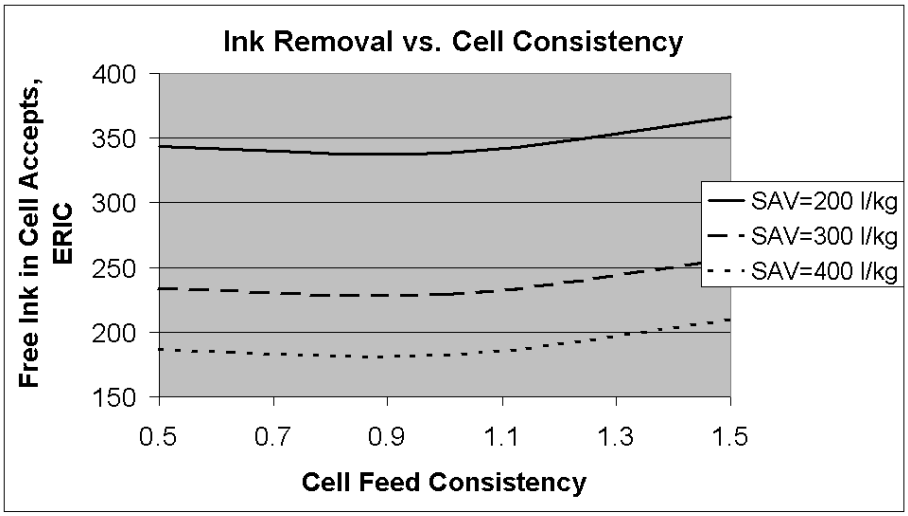

Figure 5. At fixed SAV, best ink removal is achieved at 0.8% consistency.

COMBUSTIBLE LOSSES

The ash test delineates between combustible and non-combustible materials in the cell rejects. Typically, increased rejects rates are viewed as being synonymous with improved ink removal efficiency, but this is not necessarily the case. Under certain conditions, fibre losses at elevated rejects rates can be increased while ink removal is static or reduced.

Given that ink is the principle component of combustible losses, at a specific pulp consistency, as combustible losses from the flotation cell increase, ink removal increases and pulp brightness improves (Figure 6).

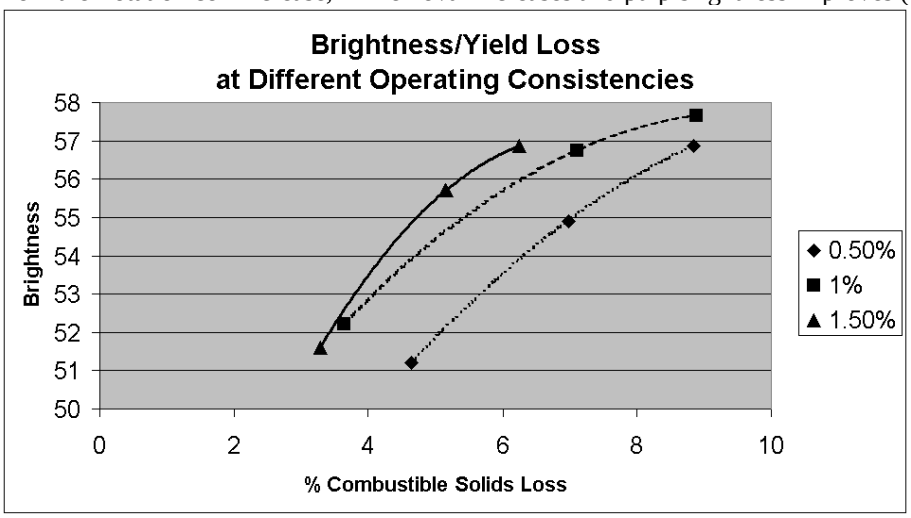

Figure 6. Increasing yield losses at a particular pulp consistency improves ink removal and pulp brightness.

Yield losses need to be considered in determining the overall process efficiency at a given target ink removal efficiency and pulp brightness. A trend of combustible losses against free ink levels shows that at higher operating consistencies the yield losses at any free ink level are reduced (Figure 7).

