Experience of a microparticle retention aid system

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ABSTRACT: This paper presents some experience from using a cationic polymer–bentonite microparticle retention aid system at an alkaline fine paper mill. An automatic control system on white water consistency maintains retention at a constant level with the polymer. Increase in the stability of the wet end was a direct result of this control loop. This procedure and access to a process database allowed identification and analysis of some important variables affecting retention.

KEYWORDS: Automatic control, bentonite, Canada, cationic compounds, control systems, data bases, paper mills, retention, stability, synthetic polymers, variables.

Domtar operates two paper machines, No. 7 and No. 8, at its fine paper mill in Windsor, Quebec, Canada. The machines began operation in 1987 and 1989, respectively. They are twin wire Bel Baie III machines. Both are 8.38 meters wide with 7.67 meters trim at the reel. The present average speed of both machines is 1000 meters/min producing a monthly average of 1260 metric tons/day (1400 short tons). Types of paper produced are xerographic, offset, envelope, and forms with basis weights varying between 59.2 g/glm^2 and 103.6 g/glm^2.

The mill converted to the alkaline process in the fall of 1991. It operates with an average of 80% bleached hardwood kraft (HWK) produced on site and 20% market bleached softwood kraft (SWK). Since the conversion, the mill uses a microparticle retention aid system based on a cationic polyacrylamide and a modified bentonite. Other major chemical additives are cationic potato starch, alkyl ketene dimer (AKD) internal size, and a slightly oxidized starch with a styrene maleic anhydride (SMA) surface sizing. The filler pigment used is a precipitated calcium carbonate (PCC) of various dimension and shape.

Mill equipment includes an on-line paper quality scanner (Measurex 2002) and a process control computer (Honeywell TDC 3000). Optical consistency sensors (Kajaani RM-200) which control the retention connect to the process control computer. The on-line paper quality scanning system controls the amount of pigment in the sheet.

Objective

The purpose of this paper is to analyze and show how the implementation of the polymer control system on white water tray number one consistency helped stabilize machine operations at the wet end. This stability allowed easy analysis of several factors that have a major impact on retention.

This work covers over 1.5 years of process data. It will show the importance of using continuous data from databases. Databases are normally very useful. Here they provided a better understanding of the mill procedures leading to optimization.

In this text, the term retention implies first-pass retention. For proprietary reasons, we report the information as percentage change.

Databases

The results of this paper come from two databases used at the mill for the past two years. These databases were necessary, since the TDC 3000 only conserves detailed data for 96 h.

The first database (PI database) is on a VAX computer that can sample any selected variable every

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minute. For every grade of paper produced, averages and standard deviations of approximately 100 important parameters transfer to a second database. This provides data to the entire mill information network.

Using these databases and laboratory data, it was possible to analyze process variables of interest for the past 18 months.

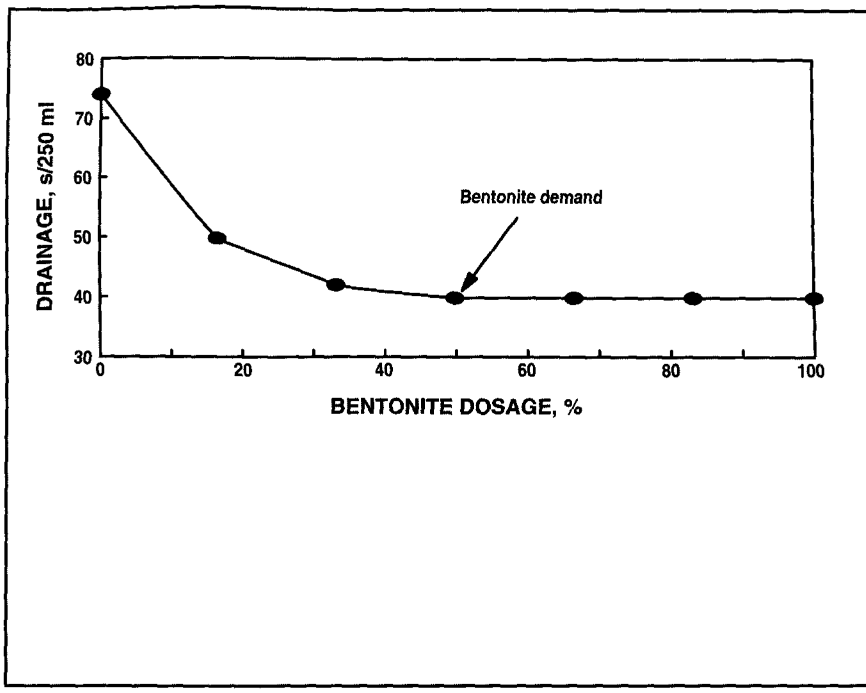
Microparticle retention system

The retention system on both machines is microparticle-based. It uses a high molecular weight (HMW) cationic polyacrylamide added before the secondary (headbox) fan pump and a modified bentonite pigment added after the pressure screen.

