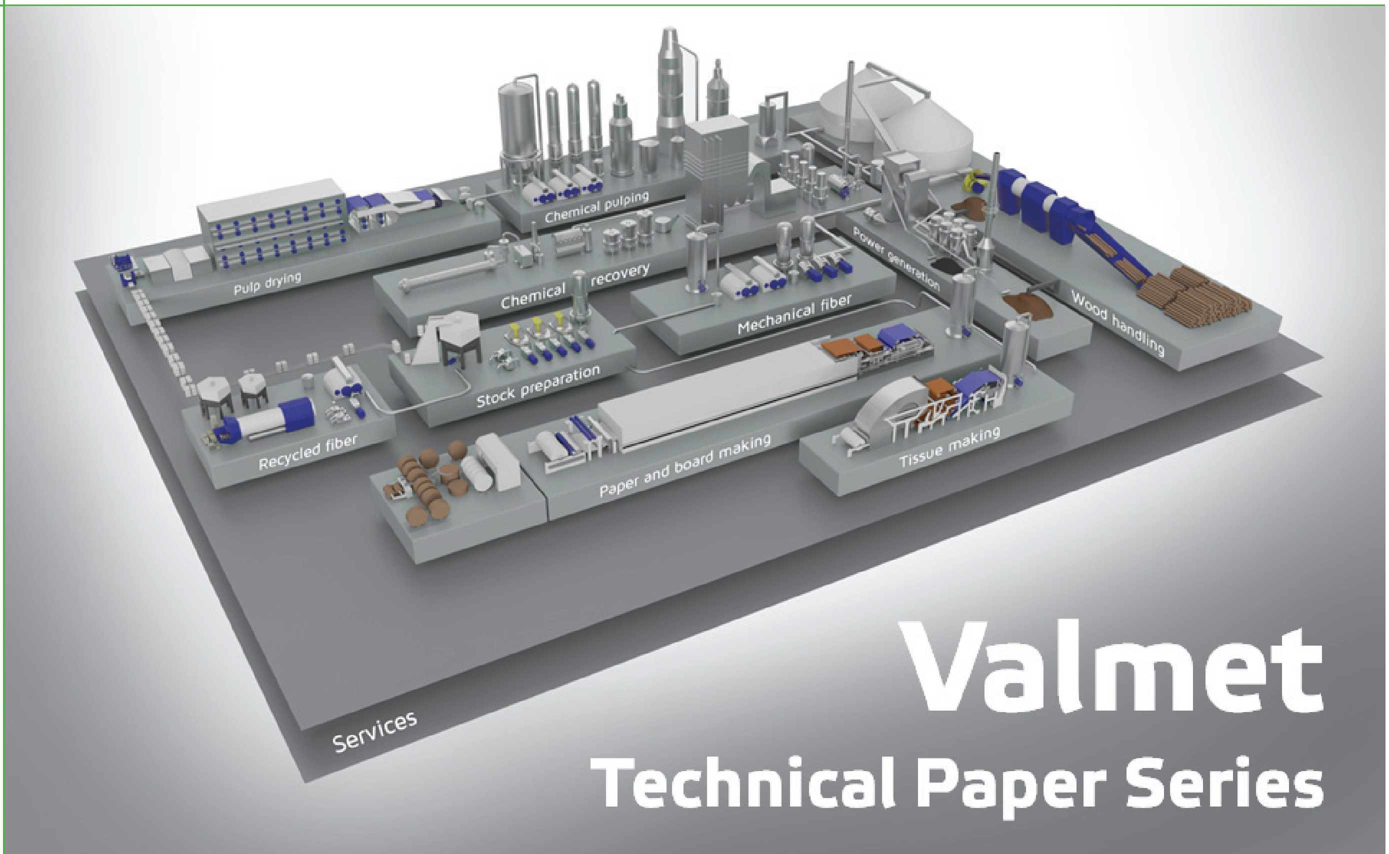

iRoll Update

Executive Summary

Valmet's intelligent roll, iRoll, has been in use in paper, board and tissue mills for a decade, solving runnability and quality problems that no other sensor can. iRoll is a mechatronic system consisting of a roll in a web handling machine that also is used as a transducer for sensing cross-machine tension or linear load. The iRoll has force sensors mounted on it in a helical arrangement. The sensors measure the force applied by the material being produced, such as a paper web, and thus provide information about the behavior and quality of the product. In addition to the force sensors, the iRoll system has an electronic signal processing module on the roll end and a digital radio link to transmit the data from the rotating roll. The receiver is connected to an automation network.