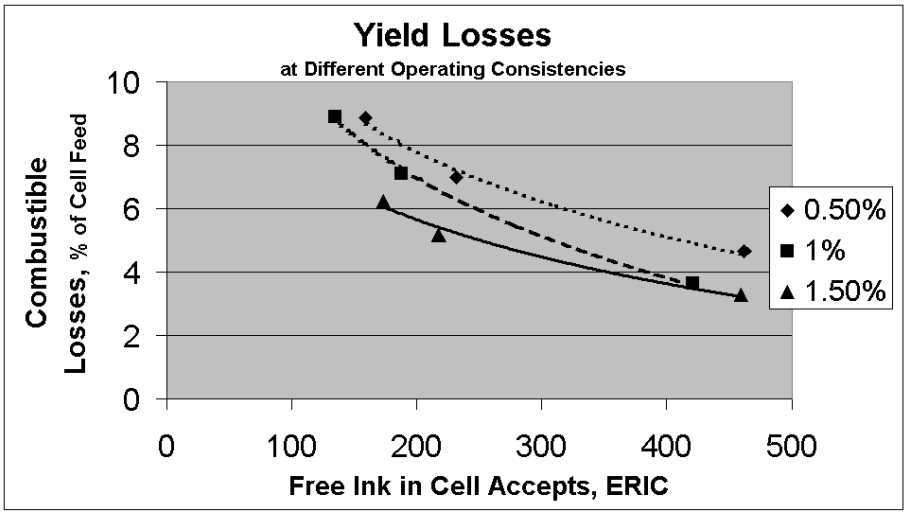

Figure 7. Yield losses at target ink removal are reduced at higher consistencies.

Inclusion of SAV in the relationship between ink removal and yield losses demonstrates that at a given ink removal level, equivalent ink removal can be achieved at elevated consistencies if the ability to add higher volumes of air over the flotation cell line is possible (Figure 8).

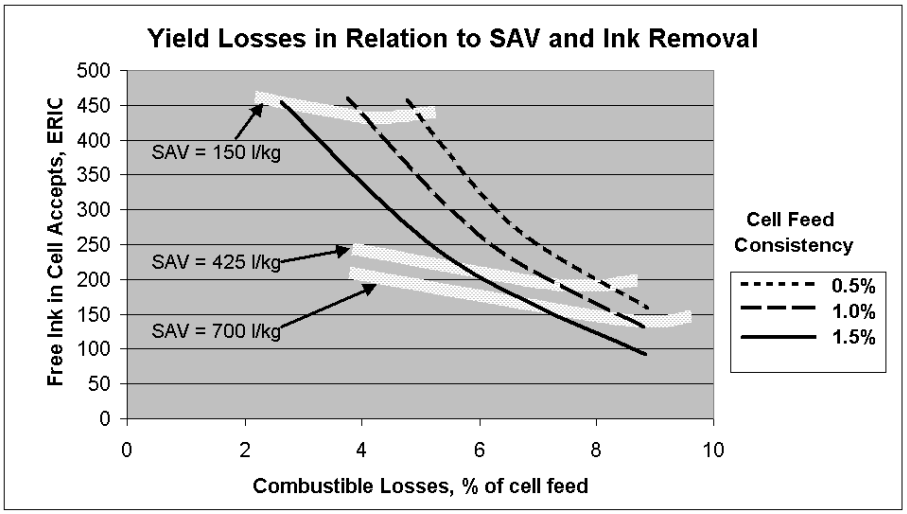

Figure 8. Higher SAV allows equivalent ink removal at reduced yield losses.

For example, if a target ink removal that results in 190 ppm free ink in cell accepts gives acceptable pulp brightness, target pulp quality can be achieved at 425 l/kg SAV at 1% consistency and 7% combustible losses, or at 550 l/kg SAV at 1.5% consistency and under 6% combustible losses. The reduction in losses implies a fibre savings equivalent to 1% yield.

CONCLUSIONS

There is a relationship between flotation cell operating consistency, specific air volume, ink removal performance and yield losses.

Ash losses are independent of operating consistency. Reduction of yield losses due to ash levels can be achieved by optimizing ink removal performance and pulp brightness with choice of system chemistry, allowing changes to furnish composition and grades with lower ash levels.

Improvement in ink removal performance is achieved with higher rejects levels and increasing air application to the pulp. At particular conditions of flotation cell operating consistency and SAV, equivalent ink removal performance can be achieved at higher operating consistencies, with higher SAV, at reduced yield losses.

The relationships can be used to optimize operating conditions of flotation cells where air input can be manipulated as an operating variable, within the existing limitations of the equipment. The findings have implications for improved design of flotation cells and system configuration.

References

1. Ben, Y. and Dorris, G.M., "Handsheet and Pulp Pad Preparation Procedures for Measurement of Total and Bound Ink in ONP/OMG Furnishes", Progress in Paper Recycling, 34-41(Feb. 1999).

2. Moe, S.T. and Roring, A., "Theory and Practice of Flotation Deinking", Research Forum on Recycling, Proceedings, p 55-60, 6th Research Forum on Recycling, Oct 1-4 2001, Magog, Que., Canada, Pulp and Paper Technical Association of Canada

3. Le Ny, C. et al., "Impact of RCF Raw Materials Quality on Deinking Performance", Preprints, pp 191-196, 6th Research Forum on Recycling, Oct 1-4 2001, Magog, Que., Canada, Pulp and Paper Technical Association of Canada .

4. Peters, H. and Fairbank, M. "Evaluation of Flotation Effectiveness in the Deinking Process", PAPTAC 93rd Annual Meeting, 2007