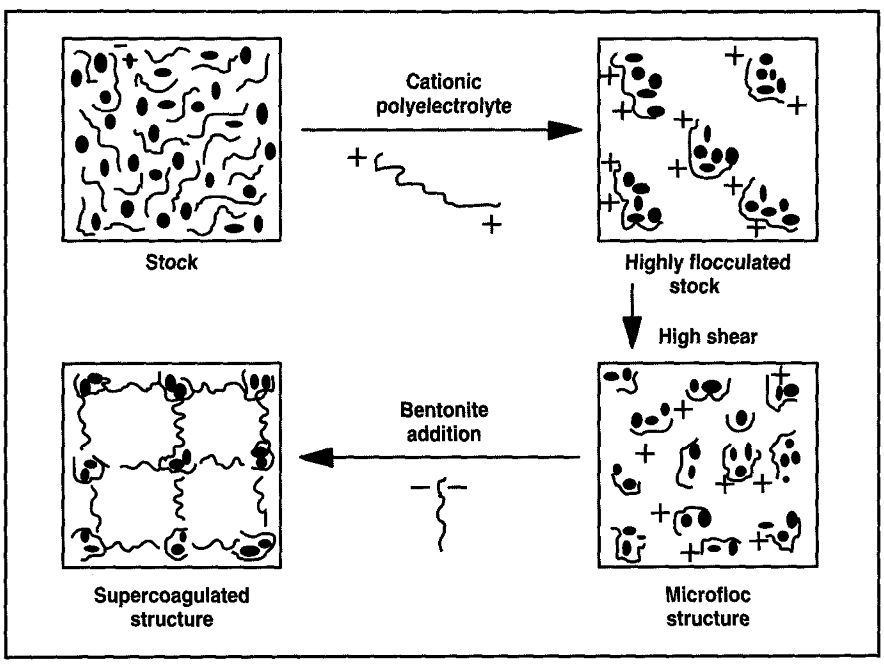
Adjusting the polymer addition rate and keeping the bentonite at a constant dosage controls the retention. Laboratory drainage tests evaluated the level of bentonite addition. These determine the bentonite demand under various wet-end conditions. **Figure 1** shows an example of a drainage curve representing the bentonite demand.

A brief description of the microparticle flocculation mechanism is helpful. Flocculation occurs immediately after the addition of the HMW cationic polymer. The shear caused by the fan pump and the pressure screen break down the large flocs into microflocs. The addition of the bentonite reforms the flocs into a supercoagulated structure as **Fig. 2** illustrates.

1. Drainage curve showing the bentonite demand for the microparticle retention system using modified CSF drainage tests



2. Diagram of the microflocculation process

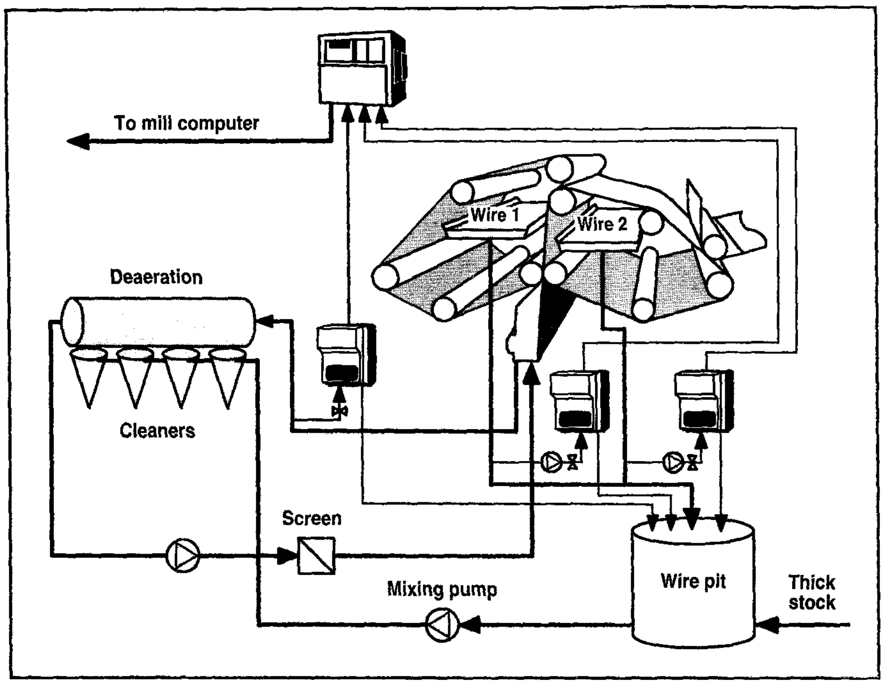


Retention control system

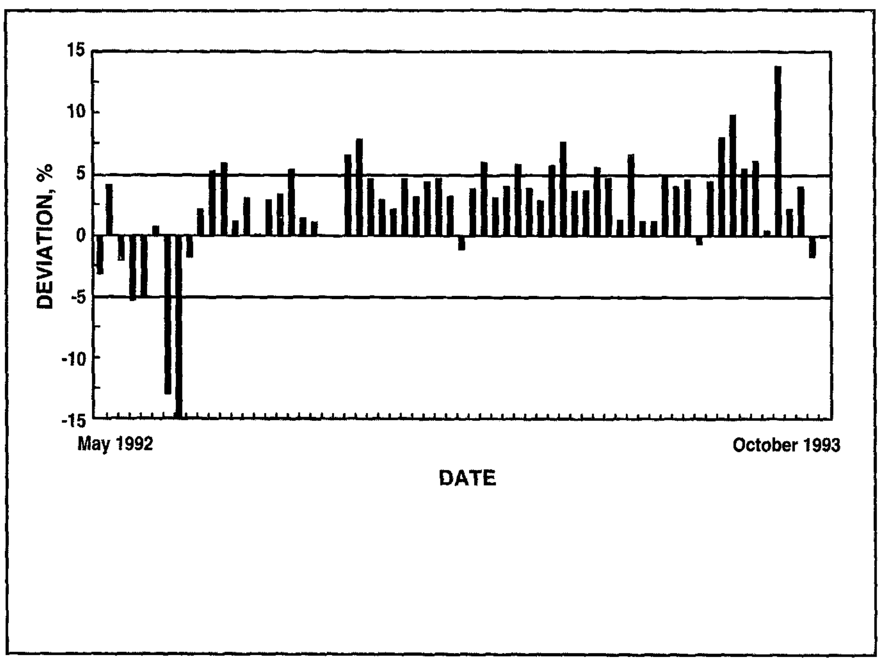
The two paper machines received an optical consistency system in 1991. **Figure 3** shows the three consistency sensors per machine installed on the headbox and white water trays. These sensors measure the total amount of solids and pigments in suspension. This enables the calculation of total retention and pigment retention.