iRoll has now been used, both in permanent and portable modes, in all grades, including downstream on printing machines. The portable version of iRoll includes the services of Valmet technicians and Valmet's papermaking expertise to perform studies of how process variables affect different areas of the machine line. Permanent iRoll installations at dozens of mills worldwide are being used continuously to predict and avoid roll cover damage and protect end product quality.

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Overview of iRoll

The principle of iRoll measurement is shown in **Figure 1**. (Detailed iRoll process information may be found in a separate white paper entitled "***iRoll – the intelligent roll***".) The nip pressure signal is measured with force sensitive film sensors. Sensors are laminated into the cover structure of the reeling drum in spiral form to measure the local pressure of the cross machine profile. The raw signal is amplified, synchronized and sent to a central data unit by a wireless link.

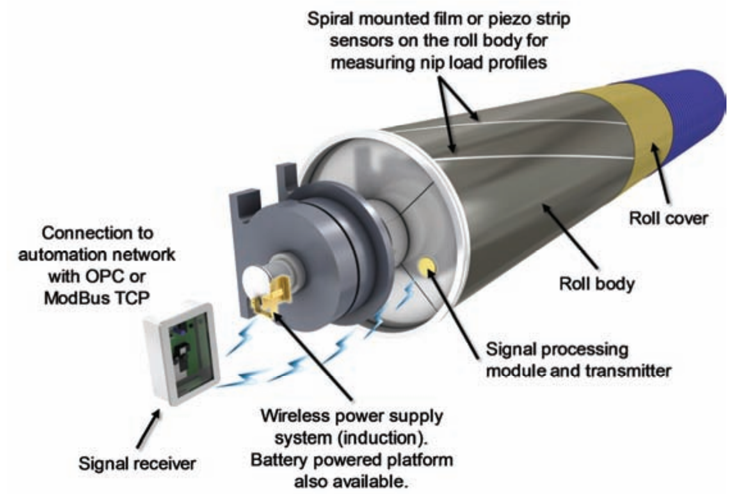

Figure 1. Principle of iRoll measurement

The iRoll 'intelligent roll' is a mechatronic system consisting of a roll in a web handling machine that is also used as a transducer for sensing cross-machine tension or linear load. It is a robust sensing system that has been in use for nearly a decade and can measure loads from 0.7 kN/m to over 175 kN/m. iRoll can be calibrated quickly in units of linear load by applying a known nip load and scaling the output accordingly. This can be done automatically by the control system in permanent installations. Calibration can also be verified with nip impression paper. Once calibrated, the output is very stable and only needs to be checked once per year as part of normal preventive maintenance. iRoll also is not speed limited, THE output signal is independent of basis weight and the CD resolution is essentially infinite, but limited to 200 data points. It requires no machine-direction space for mounting.

iRoll consists of a high-precision roll with helical grooves machined in the shell, force-sensitive electret film sensors mounted in the grooves, a roll cover, signal processing electronics, a digital radio transmitter, wireless power transmission, and a receiver connected to the mill automation network. There are practically no external devices with the iRoll concept, which makes it very convenient, easy-to-use and maintenance free. A portable version of this system, which is easily transported, uses the same technology for temporary measurements.

The portable version of this system allows almost any roll to be converted into an intelligent roll by using tape-mounted sensors. This technology enables temporary roll profile, nip load profile, and tension profile analysis to be performed by field technicians. In this manner, economic benefits can be achieved by solving difficult problems without major capital investments. iRoll can eliminate the need for external measurement devices such as scanners and their associated space requirements. iRoll acts like a conventional roll in the process, making it possible to measure how the web tension or nip profile behaves online in real time. Moreover, it can be located in various positions in the process, wherever the tension profile is critical or the nip-paper roll profile needs to be measured. The portable system enables the line to be equipped with several profile measurements simultaneously.

