

Computer-aided on-line monitoring techniques for optimization of alkaline papermaking chemistry

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Mead Research needed a way to quickly and accurately analyze both short- and long-term process variations. Computer-aided on-line monitoring was the answer.

This paper describes a fairly new approach to wet-end chemistry diagnostics and optimization which is based on a multicomponent computer-aided diagnostic system that permits continuous monitoring of key process parameters. Trend data from continuous monitoring is then stored in a standard format for further processing (trend analyses, multivariable correlations, etc.).

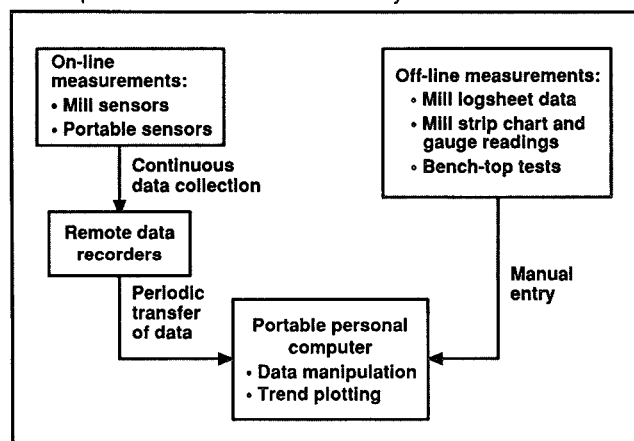
The purpose of on-line monitoring is to learn what affects the wet end, to detect and eliminate wet-end instabilities, and to optimize and provide greater information during machine trials. With on-line information, machine trials can be conducted more successfully.

In contrast, conventional wet-end studies usually resort to limited "snapshots" of key parameters from labor-intensive bench-top analyses. As a result, (a) short-term trends are often undetected because they appear in the data disguised as scatter, (b) key parameters to be correlated are often measured at different times without reference to the system lag times, therefore introducing data error, and (c) correlations are often not identified in real time, thus hindering control actions.

Computer-aided on-line monitoring system

Our approach is based on the automated collection and computer-assisted manipulation and analyses of massive quantities of data in a thorough but timely fashion. Data collection is done continuously with data loggers and on-line sensors (Fig. 1). Remote data loggers (one per signal) are mounted at the point of origin for each signal. On a periodic basis, data is quickly and simply transferred from each logger to a hand-held storage device through an RS-232 cable. The hand-held storage device can store data from up to 60 loggers. The data is transferred to a personal computer, again using an RS-232 cable. An alternative method is to transfer the data directly from the logger to a computer via RS-232. Data processing in the (personal

1. Computerized data collection and analysis



computer) pc is accomplished by data logger software and Lotus 1,2,3® macros.

Our other data collection approaches have included downloading data from mill computers to a pc and real-time data collection, data processing, and trend plotting by a Hybrid multichannel strip-chart recorder.

