

TROUBLESHOOTING MOISTURE PROFILE PROBLEMS IN THE CROSS-MACHINE DIRECTION

TAPPI ENGINEERING CONFERENCE PANEL

STEPS TO TAKE WHEN FACED WITH A POOR CD MOISTURE PROFILE

POOOR CROSS-MACHINE DIRECTION (CD) MOISTURE profiles can result in nonuniform sheet properties, converting problems, and poor runnability in the form of wrinkles and breaks. Fiber costs (heavy edges) and energy consumption can be higher than when sheet moisture is more uniform.

Final sheet moisture profiles reflect complex interactions between forming, pressing, drying, and gauging and control. Most CD profile problems originate in the press section, although they can also be caused by forming or drying problems.

Keys to good moisture profiles include:

- Uniform weight profiles
- Proper roll crowns, covers, and cover condition
- Effective fabric cleaning, conditioning, and tensioning
- Good condensate evacuation
- Full-width dryer bars
- Effective pocket ventilation.

Remoisturizing showers and steam showers are the preferred methods for controlling CD moisture profiles. Infrared profiling is used where sheet contact would be detrimental but is a last resort because of high energy costs. Some control methods used but not recommended include biasing weight profiles, using partial-width dryer bars, profiling pocket ventilators, varying size-press blade or rod pressure, using variable-permeability fabrics, and cocking press loads.

Here, we discuss steps to take and tools available to troubleshoot CD profile problems. The main steps in identifying the source of the problem are:

1. Evaluate information from machine gauging and CD control system.
2. Determine where the poor profile originates.
3. Pinpoint the cause to find an effective solution.

GAUGING SYSTEM

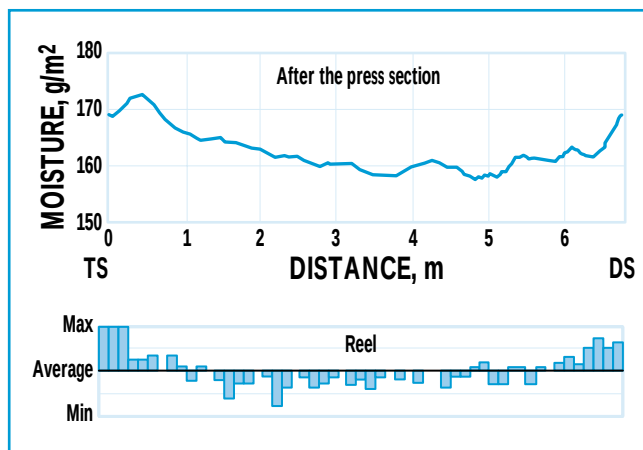
The machine gauging system can provide valuable information as to the nature and severity of profile problems. In beginning troubleshooting efforts, you would do well to keep a few tips in mind.

Do not accept the problem as described. The symptom is often not the cause of sheet profile problems. Check the weight profile first whenever moisture problems are presented to you. Caliper, smoothness, and wrinkling problems can be caused by poor moisture profiles.

Make sure there is not a false sensor indication. Begin by checking the history of the various sensors for stability. How are they calibrated? Is it often enough? Are both slope and offset being checked? Is there any change in the pattern of zero drift or calibration? Is the standardization shift excessive?

Determine whether the problem is in the machine direction or cross direction. Check the trend pages of the supervisory control system. Is the system doing a reasonable job? Are there any trends of cyclic disturbance? It may be necessary to single-point the sensors to observe machine direction (MD) trends.

Observe the reel. The reel may tell an MD or CD story. Observe the side of the reel. Is the edge of the sheet moving in and out? Is it uniform in appearance or random? Look and feel the face of the reel for soft and hard areas. Wet areas calender more easily than dry areas and can cause soft or hard spots.



1. A paper moisture profile after the press section (top) compared to the reel moisture profile

Utilize the supervisory control system. Begin on the profile pages, go to the trend pages, and then look at the CD control pages. Actuator profiles can be very helpful in pointing to the right area of the machine. It is also important to look at the system itself instead of just looking at the computer screen. Is the full sheet being scanned? A remoisturizing shower does not work if the water pump is not on.

