Advanced Quality Control (AQC)- In DIP

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ABSTRACT

In view of the increasing environmental concerns and raw material availability, recycled fiber is increasingly being used as a raw material for many paper, board and tissue grades. Recycled fiber degrades in its properties after each recycling process and hence creating the real tough task for the papermakers. The challenges a papermaker confronts when using recycled paper as a fiber source are many. How to cope with variability of fiber types, inks, contaminants and still maintain high yield of fiber for final products are the most acute. Importantly, keeping production costs to an optimum level at the same time is a challenge for the production line.

A new process control system has been developed to reduce the impact of the deterioration of recycled raw material. The control system uses a mill wide approach to minimize the cost of paper brightness. The incremental cost of brightness for the multiple brightening agents used in the deinking process is determined by performing plant tests and analyzing historical data. The brightening agents evaluated include magazine content, peroxide, caustic, silicate, soap, hydrosulphite, and optical brightener. This information is used to configure the control system. A production advisory system has also been implemented which helps the operators set production targets that maintain the required inventory while minimizing the impact on pulp quality.

Introduction

DIP is a process to separate ink and dirt from fibers step by step using stages like pulping, screening, floatation, washing, fine screening, bleaching, dispersion and post floatation. The key measurements include consistency, ash, brightness, residual ink, dirt count, pulp quality (viz. fiber length, strength, freeness etc.) and chemical properties at each step. The relative importance of each measurement depends on the process and on the end use of the pulp.

Fiber and chemical costs alone comprise of nearly one third of the total production costs followed by the capital costs which is nearly one fourth of the costs. Therefore, SAVINGS in fiber and chemicals, uniform good quality end product and least burden on the environment during production are vital.

The mill wide brightness control system combines multiple technologies including model predictive control, real-time optimization, an operator advisory system, real-time sensor validation, and automated system monitoring. These components work together to help minimize the cost of paper brightness.

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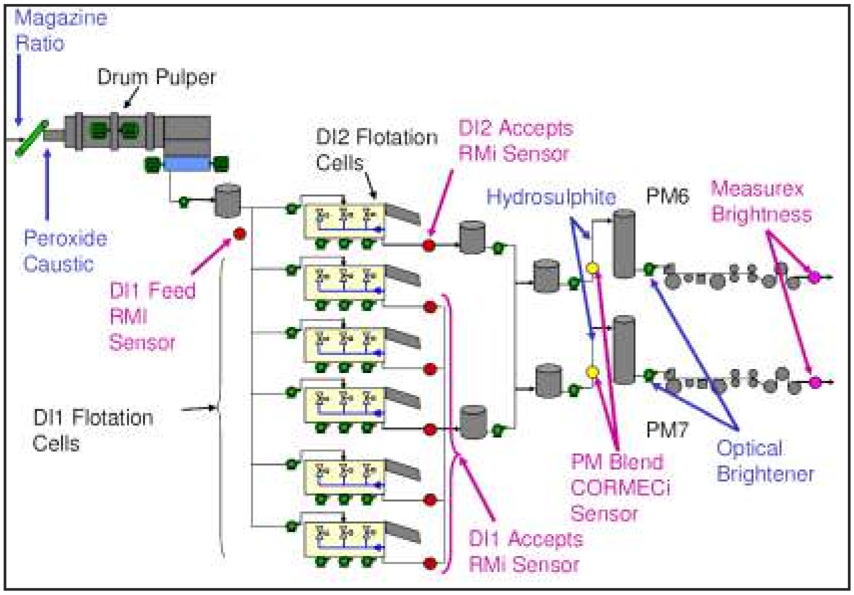
Case story, Abitibi-Consolidated's Thorold mill, Ontario.

This Canadian mill has two paper machines producing a total of 1200 tpd newsprint. The mill is well equipped with pulp and paper quality sensors in both the deinking process and paper mill. In deinking, mill pulp consistency, ash, Effective Residual Ink Concentration (ERIC), and brightness are measured at both the feed and accepts of the flotation cells. Pulp quality sensors for brightness and ERIC are also located at the exit of the pulp blend chest just prior to hydrosulphite addition. On the paper machine, the paper brightness is measured with a scanning device. Paper brightness is also measured off-line using paper samples collected for each reel.