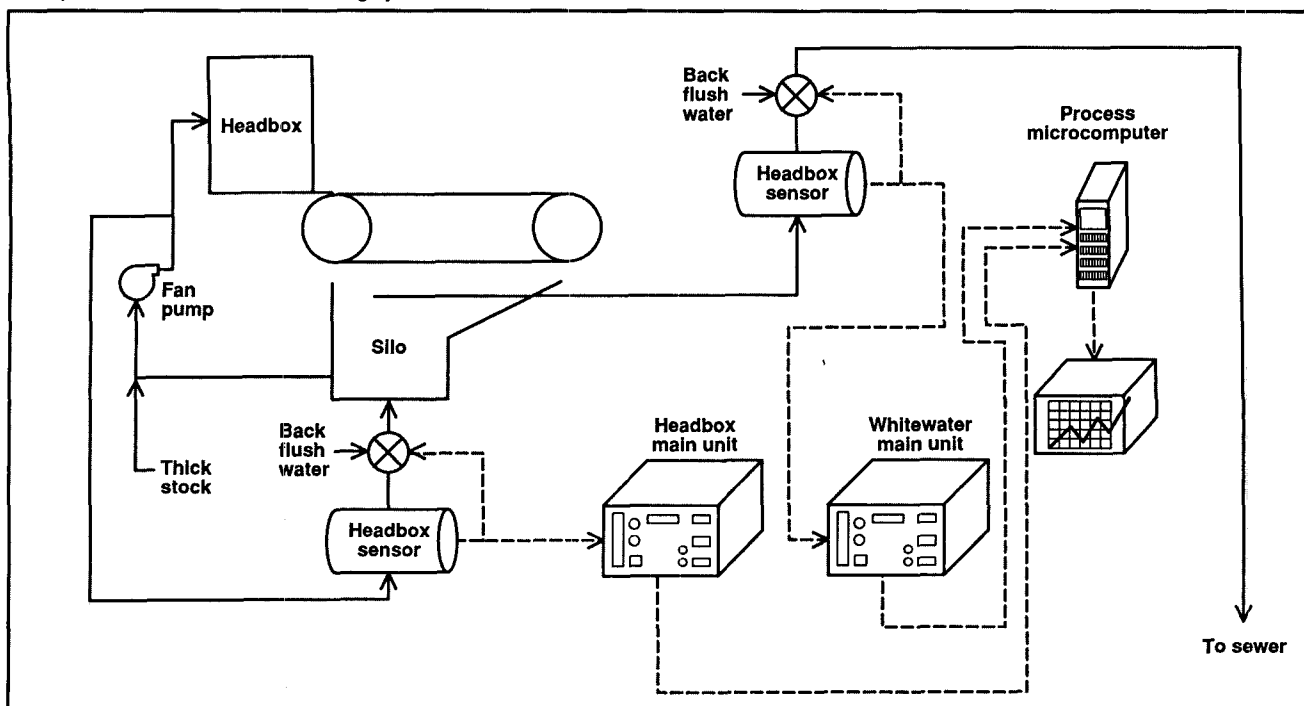
Mill and portable sensors are monitored. Commonly monitored mill sensors include basis weight sensors, moisture sensors, pH probes, chemical flowmeters, and thick-stock flowmeters and consistencies. Portable sensors which are often monitored include low-consistency transmitters, tachometers (machine speed), pH probes, and temperature probes. Other portable sensors which have been monitored or are presently being evaluated are a streaming current detector, a total organic carbon monitor, and an ultrasonic air-content meter.

Unfortunately, not all valuable data is obtainable through on-line measurements. Much of the data must still be collected from bench-top measurements, mill log sheets, gauges, etc.

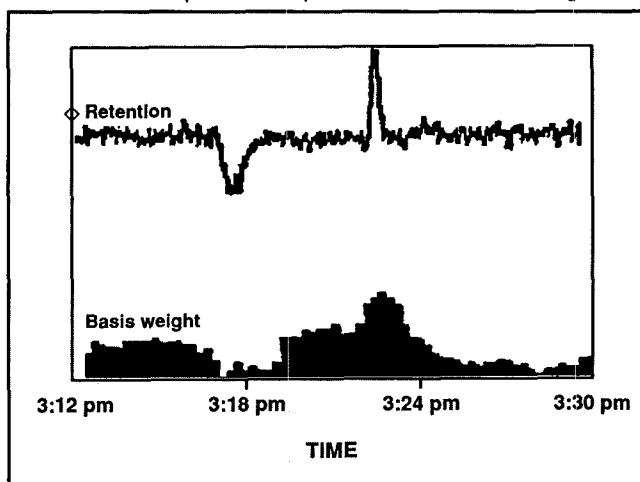
Our most valuable portable sensors are the Kajaani LC-100 low-consistency transmitters. These transmitters are set up to continuously monitor the first-pass retention of furnish solids in the sheet (Fig. 2). In addition, by tapping

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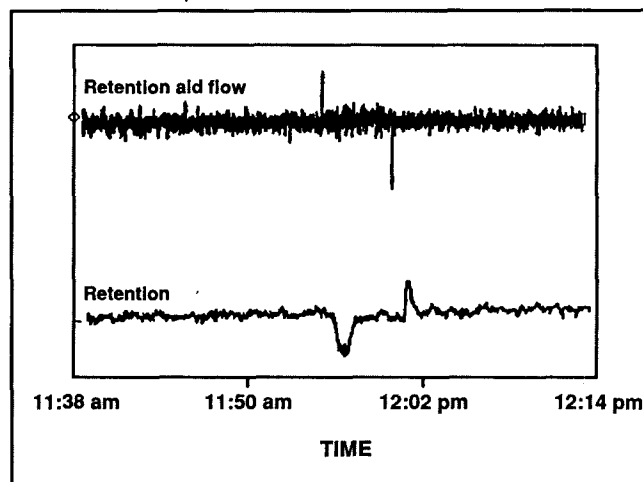
2. Kajaani LC-100 retention monitoring system