Call for the cavalry. Once it is determined that the gauging system is indicating accurately and responding appropriately, it is often necessary to utilize additional resources to identify the source of profile problems.

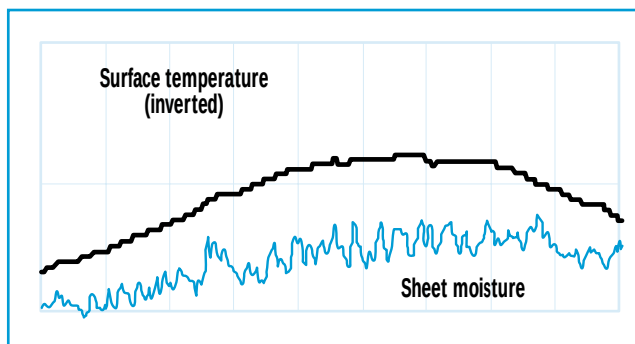
INFRARED THERMOGRAPHY

Infrared thermography provides an excellent tool for narrowing the search for the trouble. At the dry end of the machine, areas of the sheet indicated as cooler are generally wetter, so the infrared temperature profile corresponds to the sheet moisture profile. However, the relationship between temperature and moisture may be the opposite at the wet end of the machine.

Start at the reel, and relate the temperature profile to the sheet moisture indicated by the gauging system. Then work towards the wet end to determine where problems develop. Thermography can be used to look at the sheet at open draws, under unrun and single-tier dryers, and wherever the camera can see the full width of the sheet. Dryer fabric temperatures can indicate what is happening to the sheet where there is not good access to the sheet.

Draws out of the press section are a key place to look at the sheet to determine whether the problem is occurring at the wet end or dry end of the machine. Infrared thermography can also be used to troubleshoot operation of profiling steam showers and rewet showers.

Different scales are needed to evaluate temperature differences down the machine. Temperature differences



2. Surface temperature effects on the sheet moisture profile

less than 0.5°F can indicate problems in the forming section, 2–3°F can be significant in the press section, and variations greater than 10°F indicate problems at the reel.

SHEET MOISTURE PROFILES

Sheet moisture profiles out of the press section are another tool that can be used to identify the source of the problem. Portable moisture scanners can be installed in an open draw, in an area where the sheet is supported by a fabric, or under one of the first dryer cans. **Figure 1** shows an example of a profile out of the press section compared to the reel moisture profile.

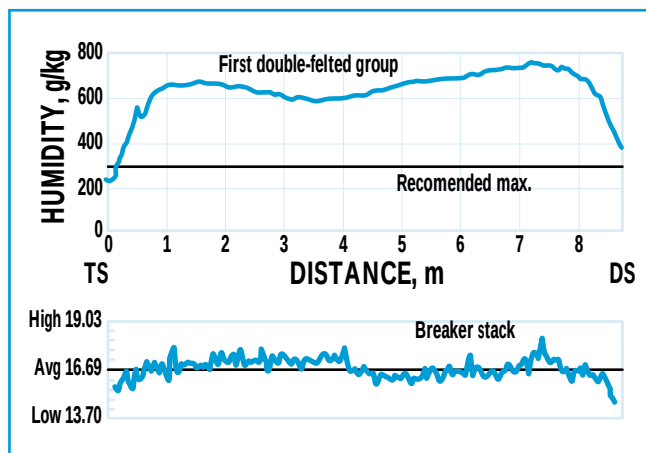
The portable gauge also can be placed in a stationary position to determine if there is MD moisture variation. The moisture gauge can be used to provide immediate feedback on the effects of adjusting nip loads, variable-crown roll settings, felt conditioning, steam box adjustments, and shoe press tilt. The scanner also can be installed before the press section examine effects of suction roll or former vacuum, deflector loading, and showering.

DRYER SURFACE TEMPERATURE PROFILES

Dryer surface temperatures can tell you if poor profiles are caused by nonuniform heat transfer through the dryer condensate layer or by nonuniform sheet-to-dryer contact. Sheet moisture profiles are usually the inverse of surface temperature profiles when there are condensate removal issues, but they are the same as temperature profiles when there are contact issues.