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iRoll is the widest "intelligent roll" platform available with measurement systems from press nips to reels, winders and even further to converting and print houses. It can be used to measure and control paper, board and tissue properties, not just the nip profiles. iRoll provides full speed online profile measurement (e.g. 5 profiles per second, 40-200 databox profiles). Some other systems measure only once per hour with a limited number of databoxes, e.g. 21. iRoll can be provided with either a full feature induction power supply or low cost battery operated platform. iRoll can be connected to automation systems and data collection systems. iRoll can also be used for online control of paper profiles and nips. iRoll has advanced tools for data analysis, drawing color maps, etc. It can be used for paper and nip profile optimization as a low cost, quick-to-use iRoll Portable service: solving runnability issues, determining the correct roll crowns, tuning winding and reeling recipes, equipment condition tests, and much more.

iRoll offerings in North America

In North America, the iRoll tool is available in two main versions: permanent or portable. The permanent system is for rolls with roll covers and is available for presses, reels, winders, sizers, web guide rolls, fabric guide rolls and calender windups (these are described later in this paper, by machine section application). It can also be used for blade and rod profile feedback on coaters.

The portable versions, represented by iRoll Portable and Portable Lite, are products designed for quick and cost efficient nip or process analysis and tuning with a temporarily installed iRoll system.

iRoll Portable

iRoll Portable is for reels, winders, parent roll hardness profiles, web/fabric tension profiles, sizer nips, sizer rods, press nips, converting machines, printing machines, etc. and is performed **online during production** as the targets are paper quality, runnability and parent roll hardness profile improvement. Typically, iRoll Portable is offered as a service where iRoll technology is not present, but it can be used in conjunction with any permanent iRoll offerings (primarily Tier 1, described later).

Figure 2. Valmet technicians install the iRoll Portable sensors on-machine in the mill.

Two or more Valmet technicians visit the mill over 2-3 days to perform the analysis. Typically, 6-8 hours of machine downtime is required for sensor installation (**Figure 2**), and a few hours for sensor removal and cleanup. Two or three roll positions are usually checked, but many more positions are possible. A full report follows the service.

The benefits of iRoll Portable include:

- Quick online measurements are possible, with 10 profiles per second. The true CD web profile is measured without the traversing delay of a measuring frame.

- Several measurement positions can be installed on a machine line. The installation can occur in multiple positions quickly – within a short shutdown. The result is cost-efficient, accurate measurement.
- CD and MD resolution is excellent. This allows fast tracking of profile-related problems in reeling and winding. Reeling recipes can be tuned up and maintenance needs found. The causes of tension profile-related runnability problems may be determined and addressed. Parent roll and tension profile optimization and process tests may be undertaken in order to improve runnability. iRoll Portable can be used for problem solving when increasing machine speeds.