The equipment requires regular supervision. Since it comprises high-precision optical sensors, regular checks are necessary using TAPPI Test Method T-240 (*1*). After weekly checking, each sensor undergoes recalibration if the error exceeds ± 5% for total consistency and ± 10% for pigment consistency. **Figure 4** shows the differences between the laboratory consistency tests and readings of the optical sensors for tray number one on No. 8 paper machine between May 1992 and October 1993. Most of the time the results fall within specifications.

3. Arrangement of consistency sensors on a twin wire paper machine



4. Variation between consistency values recorded by optical sensors and the laboratory tests over a period of 17 months



After approximately one year of use on read-only mode, the consistency measuring devices went to automatic polymer addition based on the number one tray white water consistency setpoint. There are several advantages in using one tray consistency as the only control variable (*2*). Measuring one tray consistency is simpler and more accurate, and the response time is faster. Since beginning this automatic control strategy, the system has operated reliably. Mill personnel refer more often to tray water consistency than to retention.

Understanding the control system operation requires looking at how it maintains the white water consistency setpoint of tray number one with the polymer dosage as **Fig. 5** shows. The consistency setpoint maintains a variation of ± 2%.

Each time the consistency passes through the setpoint, the polymer controller reacts to maintain the same setpoint. The control program design provides a progressive ramping of polymer dosage to prevent wet-end upsets.

Control of the process can occur from either of the trays. If for some reason the system or both tray sensors are faulty, it is possible to return to an alternate (manual) operation of controlling the polymer dosage rather than the white water consistency.

Since implementation of the polymer consistency control process on tray number one, the stability of the wet end of the paper machines has greatly improved. As **Fig. 6** shows, there has been a major decrease in consistency variations since control implementation. The values in Fig. 6 are averages for the consistency of tray number one for each run of the same grade on No. 8 paper machine. The figure compares one period of four months before the automatic control to two periods of two months with automatic control.

Figure 7 shows coefficients of variation of tray number one consistency for each run of the same grade. This number is the product of 100 times the standard deviation divided by the mean (*3*). Note that the average for the coefficient of variation decreased by 65% for the first two months after the control was in place and by 74% for the other period of two months. The larger decrease for the latter period is due to the specialization of the machine for a given grade and setting and following the control setpoint.

To see the operating benefits of automatic control, one can compare white water consistency stability to process changes by examining the second couch roll vacuum. This is an important process variable to papermakers. As **Fig. 8** shows, the weighted average of the coefficient for the couch vacuum experienced a 40% decrease after the control implementation.

It was not possible to look at other machine-related variables such as basis weight or humidity, since other systems control these. The example with the second couch roll vacuum, however, clearly shows better machine stability. After the control implementation, analysis of other variables became easier.

Factors influencing retention

Basis weight

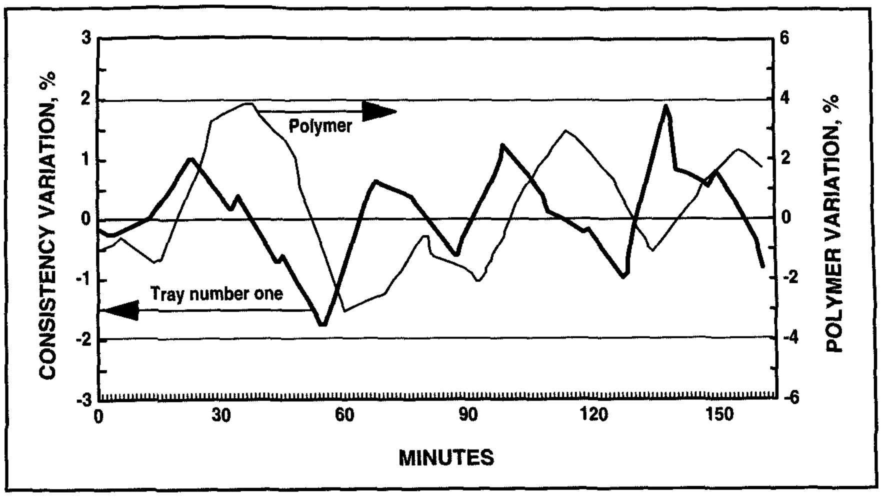
When basis weight of a sheet increases, the retention aid polymer dosage for a given consistency setpoint decreases. **Figure 9** shows that this conventional wisdom was the experience of the mill. The only exception is the 72.2 g/glm^2 grade that uses a different PCC pigment with a higher particle size (LO vs. HO). This leads to an examination of the influence of the two types of PCC on retention.