Figure 2 compares a sheet moisture profile to an inverted dryer surface temperature profile. A typical dryer temperature profile with no dryer bars is a “smile,” with the edges hotter than the center. Profile problems that can be identified with surface temperature profiles include:

- Lack of dryer bars
- Partial-width dryer bars
- Interfacing between dryer bars and siphons
- Nonuniform dryer casting
- Improper differential pressures



3.A pocket air humidity profile (top) and a sheet moisture profile into the breaker stack

- Improper siphon clearance
- Grooves in the dryer shell
- Dryers out of level
- Nonuniform dryer fabric tension
- Buildup of scale on the dryers.

POCKET HUMIDITY PROFILES

Dryer pocket humidity profiles can indicate if poor or nonuniform pocket ventilation is contributing to the sheet moisture profile. High pocket humidities restrict mass transfer of water vapor from the sheet to the air. Therefore, pocket humidity profiles tend to mirror reel moisture profiles.

Figure 3 shows a measured humidity profile compared to the sheet moisture profile dryer pocket into a breaker stack. The typical humidity profile on a poorly ventilated machine is a “frown,” with the center of the pockets more humid than the edges. As pocket ventilation gets worse, so does dryness at the edges of the web.

Opening and closing hood doors can affect profile if pockets are poorly ventilated. Good performance for humidity variation is less than 0.05 lb water/lb dry air across the width of dryer pockets. Problems that can be identified with humidity profiles include:

- Insufficient supply air for pocket ventilation
- Nonuniform air distribution through pocket ventilators
- Unbalanced air flows in the pockets
- Nonuniform air flows through the hood
- Plugged dryer fabrics.

PRESS FABRIC WATER PERMEABILITY

This portable unit has a single nozzle that injects water into the press felt and measures differences in water flow. As a result, it looks at openness of the felt and its ability to accept water. The permeability reading is not af-

fected by percent felt moisture. Cross-machine variability greater than 10% in water permeability can be troublesome for sheet moisture profiles. It is best to keep the press-felt void volume evenly open, so as not to exceed 5% variation in water permeability.

Water jet permeability is also a good tool for evaluating effectiveness of fabric cleaning programs and effective life of press felts. Profile issues that can be identified through water permeability testing include:

- Plugged shower nozzles
- Wad burns
- Nonuniformity of suction roll wear strips
- Vacuum deckles not matching trim squirt positions
- Improper roll dubbing
- Improper crowning.

FELT MOISTURE CONTENT

Cross-machine scans of press fabric moisture are another tool used to identify moisture profile problems. Felt moisture profiles are usually the inverse of sheet moisture profiles through the press section, since most water removed from the sheet enters the felt.

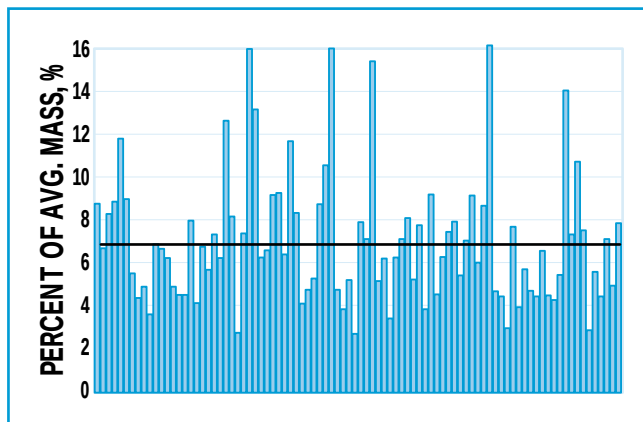
However, the relationship between nip pressure and felt and sheet moisture depends on conditions in the nip. In pressure-controlled nips, higher nip pressure will result in more water removal, a wetter felt before the Uhle boxes, and a drier sheet. In flow-controlled nips, felt moisture profiles may not correspond directly to sheet moisture profiles. (Pressure-controlled nips are those in which the mechanical resistance to compression within the sheet controls rate of water removal—including lightweight sheets, sheets with low water loads, and high-freeness sheets. In flow-controlled nips, resistance to water flow within the mat of fibers controls the rate at which water can be removed—characterized by high water loads, heavyweight sheets, and slow draining stocks.)