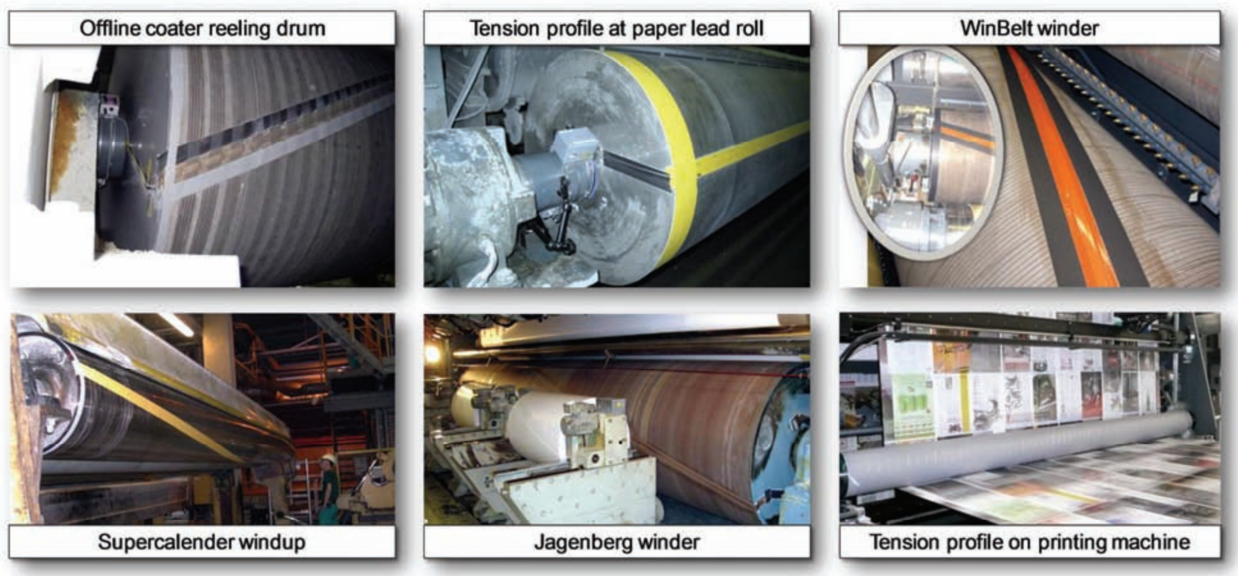

Figure 3. Examples of iRoll Portable locations

Typically, an iRoll Portable project follows three phases: Analysis, quick wins and long term enhancement. During the analysis phase, a series of measurements with response tests are undertaken, such as calender profiling, basis weight, coat weight, nip loads, steam box and moisturizer. Root causes for the problem are determined. Tools for solving the problem are investigated and tested, such as which actuators are effective and how much.

During the quick wins phase the optimal target profiles are achieved. Immediate maintenance actions are determined and implemented. Reeling and winding recipes are improved and saved for future use.

The long term enhancement phase uses an action list designed to develop the papermachine line in the long run. This may include online control using iRoll Tension, iRoll Reel Drum, etc. Other rebuilds or upgrades may be recommended.

Over 180 iRoll Portable measurements have been performed since its introduction in 2006.

iRoll Portable Lite

iRoll Portable Lite is done **during a shutdown** in order to measure and optimize press nip, sizer nip and sizer rod profiles and to give information for maintenance needs. It is applicable in all situations where iRoll Portable may be used, and can also be applied to rolls such as a sizer backing roll to measure rod loading and nip profiles in a non-production condition.

