Measuring moisture after the press
Introduction

The stability of the paper machine short circulation, forming and press section are tightly connected. A new online measurement, IQInsight, now provides true instantaneous MD and CD profiles from the press section. This unique measurement device provides new possibilities for stabilizing and optimizing paper machines. The accurate and continuous moisture profile just after the press section can be used to significantly improve paper quality. With an additional one percent dryness out of the press section the dryer section steam consumption can be reduced by three to four percent. On dryer limited machines, it can provide a capacity increase. Good moisture profile control also improves runnability. Significant savings can be achieved from reduced wet end and press breaks.

At the dry end of the paper machine, at the reel, traditional scanners function very effectively, but the substantial delay through the long dryer section and the drying itself masks any useful data for wet end control. Quality problems cannot be responded to in time, so adjustments must be made based on obsolete information.

Most of a paper machine is devoted to dewatering but papermakers have traditionally had very little visibility into this process. Moisture measurement after the press gives a valuable window into how this dewatering is taking place. A dry end moisture problem that can be seen already just after the press means no time is wasted searching for dryer section causes. If the moisture profile out of the press is good, attention can be immediately focused on the dryer section. Press moisture profiles can be used by papermakers to quantitatively assess press clothing condition and evaluate the performance of alternative fabric designs. The effects of operating adjustments such as nip loading, variable crown adjustments, suction box and forming section vacuums and press felt showers can be immediately seen without the uncertainty and delay introduced by an imperfect, real-world dryer section. Being closer to the source of a problem, means that an after press moisture measurement is an excellent tool for diagnosing problems whose source is upstream of the machine itself.

Background

The first attempts to measure after press section profiles with mechanical scanners were made in the 1970s. Installed across open sheet draws between the press section and the dryer section, these scanners suffered from the effects of the wet, corrosive environment and required frequent cleaning to remove paper debris and other contaminants. With poor reliability and difficulties in calibration, many of these early measurement systems fell into a state of disrepair. Those that did survive suffered from slow scanning speeds relative to the speed of the paper and thus the difficulty in separating, or even seeing, fast CD and MD variations. This poor performance meant that, as systems were replaced; wet end scanners were rarely purchased, particularly for fast paper machines producing light weight grades.

Advances in both optical technology and electronics have recently revived interest in cross direction profiling close to the wet end. As machine speeds have increased, paper machine designers have focused on minimizing or eliminating open draws for improved runnability. Now that draws are closed or non-existent a traditional scanning measurement system simply does not fit into a modern machine. Two commercially available systems, designed to measure the elusive press section profile, use faster redesigned scanning techniques. A third system from Metso Automation avoids the disadvantages of mechanical scanning and uses an array of optical modules to take a moisture profile of the full width of the web many times per second.
The Scanning Speed Dilemma

The cross-direction profiles measured by a scanning platform are a complex mixture of CD and MD variations. Several hundreds of meters of paper pass by while a conventional scanning platform traverses the web, separating the CD measurements in time and space along both dimensions of the web surface. There is no algorithm that can completely separate the MD and CD information from a scanning measurement. The filtering and averaging used with scanners to minimize this MD contamination of profiles (CD aliasing), masks any useful data from the dynamic and fast changing wet end. The filtered MD variations may appear from time to time as temporary, phantom streaks in the scanned profile. This so called “aliasing” of profiles by MD variations introduces a “ghost” variability to the raw and filtered profile views. This misleading information has been puzzling papermakers for years and operating personnel can take incorrect actions as a result. Automatic CD controllers acting on the fictitious information will also continuously introduce more variability.

In the machine direction, a scanning sensor is essentially "blind" to variability faster than two scan periods. If it takes, for example, 10 seconds to traverse the sheet, variations under 20 seconds cannot be detected by the measurement. The result of the time delay from the valve to a dry end scanner is that only much slower variations can actually be controlled.

The “brute force” solution to the scanning sensor's blind spot is to increase the speed of the scanner across the web. This approach does not solve the problem, as seen in Figure 1, the measured property will still contain far more MD than CD variation. All that increasing the scanning speed does is to change those MD frequencies that will badly “alias” the CD profile. Unfortunately, the increased speed will also result in a worse signal to noise ratio and require more filtering.

![Figure 1. Even for what is to be supposed to be a fast scanning speed, the “fast” scanner’s CD profile contains more MD than CD information. Many paper variations are just too quick for a scanning system.](image)

Simultaneous, across the web profiling

In response to the shortcomings of the traversing scanner, Metso Automation developed a cross machine, full sheet measurement system. IQInsight is a revolutionary new concept, patented by Metso, based on multiple parallel optical channels and infrared spectroscopy. It provides true CD profiles measured simultaneously from an array of optical modules every 100mm across the full machine width. A system of fiber optics and individual optic assemblies focus a common infrared light source to the surface of the paper and transport the reflected light back to an off-machine spectrometer (Figure 2).
Figure 2. With IQInsight, light from each measured position, every 10 cm, across the machine is focused at the off machine spectrometer where an infrared camera records the spectra simultaneously from each measurement point.