PCC type

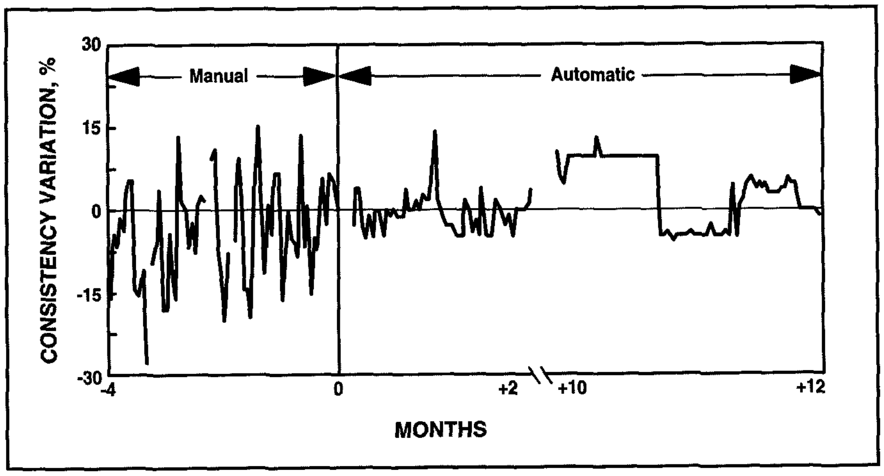
The 72.2 g/m^2 is the only grade using PCC LO. Looking at the difference between the two types of PCC, one sees that PCC LO has a smaller surface area than PCC HO as the distribution curve in **Fig. 10** indicates. Since a particle with a large surface area is more difficult to retain, it is not surprising to see the consumption of polymer fall for the 72.2 g/m^2 grade that uses PCC LO.

In one instance, an operator replaced the PCC HO by PCC LO during a run. **Figure 11** shows the results. The polymer dosage decreased by approximately 20% with PCC HO replacement by PCC LO.

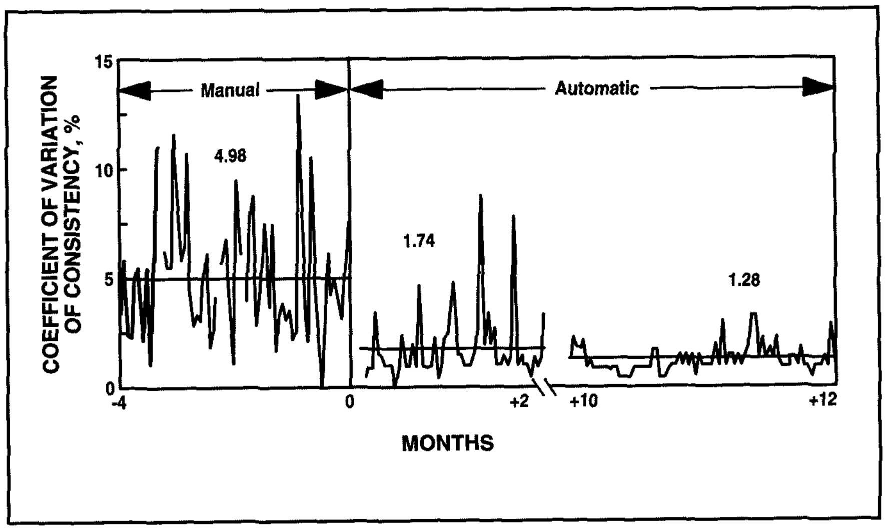
5. Minute-by-minute data showing the consistency control of tray number one with cationic polymer



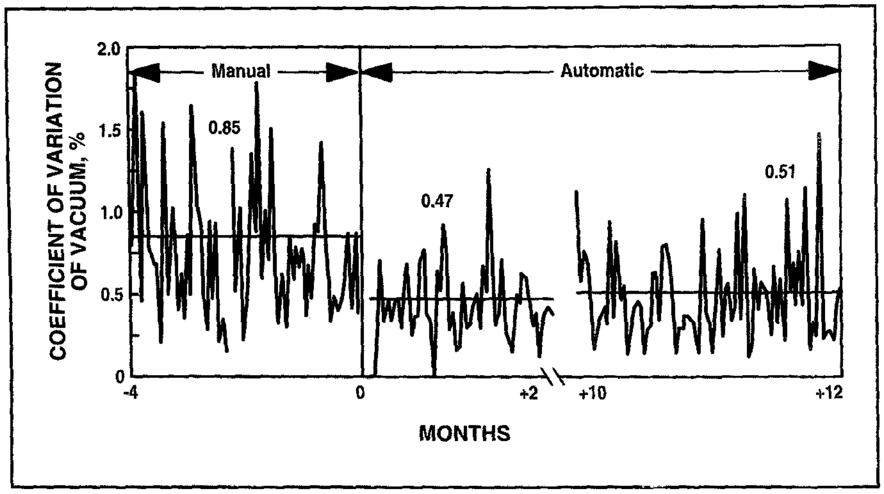
6. Variation in consistency on tray number one before and after the implementation of the control system