Sheet moisture profile problems that are commonly identified with felt moisture profiles include:

- Improper roll crowning
- Worn doctor blades
- Felt closure
- Plugged showers
- Uhle box problems.

NIP IMPRESSIONS

Nip impressions provide a tool to determine what is happening in the press section and other nips on the machine. Available nip impression tools include carbon paper, embossed foil, pressure-sensitive film, and electronic sensors.



4. Cross-direction 2-sigma variation

Electronic sensors allow nip impressions to be performed more quickly with traditional methods. Electronic nip impressions give the papermaker the chance to alter press loading and to determine instantaneously its effect on nip pressure uniformity. They also give the papermaker the ability to examine multiple nips simultaneously. The effects of load changes and cocking the front and back loading mechanisms can be evaluated to determine conditions that provide a uniform nip. Theoretical models can be used to determine the effects of roll vacuum on crown profiles.

Typical press loading problems include cocked (skewed profile), under-crowned ("frown" profile), and over-crowned ("smile" profile).

FORMING SECTION PROFILES

Forming section profiles can be obtained by attaching the head of a wet-end-drainage gamma gauge to a tee bar in the forming section. The ideal position is just before the high-vacuum boxes. The further towards the dry end of the former, the more closely the profile resembles reel profiles. Closer to the headbox, the volume and thickness of the slurry tend to dampen or mask the true profile.

Machine-direction analysis is often done to identify low-frequency weight variation and to determine the length of time needed for each CD reading to eliminate the effects of MD variation on CD profiles. **Figure 4** shows MD 2-sigma variation observed on several paper machines. A good performance level is less than 2% of average mass.

Average CD 2-sigma variation is 7% of average mass. Cross-machine profiles are compared to reel and size press scanners and headbox actuator positions. This tool can also be used to optimize positions of headbox slice actuators. Cross-machine problems that can be identified with mass profiles in the forming section include:

- Headbox delivery
- Forming section alignment
- Forming roll plugging
- Improper showering
- Deckle waves.

Measurement	Good performance
Reel	
Sheet moisture	< 1 percentage point peak-to-peak (1.5% on heavyweight grades)
Actuator positions	All within 20–80% control range
Dryer section	
Sheet temperature	< 10°F variation
Surface temperature	< 5°F variation
Pocket humidity	< 0.05 lb water/lb of dry air variation
Out of press section	
Sheet moisture	< 1 percentage point, peak-to-peak
Press section	
Sheet temperature	< 2°F variation
Water permeability	< 5% variation
Felt moisture	< 5% variation (10% acceptable)
Forming section	
Sheet temperature	< 0.5°F variation
CD mass	< 7% variation
MD mass	< 2% variation

I. Measurements for troubleshooting cross-machine moisture profile problems

SUMMARY

Efforts to troubleshoot CD moisture profile problems should start with information from the machine gauging and CD control system. Infrared thermography can then be used to identify the source of the problem.

Once the search is narrowed, more specific profiling tools can be used to identify the cause. Parameters include dryer surface temperature, pocket humidity, sheet moisture, press felt permeability, felt moisture, nip impressions, and wet-end mass. **Table I** summarizes available cross-machine measurements for each and presents values that indicate good performance.

In most cases, a poor profile for the sheet at the reel is caused by several of these factors. For example, to compensate for chronic "frown" moisture profiles in the dryer section, press rolls may be over-crowned, or sheet edges may run heavy. To develop a uniform reel moisture profile, it is important to have a good understanding of the effects on moisture profile that pertain to each area of the machine. TJ

This article is based on a panel discussion held at the 1999 TAPPI Engineering Conference. Jeff Reese, who is with Georgia-Pacific, was the moderator. Panelists included: Dennis Kalberg of International Paper, Norm Gaver of Voith Fabrics, Dan Thomas at Valmet, Gary Baker with Dubois, Bill Butterfield of Stowe Woodward, and Ron Christman of AstenJohnson. The TAPPI Water Removal Committee plans to convert this information into a TIP sheet. If you have any suggestions for improving this information, please contact Jeff Reese at: jrreese@gapac.com.