Figure 1 shows a simplified flowsheet of the mill with the key pulp quality measurement points and brightening agents.

Figure 1 Thorold Mill Layout



Prior to advanced control implementation, there was a regulatory control system in place that manipulated the hydrosulphite dosage to keep paper brightness on target. This brightness control system was relatively slow and often was manually overridden by operators when brightness was below target. As a result paper brightness was often above target due to excessive manual increases in hydrosulphite dosage, and a slow response by the control system to reduce the hydrosulphite dosage target.

During periods of low pulp brightness, the mill also had the option to manually add optical brightening agent if the hydrosulphite was at the high limit. This was considered a very expensive option. Since it was manually controlled it would sometimes be increased too much and left on for too long resulting in higher than required cost of brightness.

Peroxide and caustic, added at the drum pulper feed, were also manually adjusted to help compensate for periods of low brightness pulp. In the summertime, as is common practice, the peroxide and caustic would be increased, and periodically changed as required. Overall the balance between the brightening chemicals and other brightening agents such as magazine was not optimized to minimize cost.

Process Audit

In order to estimate the potential for improving plant economics a Performance Audit was performed. Multivariate analysis and other analysis techniques were used to evaluate the potential for advanced control. The main focus of the study was to determine the potential for reducing visible dirt levels and reducing brightening chemical costs.

Based on the audit results it was determined that the greatest potential for return on investment was to reduce the cost of brightness through the optimization of the multiple brightening agents in the mill.

The Control System

In order to prove the potential for advanced control to reduce the cost of brightening, a trial control system was implemented and tested. The trial control system manipulated drum pulper peroxide and caustic to control the brightness of DI2 accepts. Model predictive control software was used as the control platform to effectively handle the long process delays. The objective was to control the accepts brightness to a target that provided the best trade-off between brightening chemicals added at the pulper and brightening chemicals added close to the paper machine. Since the optimal deink brightness target is not stationary, the target was periodically manually adjusted to keep the required brightening chemical balance across the mill. The DI brightness target adjustment was automated as part of the full-scale system.

The trial control project showed sufficient brightening chemical savings to proceed with the mill wide brightness control project.

Incremental Cost of Brightness

The objective of mill wide brightness control is to implement a system that minimizes the cost of paper brightness. It is important to evaluate the performance for paper brightness as opposed to pulp brightness which can give very different results due to pulp brightness loss across the plant. For example the addition of paper machine white water reduces the pulp brightness as it approaches the paper machine. In order to accomplish this objective the incremental cost of brightness for the various brightening agents was measured by performing a series of plant tests. The incremental impact on final paper brightness was combined with the cost of the given agent to give an incremental cost of brightness for each. The incremental cost of brightness was calculated for peroxide/caustic, silicate, magazine ratio, DI mill throughput, soap, optical brightener, and hydrosulphite.

Through the process of determining the incremental cost of brightness the final selection of the manipulated variables for the control system was made. The following variables are considered part of the cost of brightness optimization:

- Peroxide/caustic
- Magazine Ratio (manually adjusted)
- DI Throughput (Production advisory system)
- Optical Brightener
- Hydrosulphite

The DI accepts brightness control includes the followings variables:

- Peroxide/caustic manipulated variable
- Cell feed brightness constraint variable
- Alkali to peroxide ratio constraint variable
- Composite cell accept brightness controlled variable

The composite cell accept brightness is a mass weighted average of the brightness signals from both DI1 and DI2 flotation lines. The brightness signals are validated and replaced if sensor failure is detected as described in the sensor validation section below.

The cell accept brightness target is optimized to minimize the cost of brightness as described in the real time optimization section below. Figure 3 shows the layout of the DI accepts brightness control.

Figure 2 (is a flow diagram of the system components for the mill wide brightness control system.)