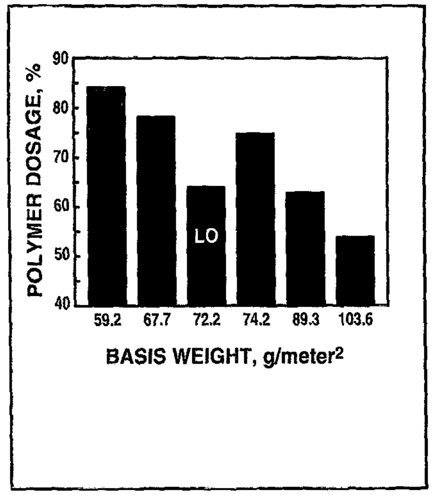
7. Coefficient of variation of consistency on tray number one before and after the implementation of the control system



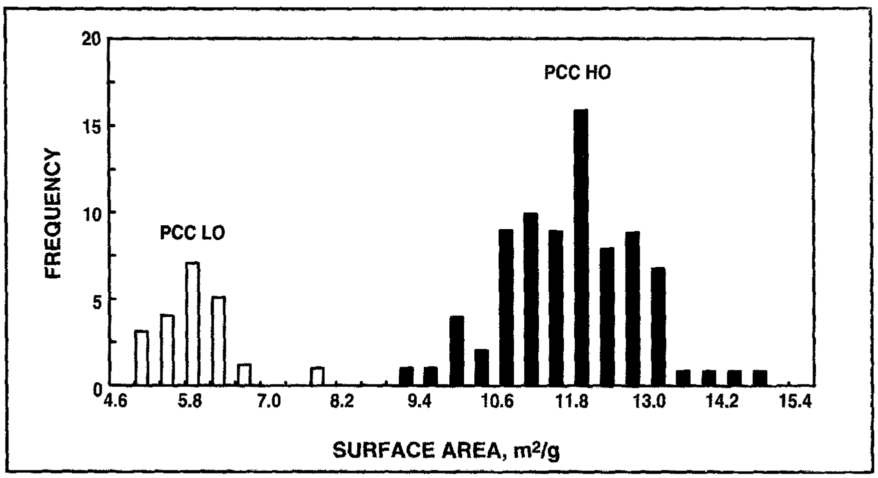
8. Coefficient of variation of second couch roll vacuum



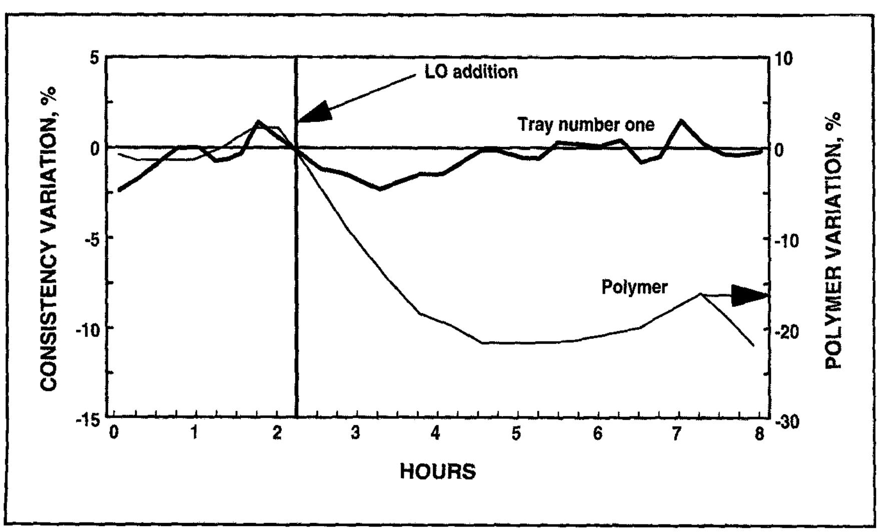
9. Variations in polymer consumption vs. basis weight



10. Distribution of surface area for PCC LO and PCC HO



11. Influence of the replacement of PCC HO by PCC LO on polymer retention control system dosage



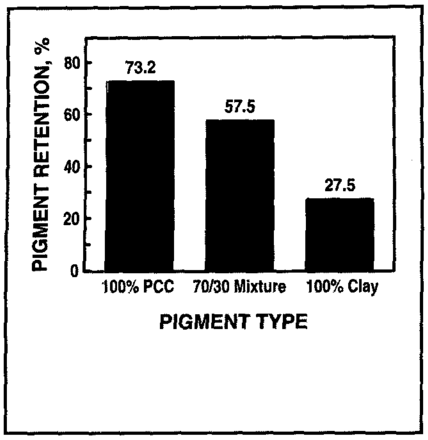
PCC HO improves opacity. Since PCC LO retains easier, it would be interesting to try to replace part of the PCC HO with PCC LO on grades where the opacity allows it.