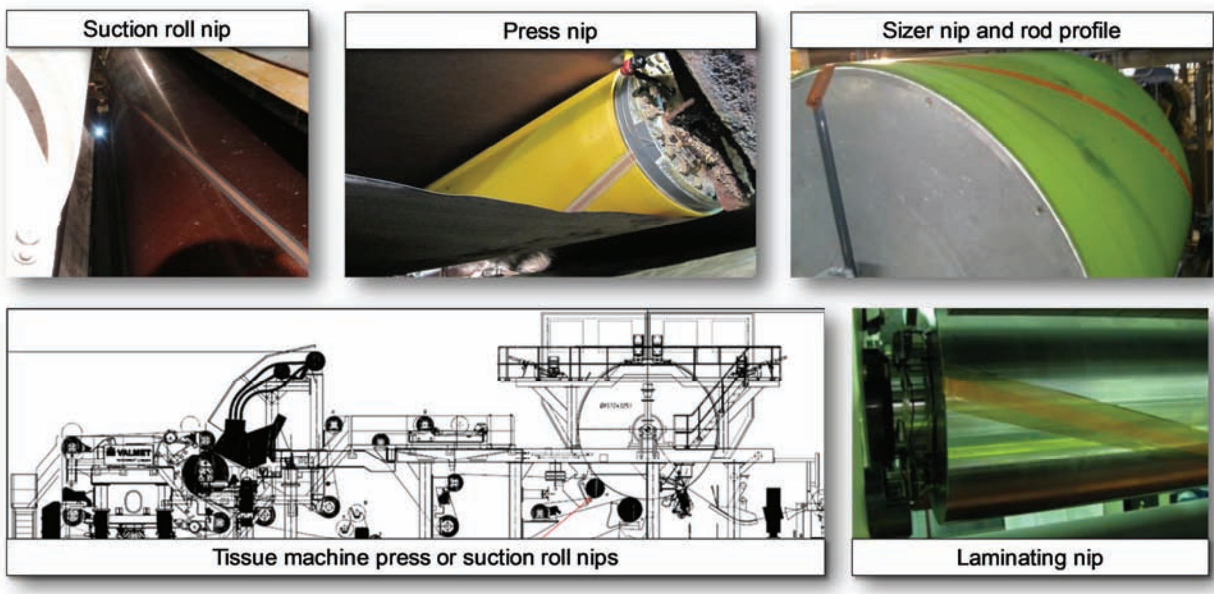

Figure 4. Examples of iRoll Portable Lite positions

Online viewing of the profiles with iRoll Portable Lite provides quick results. During iRoll Portable and Portable Lite measurement, the profile data can be viewed with online graphs (**Figure 5**). A color map and waterfall graphs are also presented during measurements (**Figure 6**, next page).

One or two Valmet technicians visit the mill, typically taking 6-8 hours of machine downtime for sensor installation and 1/2 hour for sensor removal and cleanup. A typical test series takes one day, and is especially suitable for positions which cannot normally be checked during papermaking operations. One roll position is usually checked and analyzed, with a full report following the service.

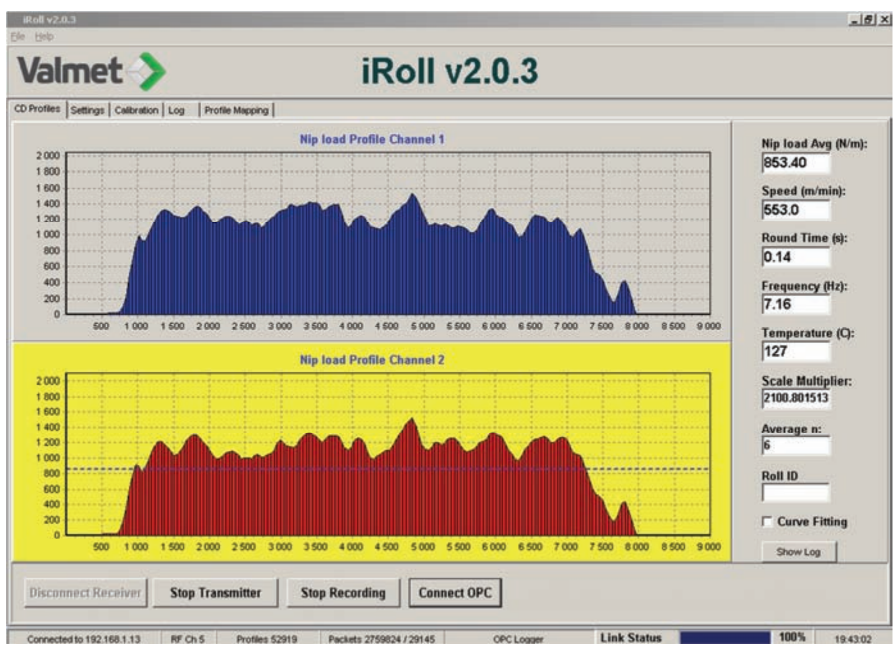

Figure 5. iRoll Portable and iRoll Portable Lite allow for online viewing of process profiles.