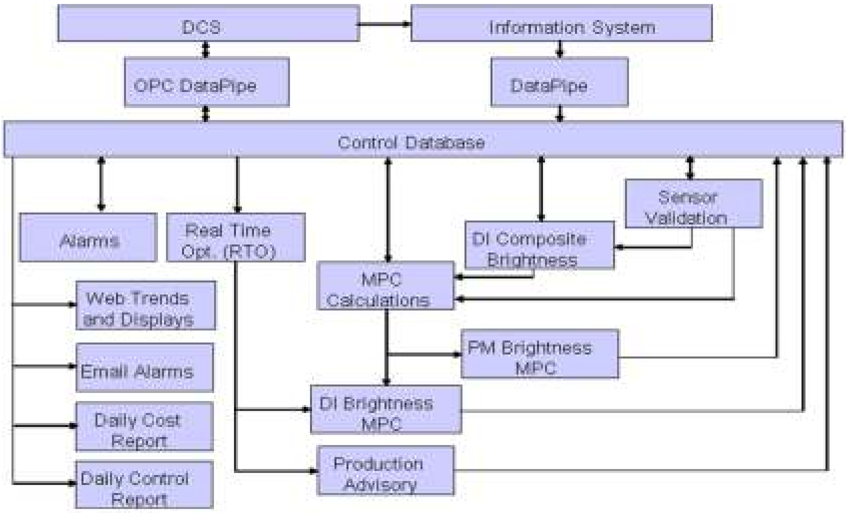
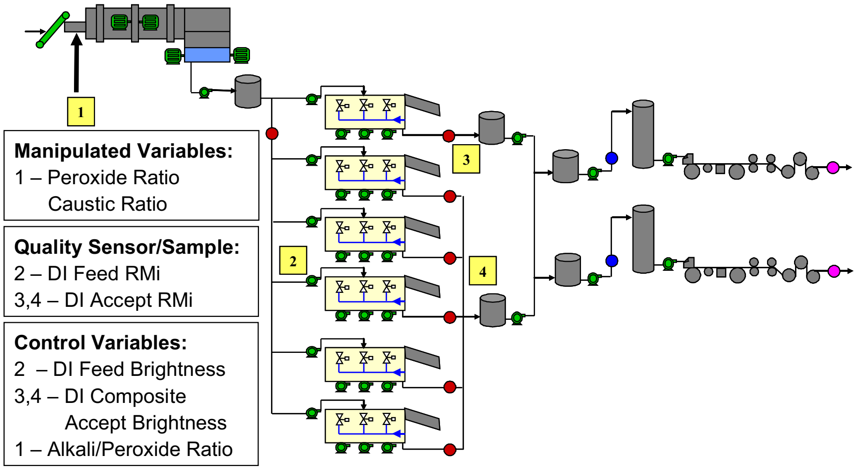


Figure 3 DI Accepts Brightness Control



Manipulated Variables:
1 – Peroxide Ratio
Caustic Ratio

Quality Sensor/Sample:
2 – DI Feed RMi
3,4 – DI Accept RMi

Control Variables:
2 – DI Feed Brightness
3,4 – DI Composite Accept Brightness
1 – Alkali/Peroxide Ratio

Paper Machine Brightness Control

Model predictive control software replaces the existing regulatory control for PM brightness. There are several features of model predictive control that have improved the overall performance of the PM brightness control including:

- Better deadtime compensation than PID control.
- Feed-forward control using the pulp brightness sensor before hydrosulphite addition.
- Multiple manipulated variables hydrosulphite and optical brightening agent.
- Gain scheduling to account for the hydrosulphite brightening curve.
- Linear programming (LP) to optimize the chemical cost tradeoff between the hydrosulphite and optical brightener.