3. Simultaneous upsets in first-pass retention and basis weight



4. Simultaneous upsets in retention aid flow and retention



internal signals within the LC-100s and processing appropriately, our transmitters can simultaneously monitor the retention of expensive fillers in the sheet. Unlike some retention monitoring systems which alternate headbox and white water flows through the same sensors, the Kajaani system is capable of detecting extremely short-term variations. This capability proved valuable in our first application example.

Wet-end chemistry optimization of an alkaline machine

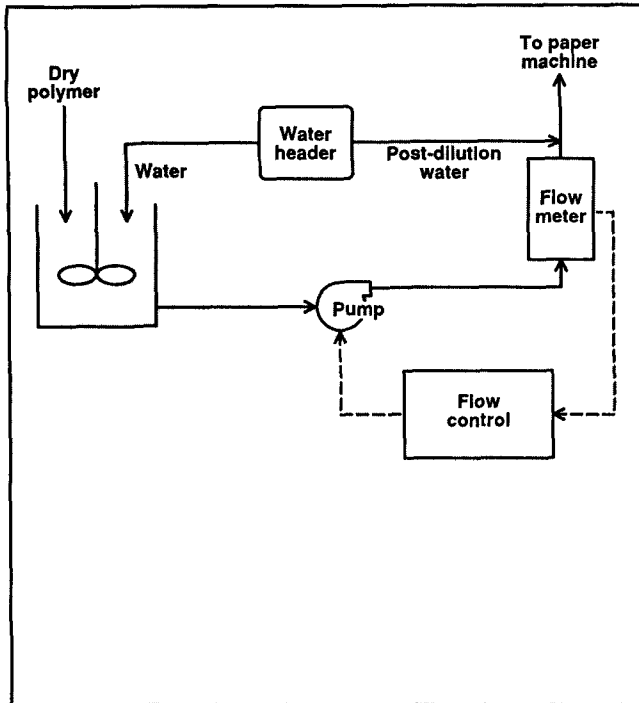
One application of our multicomponent computer-aided diagnostic system was to assist the chemistry optimization of an alkaline paper machine. Two of the problems

addressed during the study were basis weight and retention instabilities.

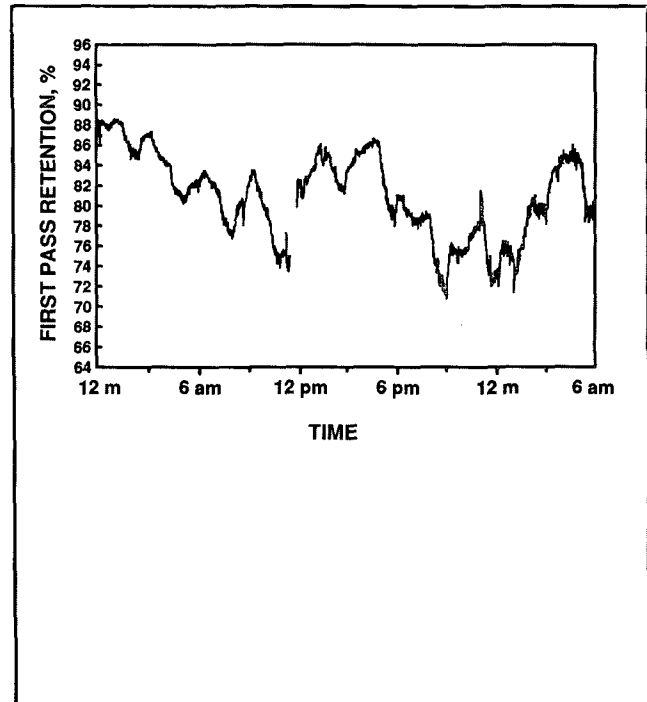
Basis weight fluctuations

Basis weight fluctuations were found to occur several times a day. Each fluctuation began with a dip in basis weight of approximately 0.9 g/m² followed five minutes later by a peak of similar magnitude. The on-line monitoring and trend charting permitted detection of simultaneous changes in retention and retention aid flow. Corresponding changes in retention were observed first (Fig. 3). The ups and downs in retention matched the ups and downs in basis weight. Next we observed that (a) seven events per day was the most common and (b) events often occurred at roughly similar times on adjacent days between operator shift rotations. This indicated that the