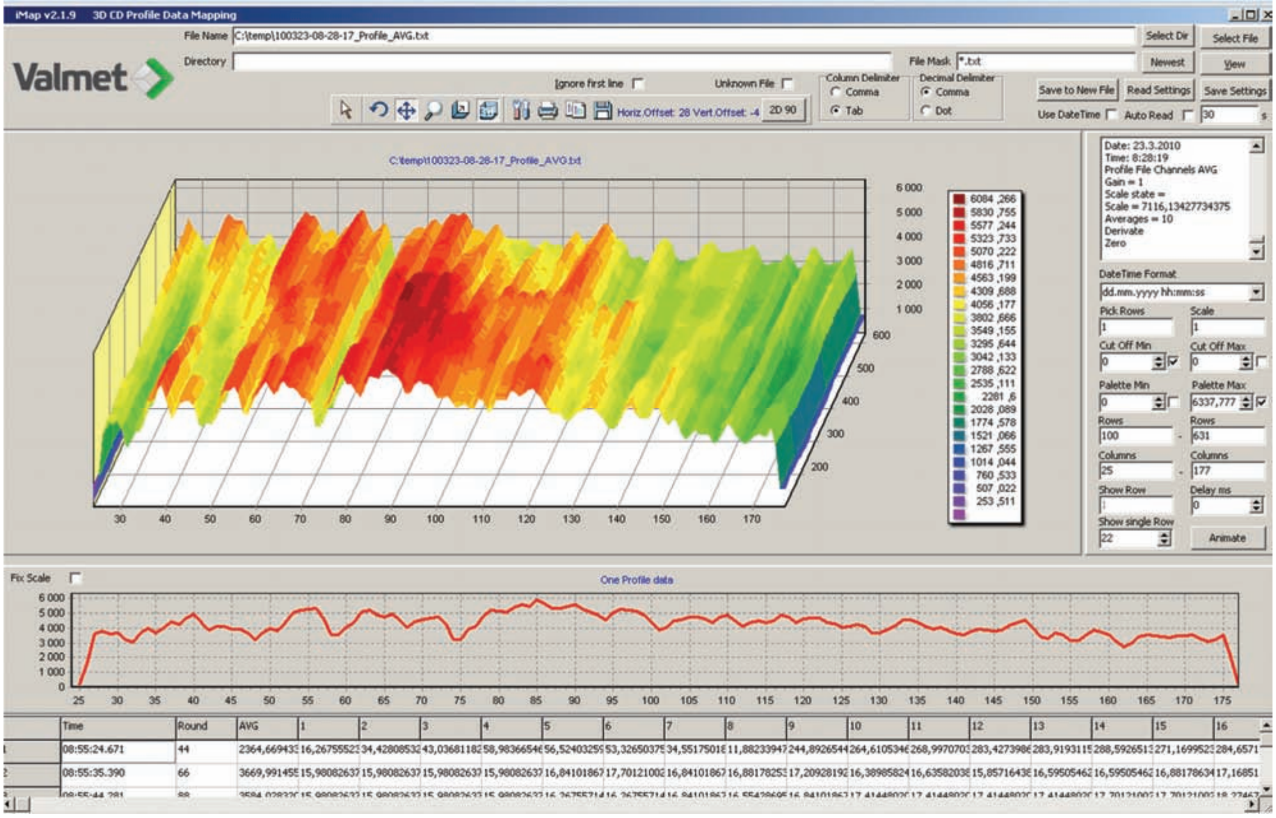

Figure 6. iRoll Portable and iRoll Portable Lite enable real-time viewing of color maps and waterfall graphs.

iRoll Portable Lite for press nips can be used for paper, board and tissue machines to replace old static measurement methods and nip films. Sizer nip and rod profile measurements can be used to optimize coat weight profiles and analyze nip straightness. True nip load information can be obtained for deciding the right crowning parameters. With iRoll Portable Lite, papermakers can test the effect of changing process parameters and tune them up online, such as Yankee cylinder temperature, Sym roll crowning and film sizer rod profiling.

Over 20 iRoll Portable Lite analyses have been performed since its introduction.

iRoll customizability

The iRoll system is offered in five tiers, from rudimentary to deeply connected, with each tier upgrading the previous tier by adding functionality.

Starting with Tier 1, iRoll is embedded in a roll but not hooked up to anything for feedback, display or control. This allows iRoll Portable to be used in cases that would otherwise not allow for active analysis during actual production conditions, such as press rolls or sizer rolls.

In Tier 2 standalone feedback is added via a permanent connection to a display to allow monitoring and trending with charting and data analysis tools. This allows for continuous roll profile monitoring and updates the profiles as often as five times a second if necessary. Batteries are used to power the sensors in the roll. The mill provides a GUI including a PC monitor and Ethernet cable.

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Tier 3 adds an open protocol output to another mill system for display and data gathering. The mill provides an Ethernet connection to the mill system and the programming in that system to receive and use the profiles that iRoll sends.