The IR spectra are processed simultaneously to ascertain the moisture value; each frame is a snapshot of the infrared spectra across the machine at the same instant. This technology is incredibly fast. With a special diagnostic mode selected, the update period is as short as 10 milliseconds. For higher resolution profiles, the individual measurement beams are swept back and forth every second to fill the gaps between measurement points. A much larger percentage of the sheet is measured than with conventional scanning gauges. Since the measurements are at the same instant in time, true CD profiles are seen and complete separation of MD from CD information is achieved. The MD profile at each CD position draws an accurate picture of machine conditions that, until now, have not been available.

Figure 3. IQInsight can take 250 true profile snapshots while the fast scanner has made only one pass across the machine.

Traversing scanners can only measure true MD information if they are stopped in a fixed CD position. However, this means the loss of all profile information and the suspension of MD and CD controls. As a result, it has only practical to take fixed-point data for trouble-shooting when there are serious problems known to be in the machine direction. Choosing a particular CD position to stop the scanner or place a dedicated MD sensor can also have a great impact on results. Hence, many MD variability issues have gone undetected, unresolved, and uncontrolled. With IQInsight, MD variability is continuously collected every 100mm across the web, showing the true picture at all times.
Figure 4. Conventional scanning techniques are very poor at MD problem resolution compared to IQInsight’s instantaneous snapshots of the web.

Figure 4 shows the same paper measured with a conventional scanner and with IQInsight. The machine direction variation is easily seen with IQInsight, but is very difficult to ascertain from the scanner profile. In fact the MD variation totally masks the CD profile as well. This situation was caused by a piping design problem. Every rotation of the agitator caused the machine chest output to surge, causing consistency variations, which generated the cyclic MD variations in moisture.

Figure 5. A comparison of profiles; IQInsight at the top left; conventional scan with the aliasing problem visible (center) and the very noisy picture with a high speed scanner (lower left)

Figure 5 is raw profile comparison of the three measuring techniques using the same profile data shown on the left. The MD aliasing of the CD information is clearly seen from the conventional scanner at 50 cm/s (center left). The increased speed of the fast scanner at 400 cm/s (lower left) shows the increased noise that hides smaller variations. The only solution to measuring the profile with true MD/CD separation is with IQInsight (top left), where the CD profile can be seen quite clearly.
Measurement Location

With traditional dry end scanning technology, poor profiles that affect sheet quality, stability and runnability can only be detected after the problem is already evident in the final product. That may be several minutes after it originated due to long transport delays but more importantly due to slow profile acquisition capability of the scanning technology. IQInsight is installed at the beginning of the drying section just after the press. Because of the high water content in the press section felts, accurate web moisture is almost impossible to measure in the press. The earliest practical location for a true profile measurement is the pocket between two vacuum rolls early in the first dryer section (Figure 6).

Figure 6. The space available for a measuring system is tight.

The first dryer section is an area of high humidity and temperature with the possibility of airborne particles and water that can contaminate the sensor. The optical modules are sealed, IQInsight has no moving measurement sensor open to this harsh environment, eliminating the need for regular maintenance or cleaning. The machine-width protective enclosure for the optics is purged with filtered air to be able to operate in the hot and humid, upstream location. The sheet is measured as it passes around a vacuum roll (Figure 7). During web breaks or machine cleaning, an “eyelid” closes the measurement slot across the machine to prevent any debris from entering. With the measurement slot closed, the entire optic array can be withdrawn without moving the array frame or even stopping the machine. Compared to scanning techniques, IQInsight addresses all of the reliability concerns associated with moving sensors or optical modules open to the process environment.

Figure 7. The moisture array measurement points can be seen as spots of light on the 2nd vacuum roll.
Standardization

The measurement consists of an array of identical passive optical modules fed from a common light source eliminating the requirement for a complicated standardization routine. Measurement integrity is ensured with a unique method that also mechanically cleans the individual measurement windows across the machine. The sliding standardization module moves across the machine, presenting the same standardization target to each optical module, taking only a few minutes and typically performed every three hours (Figure 8).

![Sliding Standardization Module](image)

Figure 8. Purge air maintains positive pressure in the measurement enclosure and the individual windows are cleaned during calibration.