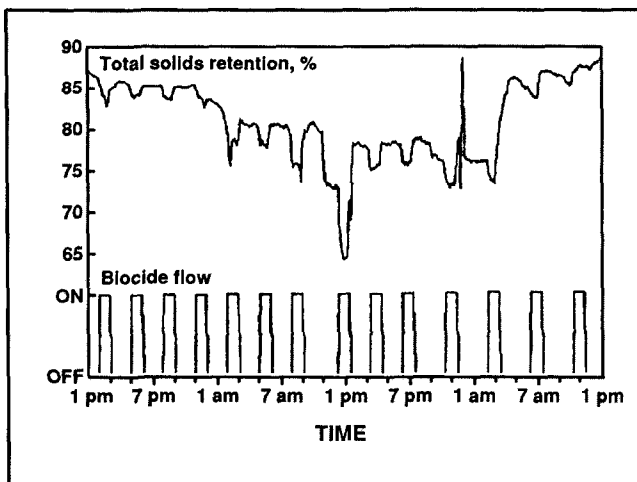
5. Retention aid makeup system



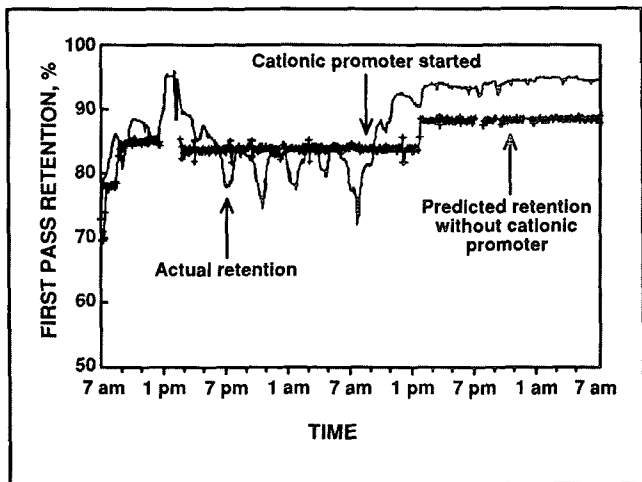
6. Occurrence of three-hour cycle



7. Effect of biocide on retention



8. Effect of cationic promoter (77 g/m² basis weight)



problem was shift related and tied to an operation affecting retention and requiring manual assistance seven times a day.

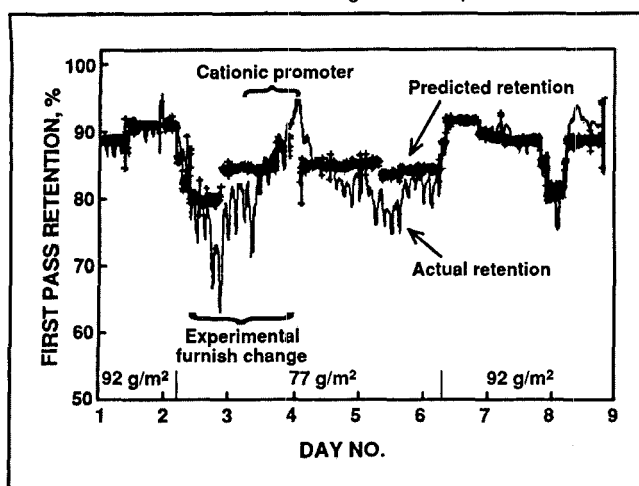
Based on this information, the retention-aid makedown system was examined. Real-time strip charting of the retention and retention aid flow signals revealed simultaneous upsets (Fig. 4) which corresponded to a basis weight upset. Also observed during the upsets was the makedown of a fresh batch of retention aid. We found that approximately seven batches of retention aid were prepared daily. Each batch required five minutes of water flow into the makedown tank.

An analysis of this information revealed the following problem and solution. Both the polymer makedown water and the post-dilution water were drawn from the same water header (Fig. 5). Consequently, any sudden change

in the makedown water flow caused corresponding changes in post-dilution water pressure and polymer-pump back pressure. The back-pressure variations were too quick for the retention aid flow controller to handle. This resulted in machine upsets due to variations in retention aid flow and concentration. The solution to this problem was to draw makedown and post-dilution water from separate water headers. The machine upsets immediately disappeared upon completion of the task.