Filler clay

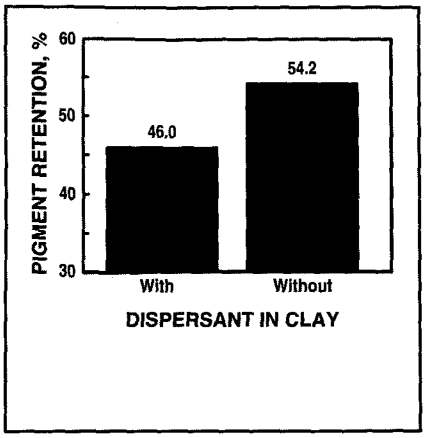
The mill has not used filler clay for approximately one year. It appeared to be detrimental to retention. Britt Jar tests (*4*) looked at its influence on retention. Using the mill databases with operational data, **Fig. 12** shows that adding clay to replace PCC reduced the pigment retention. Replacing the PCC completely with clay caused the pigment retention to fall from 73.2% to 27.5%. This leads to the conclusion that clay was more difficult to retain than PCC.

An understanding of the reason for clay being more difficult to retain became important. The most significant difference between filler clay and PCC is the presence of dispersant in the clay. The on-site produced PCC has a concentration of 20% and does not require a dispersant. Purchased clay has a 70% concentration with a dispersant to keep it in suspension. The influence of the dispersant was evaluated using the Britt Jar with clay (with and without dispersant). **Figure 13** shows the results for pigments comprising 70%

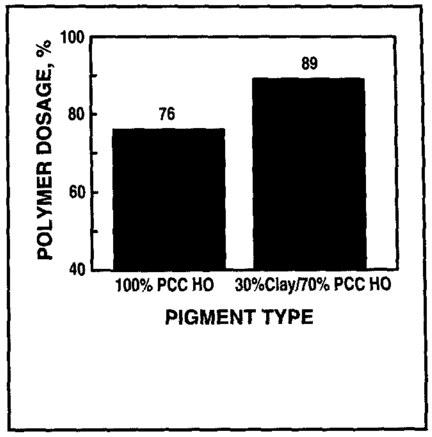
12. Results of Britt Jar pigment retention tests showing the influence of clay compared to PCC



13. Results of Britt Jar pigment retention tests showing the influence of the dispersant in clay



14. Weighted averages of polymer dosages for samples with filler of 100% PCC and with 70% PCC and 30% clay at constant retention

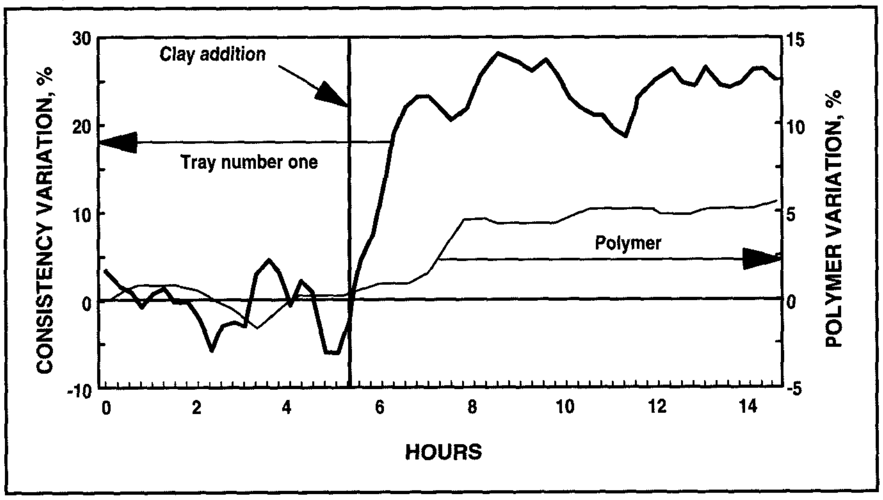


PCC and 30% clay reflecting the proportions in use at the time.

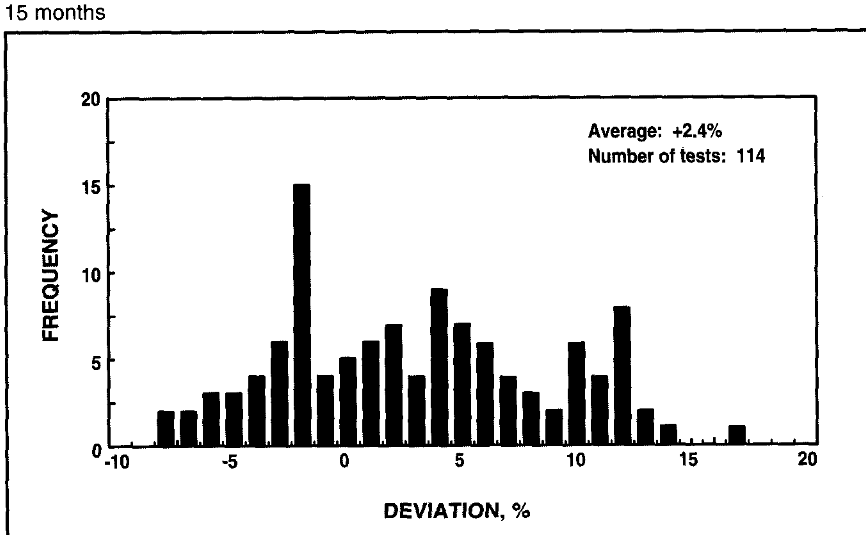
Using the clay without dispersant, pigment retention increased from 46% to 54.2%—an improvement of 18%. The dispersant is a significant factor that interferes with retention. Using the databases allowed determination of the influence of clay in the process. There were two instances of long production runs of the same grade with the clay content being the only difference. The grade was 67.7 g/m^2 on No. 7 machine. There were 13 runs without clay and 14 runs with an average of 30% clay in the total pigment. Using a test of a statistical hypothesis about two means with a confidence level of 95% confirmed the hypothesis that clay would use more polymer than a sample without clay. **Figure 14** shows the weighted averages for the two samples.