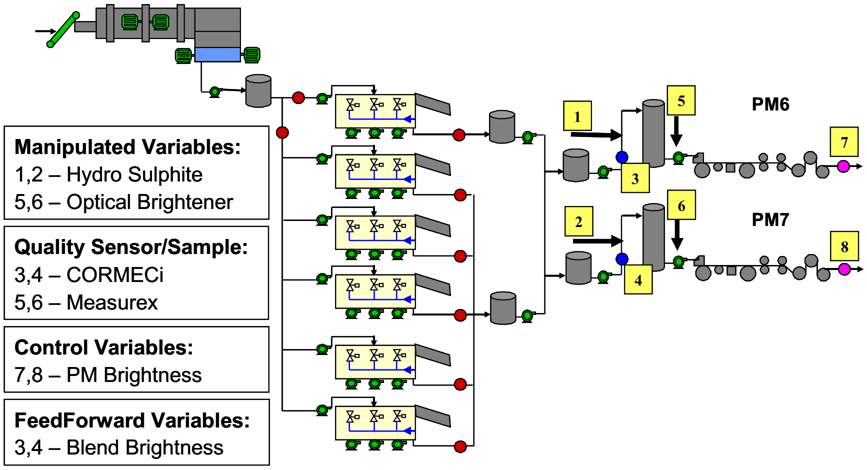
The implementation of the new PM brightness control has resulted in a significant decrease in the PM brightness variability and has reduced the PM brightness average so that the mill no longer runs above target brightness.

The LP optimization in the model predictive control software allows for the continuous real time optimization of the cost of brightness using the hydrosulphite and optical brightener. When this is combined with the real time optimization, described below, the cost of brightness across the entire mill is minimized. Figure 4 shows the layout of the PM brightness control.

Production Advisory System

It had been shown that high production rates resulted in higher residual ink content at the blend chest, which is difficult to compensate for with brightening chemicals. The Production Advisory System was developed to help the mill avoid unnecessarily high production periods while still maintaining inventory. The Production Advisory system recommends a production level for both DI1 and DI2 based on the projected inventory over the next six hours. The inventory target range is set by operations management. The Production Advisory inventory target allows the mill to effectively plan for PM or pulp mill shutdowns days in advance, to help avoid high production/low quality periods.

Figure 4 PM Brightness Control



Manipulated Variables:
1,2 – Hydro Sulphite
5,6 – Optical Brightener

Quality Sensor/Sample:
3,4 – CORMECi
5,6 – Measurex

Control Variables:
7,8 – PM Brightness

FeedForward Variables:
3,4 – Blend Brightness

Real Time Optimization

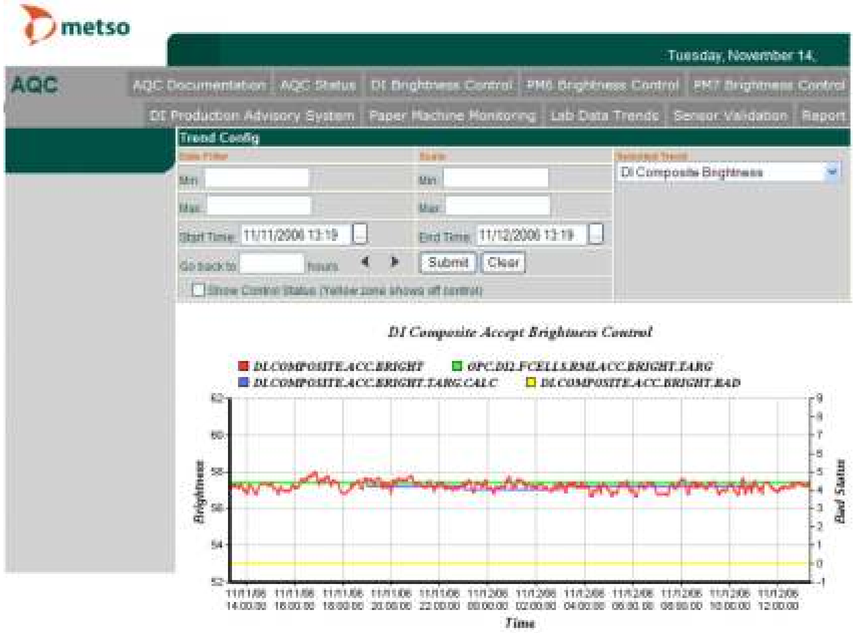
Using the incremental cost of brightness for each brightening agent, a real time optimization (RTO) system has been designed and implemented. The RTO system moves the composite accept brightness target depending on the paper machine chemical consumption (hydrosulphite and optical brightener) to achieve the lowest cost of paper brightness. Every four hours the system looks at the brightening chemical usage on the machines (hydro ratio + optical brightener). Based on the PM chemical usage, the system moves the DI composite accepts brightness target, but only if the DI accepts brightness control has the capability of achieving the new accepts brightness target.