Visualizing the New Information

The large volume of data is processed into 3-dimensional displays, which can be scaled and rotated according to the operator’s preference. To highlight problems, a zoom function is available. The multi-dimensional display system helps paper-makers visualize and interpret patterns of instability. High performance analysis tools are also available that can deal with the large amounts of data that the measurement can provide.

![Figure 9](image)

Figure 9. Zoom in to analyze the problem more closely with 3 dimensional displays of accurate profile data.
Stabilizing with IQInsight, First trouble-shooting experiences

The first IQInsight was installed on a rebuilt machine making pre-coated base paper. The on-line measurement was immediately used to isolate the causes of various process problems and assist the papermakers in start-ups and disturbance detection. The visibility provided by the new measurement helped the mill optimize press operations and improve machine runnability (Figure 10). The new measurement proved to be instrumental in diagnosing cross direction and machine direction moisture instabilities and in optimizing press loading to achieve extra sheet dryness. The MD/CD separation features helped the mill to identify upstream MD problems caused by piping design faults, or consistency problems and other oscillations that would be impossible to detect by the traditional scanning technology.

Two months after the commissioning of IQInsight, the mill ordered a second unit for another machine. This machine makes copy, envelope and forms papers. Managing small changes in sheet moisture levels and profiles have proven to be important for maintaining and increasing machine speed and improving runnability. The operating personnel on the second machine immediately saw a severe wet edge problem after a machine startup Figure 11). The online measurement was instrumental in isolating the cause of moisture profile problems to the third press roll. After changing the roll and then changing the crown control settings, the problem disappeared and the speed was increased by 150 meters/min. The machine went on to set speed and production records.

The operators use the measurement as an everyday operating tool, adjusting press loading and steam box profiling. The speed of the paper machine depends on the moisture level and profiles after the press section. It is possible to control the moisture after the press section and then raise the speed of the paper machine as high as possible without runnability problems.
A Unique Tool

Intermittent or cyclical MD variations can be created within the paper machinery or by the machine clothing that have rotation periods of only a few seconds. Before IQInsight, these variations could not be measured and seen during the production run. This effect is clearly shown in Figure 12, the size press profile (upper profile) appears very flat whereas the wet end profile (center profile) shows a streak near the center of the sheet. The 3-dimensional wet end profile shows that this wet end streak had a strong, repetitive machine direction component. The period of this variation was the same as the first dryer felt rotation period, which was 1.92 seconds at 1150 meters/min. The problem disappeared when the felt was changed.

![Figure 12. The size press moisture profile (upper profile) appears flat whereas the wet press profile shows a streak. In the 3-D analysis display, this streak is shown to have a strong MD cycle.](image)

The ability of IQInsight to measure fast CD and MD variations has led to the development of the IQFeltmap tool. Position sensors synchronize the felt position to custom displays allowing an in-depth view of the felt condition and its effect on the web (Figure 13). With this display, papermakers can see where on the felt a problem might be developing, greatly facilitating press clothing management.

![Figure 13. IQFeltmap is a picture of moisture synchronized to the running felt.](image)
Because of the array nature of the measurement, the operators can see the moisture first in the tail and then in the full sheet as it is widened across the machine during start-up. This feature allows measurement of tail moisture before full width threading is achieved. If it is at the wrong level, the tail moisture can be corrected to ensure fast and trouble free startup.

Figure 14. IQInsight at machine start-up. This information is impossible to see with a scanning measurement.

**Better Moisture Control**

The rapid, true CD moisture profile from IQInsight, makes it the ideal signal for controlling a steambox. The pure CD nature of the profile requires minimal filtering and allows more aggressive control of faster disturbances. Metso has developed a unique cascade CD moisture control where the dry end scanner is used to calculate the shape of the press moisture profile required to achieve a flat moisture at the dry end despite the imperfections of real-world dryer sections. Thus IQInsight is used in a fast loop for better disturbance rejection while the dry end scanner’s role is to compensate for the much slower variations in the condition of the dryers themselves.

Figure 15. Cascade CD Control for better moisture control
Conclusion

Despite compelling advantages, press moisture measurements have not often been successfully implemented. Scanning type measurements are unable to capture the fast variations present after the press and seem to provide the most useful information when stopped in a particular CD position. The new measurement technology available with IQInsight overcomes the problems of measurement accuracy and the mechanical difficulties of moving sensors in such a harsh environment. In addition, this new moisture measurement array provides much more frequent profiles and achieves the perfect separation of MD and CD information that traditional scanning technology cannot provide.

- Superior environmental protection, reliability and serviceability
- A compact, single sided design that fits into a small space
- No threading or cleanliness issues
- The ability to separate MD from CD effects
- Fast profile update times to show rapidly changing machine conditions
- Measures a much larger percentage of the sheet than traditional scanning sensors
- A multi-dimensional display system helps papermakers visualize and interpret results

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