In another case using manual mode, an operator added the filler clay while the run was in progress. **Figure 15** shows the effect of replacing part of the PCC with clay. The consistency of tray number one went up by approximately 25% when the operator increased the polymer by approximately 5%. The clay had a significant influence on the consistency of white water.

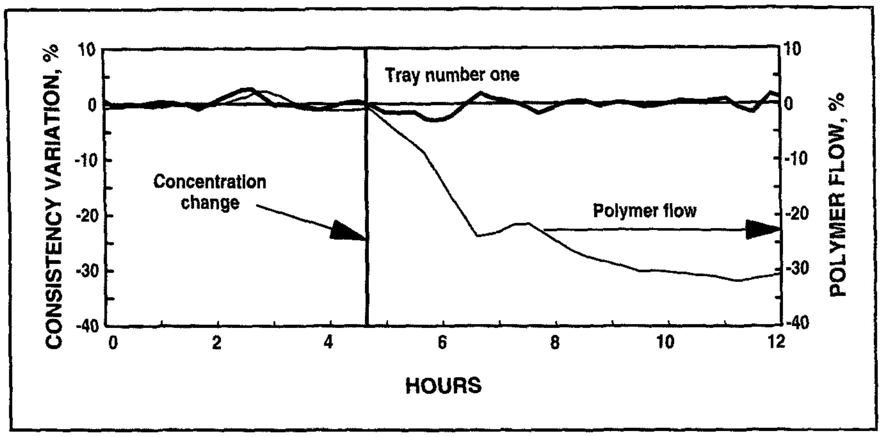
15. Influence of the replacement of part of the PCC with clay on white water consistency in the manual mode



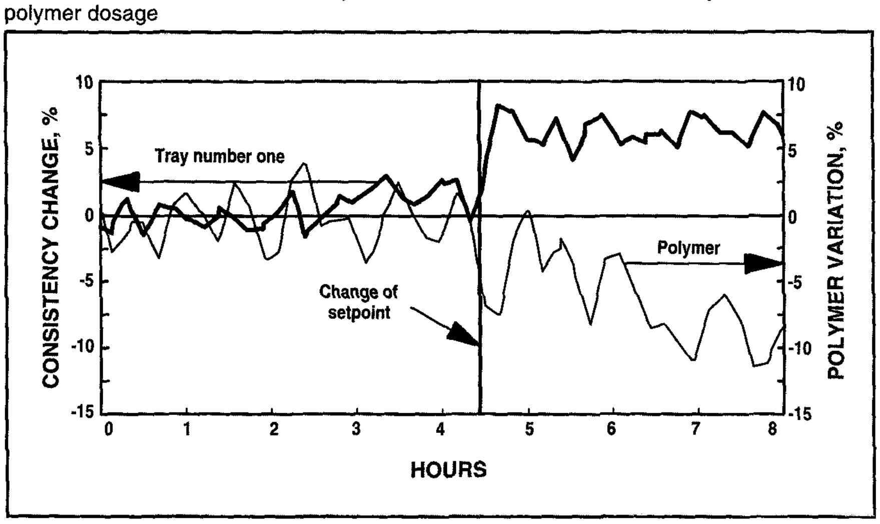
16. Deviation in percentage of polymer concentration compared to the target in a period of 15 months



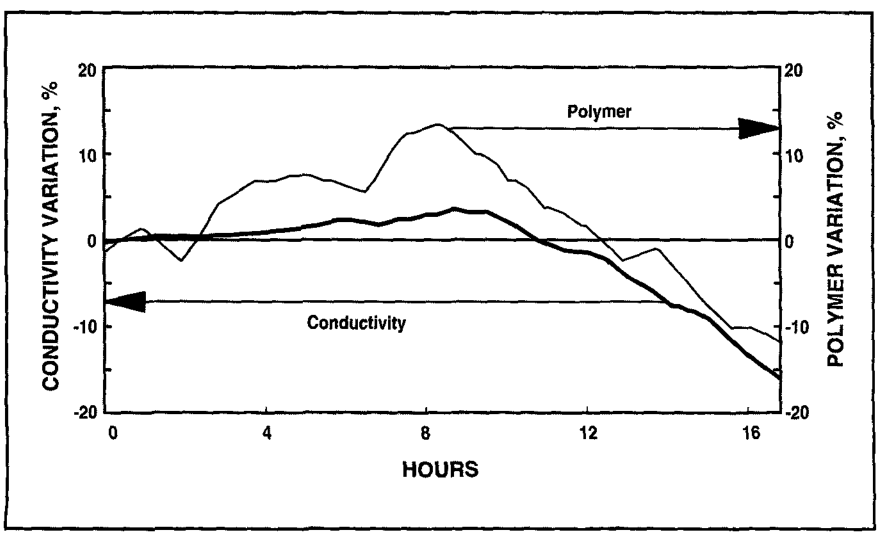
17. Effect of changing the polymer concentration from 0.50% to 0.75% on polymer flow when the system is under control



18. Influence of the variation in tray number one white water consistency setpoint on the polymer dosage



19. Variation in polymer dosage with the white water conductivity



Polymer concentration

Another factor that may influence retention is the variation in the polymer concentration. Regular checks of the concentration occur. **Figure 16** indicates the variation from the target value. The polymer comes in a solid form at the mill for preparation on-site at a concentration of 0.50% or 0.75%. In Fig. 16, deviations from the target vary from –8% to +16%. This corresponds to a variation of 0.46–0.58% on a desired polymer concentration of 0.50%. Because of the consistency control loop, these variations do not influence the process. The control loop checks to detect if the polymer dosage is sufficient to maintain the desired tray consistency regardless of the polymer concentration.