The variations in first-pass retention which led to this discovery would not have been detected if the retention monitoring system did not have separate sensors for monitoring white water and headbox consistencies.

9. Predicted vs. actual retention using a cationic promoter



Retention instabilities

In addition to the retention instability caused by the polymer makedown system, a three-hour retention cycle was monitored (Fig. 6). An examination of mill chemical addition records indicated that biocides were added on a cyclic basis. The cyclic additions serve to minimize the chemical requirement while still providing the required threshold concentrations needed to kill biological growth. The biocide was added to the fan pump on a three-hour cycle (one hour on, two hours off). Close examination revealed that the "on" periods corresponded to the drops in retention. This was confirmed by the retention response when the biocide addition was changed to a four-hour cycle (Fig. 7).

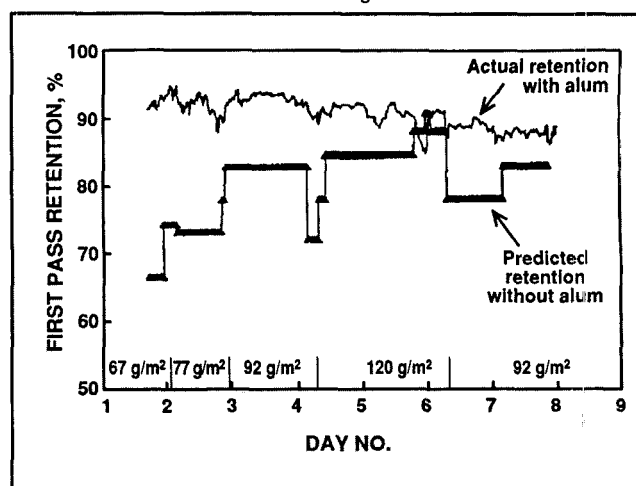
In response to the retention upset, a new biocide was tried. The effect of the new biocide on retention was approximately half that of the old biocide. Unfortunately, the new biocide was not as effective in controlling biological growth and had to be discontinued.

A better approach to eliminating the three-hour cycles was to maintain high retention. On-line trends show that as retention improves the biocide effect almost disappears (Fig. 8). This illustrates that retention control is a good solution to the problem. For good retention control, the importance of on-line monitoring cannot be emphasized enough.

Retention modeling

To accurately evaluate the effects of trials on retention, the effects of routine process changes that occur during the trials must be understood and quantified. On-line monitoring and computerized data processing permitted the correlation of routine process changes to retention and the development of an empirical model. Basis weight and broke level were identified as the dominant process changes affecting retention. During trial evaluations, this "predicted retention" model was used as a baseline for comparison to actual retention (Fig. 9). Any deviation of actual retention indicated that other factors were influencing retention. In Fig. 9, there is very good agreement between predicted and actual retentions, except during periods when trials were conducted.

10. Predicted vs. actual retention using alum



Retention control

A cationic promoter and alum were both useful in improving retention during machine runs at low basis weight or high broke levels. The cationic promoter is a highly charged cationic polyelectrolyte designed to neutralize anionic trash which would otherwise interfere with the functions of other cationic additives (e.g., retention aids). The promoter was added at the blend chest outlet. Figures 8 and 9 illustrate the effectiveness of the promoter on retention. In each case, high retention was restored when the promoter was added during low-retention periods.

Alum would be expected to function in much the same way as the cationic promoter. Figure 10 shows the effect of adding 2.5 kg/ton alum (split between blend chest and white water silo). The magnitude of its effect is demonstrated by (a) the difference between actual retention and predicted retention and (b) the absence of the three-hour biocide cycles. Alum appears to be more effective than the promoter in improving and stabilizing retention.

Conclusions

On-line monitoring has provided us with valuable information unobtainable through conventional wet-end monitoring. This information comes from the identification of short-term process trends, rapid analysis of many process parameters, and the monitoring of new process parameters. With the information from on-line monitoring, the capability exists to solve both more problems and problems of greater difficulty. The capabilities of this approach are expected to grow further as improved data-handling techniques, new technology, and new sensors are developed. □

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