Tying the iRoll to a PLC system is included in Tier 4, allowing actions to be performed based on the profile feedback. For example, if a calender nip high load is detected, the calender nip could open, an alarm could sound, and a cutoff knife may activate. The mill provides the necessary PLC hardware in addition to the equipment and connections required as part of the previous tiers.

The most deeply connected method is Tier 5, wherein the iRoll system is tied to a process control system in order to control CD profile variations (very similar to how a scanner functions). The iRoll therefore provides the necessary input for the mill computer to perform closed loop control. For example, iRoll Reel feedback may be used by the mill process control system to control induction profilers on a calender. The mill would provide the equipment and connections from previous tiers, plus the programming, profile manipulation and actuator response and control on the process control end. This system greatly improves paper quality and machine operation.

iRoll software

The software for the iRoll system is a family of products that form an advanced toolset for analysis of profile data (**Figure 7**).

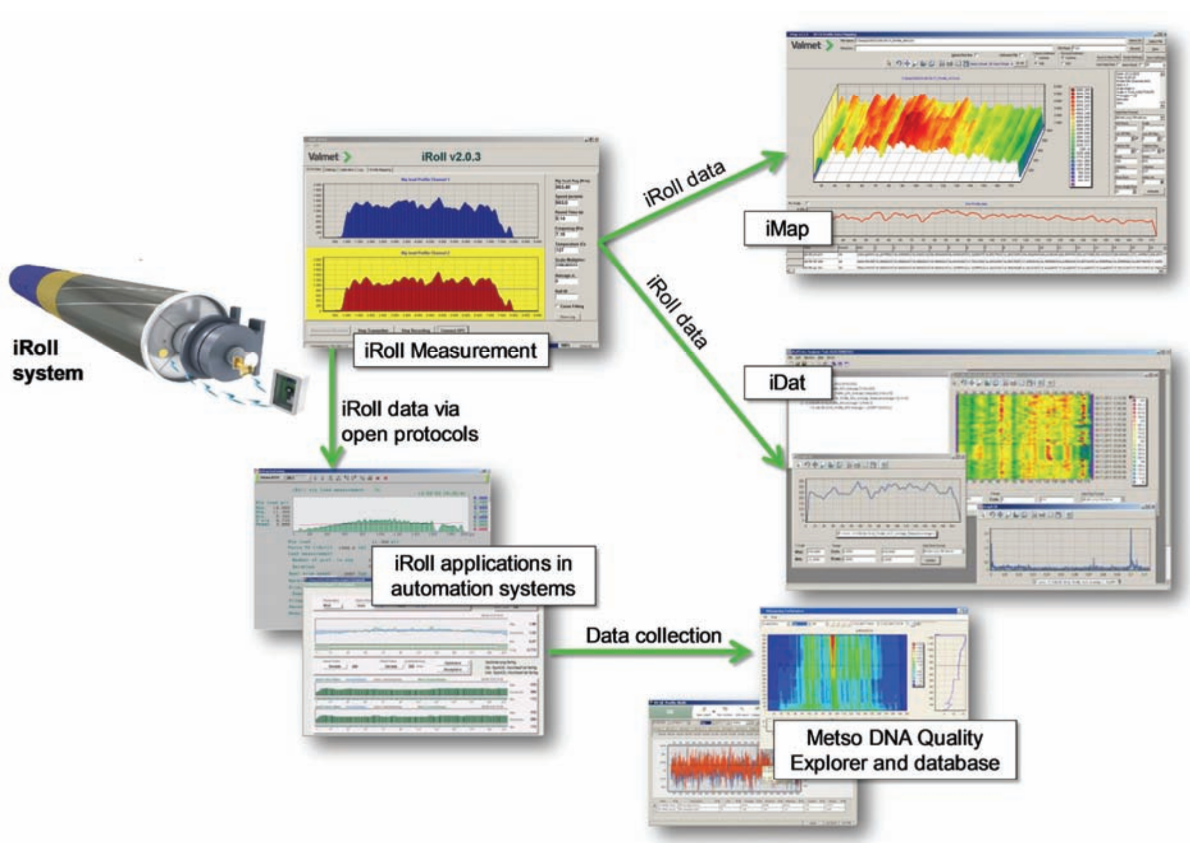

Figure 7. iRoll software forms an advanced toolset for analysis and presentation of profile data.