To illustrate this point further, the investigation included behavior of the control system when the polymer concentration changed intentionally from 0.50% to 0.75%. The graph in **Fig. 17** shows this transition. The figure indicates that the system holds the white water consistency constant with only polymer flow adjustment.

This does not mean that the variation in concentration does not influence the measured polymer dosage. Since there is only polymer flow measurement, the dosage calculation in kg/ton comes from the flow and the presumed concentration. Since these dosages are useful for troubleshooting and setting recipes, there was a system modification to keep the polymer solution at the same concentration always.

Tray water consistency setpoint

Another important factor is the tray water consistency setpoint. Since this is the control parameter, the consistency must always be constant to maintain a stable retention on each grade. This results in stability at the wet end and makes it possible to optimize other variables.

Figure 18 shows that an intentional variation of 7% of white water consistency setpoint affected the polymer dosage. The consumption of polymer decreased by approximately 7%. A decalibrated sensor or a different setpoint can cause significant variations at the wet end. Regular checking and good maintenance are essential for sensor calibration.

White water conductivity

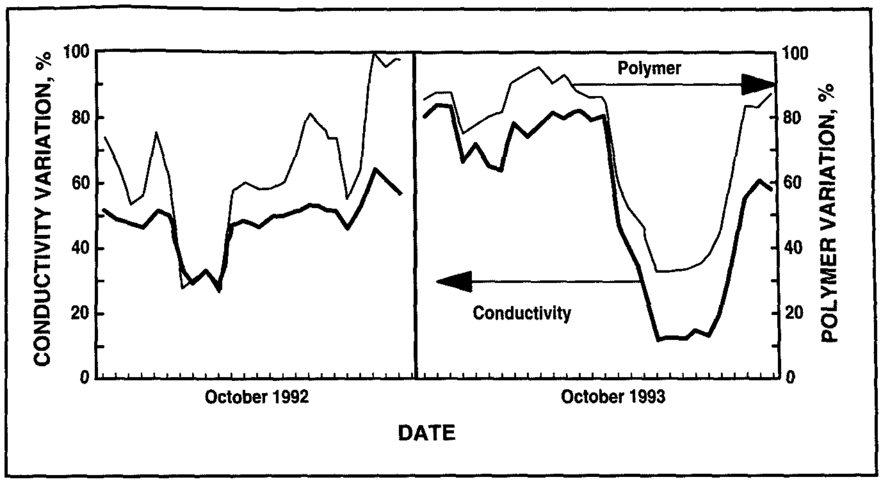
White water conductivity is undoubtedly the most influential factor on retention at the mill. Conductivity is a measure of the presence of anionic materials and dissolved solids in the pulp. These are the result of inadequate washing in the HWK process.

Figure 19 shows one day during which conductivity varied widely while all other conditions remained constant. This allowed determination of the influence of conductivity on retention or on the polymer dosage. This figure represents the situation frequently seen in the mill that polymer dosage follows conductivity.

Figure 20 records dosages for polymer and white water conductivity for the same grade for the months of October in 1992 and 1993. These months are significant because there was a complete shutdown in the kraft pulp mill then. That meant the paper machines used baled pulp—a very clean pulp with low conductivity. The two lower peaks on the graph represent the pulp mill shutdown.

In a period of low conductivity, the figure shows that it is possible to reduce the polymer dosage by half compared to periods of high conductivity. In addition, the demand for bentonite is lower during periods of low conductivity.

20. Polymer dosage variation with white water conductivity during the months of October in 1992 and 1993 for the same grade on No. 8 paper machine



Conclusion

This study is far from complete. It only includes examination of a few factors that affect retention. There are many others such as the type of fabric used, the jet to wire ratio, adjustments at the headbox, and quantity of filler used to name a few.

From the work reported here, it is possible to draw the following conclusions:

- The implementation of retention control enabled the mill to decrease the consistency variations in tray number one by more than 60%. Controlling this parameter gave a resulting decrease of approximately 40% in the variation of the second couch roll vacuum and more stability at the wet end. Since the implementation, there has been an increase in confidence of the control system. Users call it "cruise control." It has passed its operational test. Today the operators would never want to return to the old system.
- The use of the control loop combined with the process databases has made it possible to analyze several important factors that influence retention: basis weight, filler type used, white water consistency setpoint, polymer concentration, and white water conductivity. The quantification of these factors will now allow the study of other factors. All this will help to analyze and troubleshoot more quickly and effectively the problems related to retention.
- The key findings of this study are the need to have an effective retention system, the ability to set it up effectively on control, and the access to a large quantity of good process data. This data should cover a sufficient period to provide a global view of the system. Together with several other major improvements, the implementation and fine tuning of the retention control system has contributed to increased production by 40% since September 1992.
- This type of work has contributed to making keywords like control, database, and stability part of the everyday working vocabulary of the mill.

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