The RTO system also manages the Production Advisory inventory target. If DI accepts composite brightness is above the RTO accepts brightness target, the inventory target will increase to fill up the tanks when the quality is good. If the brightness is low, the inventory target decreases to reduce throughput, which helps improve quality. The relative speeds of the DI accepts brightness control, the DI accepts brightness target optimization (RTO), and the inventory target optimization (RTO), are tuned so that they do not interfere with one another (i.e. cause cycling).

Sensor Validation

Multivariate models have been developed and logic implemented to cross-validate the pulp quality measurements. The models include the consistency, ash, ERIC, and brightness signals for the common cell feed and the six cell accepts measurement points. The quality measurements are used to cross-validate one another. If the measurement deviates too far from the model the measurement will be replaced with the model. Automated email alarms are sent if this occurs.

Figure 5 Web Based Monitoring System



Web-based trends are configured for all pulp brightness signals, showing both the actual measurement and the sensor validation model.

System Monitoring

A web-based monitoring application has been configured to allow both Metso and Thorold personnel to monitor the system. The user either needs to be on the local network or connected remotely via VPN. The user selects the menu items at the top of the display to access different groups of trends, tables, documentation, and automated reports. Figure 5 shows the main page of the web based monitoring and a sample trend.

Two automated daily reports are generated, a Daily Control Report which summarizes system control performance, and a Daily Cost Report which estimates the brightening chemical cost on a daily basis and gives month to date estimates. The reports are emailed every morning. They are also posted on a calendar in the web based monitoring application.

The system is configured to send automated email messages for system alarms such as control status, sensor problems, or communication problems. Critical email alarms are sent to the 24x7 support center. The Metso support engineer will contact the operator if there are any questions or required actions.

Results

The Mill Wide Brightness Control system has yielded significant cost savings and improved quality at Thorold. Figure 6 shows the brightness control error with regulatory and advanced control for PM7. Table 1 shows the PM brightness standard deviation reduction for PM6 and PM7.

Figure 6. PM7 Brightness Control

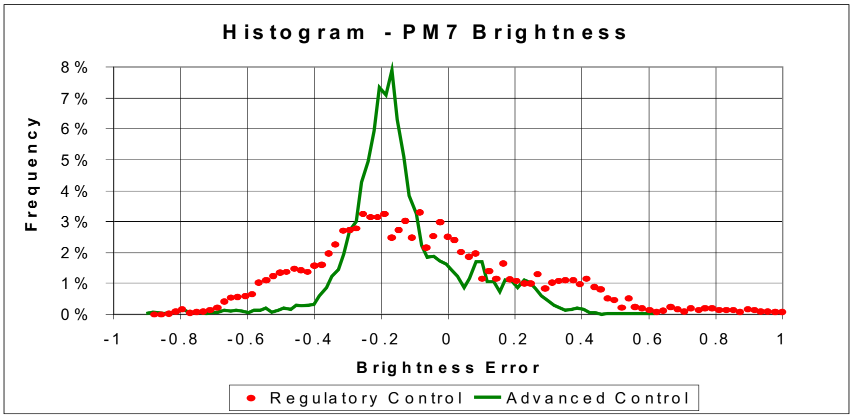


Table 1 PM brightness standard deviation

	Regulatory Control	Advanced Control	% Reduction
PM6	0.304	0.207	31.90%
PM7	0.318	0.181	43.10%