First is the iRoll Measurement software which is the basic user interface for operators. Experts may also use it as a tool to set parameters. Data is stored in files for further analysis.

The iMap module is a color mapping tool. It receives the data files from iRoll Measurement and allows viewing of the iRoll data in waterfall 3D color mapping style. It is a tool for production supervisors, development engineers and advanced operators.

The iDat module provides advanced analysis of the data received from the iRoll Measurement module. It is a tool for development engineers and R&D personnel.

Via the open protocol, the iRoll Measurement module may also send data to iRoll applications in an automation system. These include user interfaces for operators, online profile controls and Metso DNA applications.

The Metso DNA Quality Explorer and database system allows long term data collection and sorting of data by roll ID. This tool is used by production supervisors, customer service personnel and development engineers.

iRoll Portable case studies

Typical iRoll Portable runnability analysis cases include the following:

1. Reeling defects and roll buildup cases
    - Crepe wrinkles, glossy spots, bagginess, worm trails, air bubbles due to bad profiles, telescoping
    - iRoll roll hardness profile measurements and process tests find reasons for the profile variation. Online measurement of reeling nip loading and tension
2. Customer complaints from printing house or converting due to bad runnability (downstream)
    - Typically slack edges and runnability problems with edge rolls
    - Tension profile and roll hardness profile measurements are used to find tools to improve edge roll runnability + process tests.
3. Off-machine coater web shifting
    - Typically web breaks during splicing on unwind
    - iRoll tension profile and roll hardness/reeling nip profile measurements find the root cause + process tests.
4. Runnability problems on sizer, reel or calender
    - Wrinkling of web when run into e.g. sizer nip, causing web breaks and broke
    - Tension profile measurements + process tests, sizer nip profile measurements
5. Offline multinip/supercalender profile optimization
    - Hard/soft roll edges, tension profile issues, bumpy rolls, winder runnability problems, bagginess, gloss profile issues, optimizing Calcoil for lower energy consumption
    - Roll profile and tension profile measurements
6. Winder problems
    - Reeling defects, edge shifts, cracks, winder recipe tuning needs
    - Winding nip profile and customer roll hardness profile measurements
7. Pre-studies for rebuilds

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- May be compared to vibration analysis, but iRoll targets process issues
- Controls upgrades, runnability improvement when speed increases, etc.

Permanent iRoll tools by application

Valmet iRoll tools are capable of measuring not just the nip profiles, but also the paper, board and tissue quality – almost anywhere on the machine (**Figures 8 and 9**). iRoll is also suitable for converting and print house equipment. Here are some iRoll tools and their capabilities by machine section:

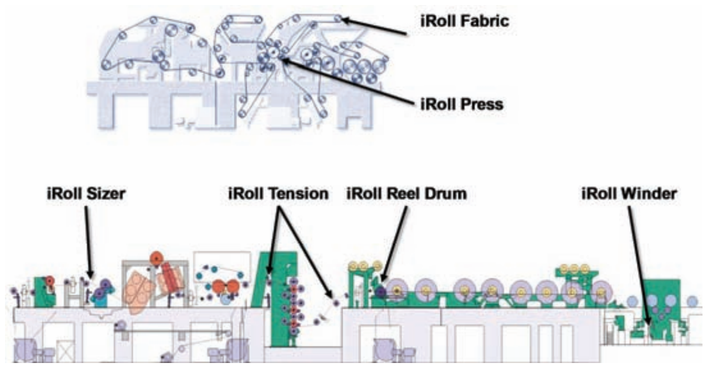


Figure 8. iRoll tools by machine section application

- iRoll Press accurately measures nip load profile for further process control.
- iRoll Fabric measures the tension and tension profile of felts and wires.
- iRoll Sizer measures the nip load profile and applicator rod profile of a film sizer press.
- iRoll Tension measures web tension profiles.
- iRoll Reel Drum measures parent roll hardness profiles and reeling nip load profiles.
- iRoll Winder measures winder nip loading as well as the end product runnability and quality.

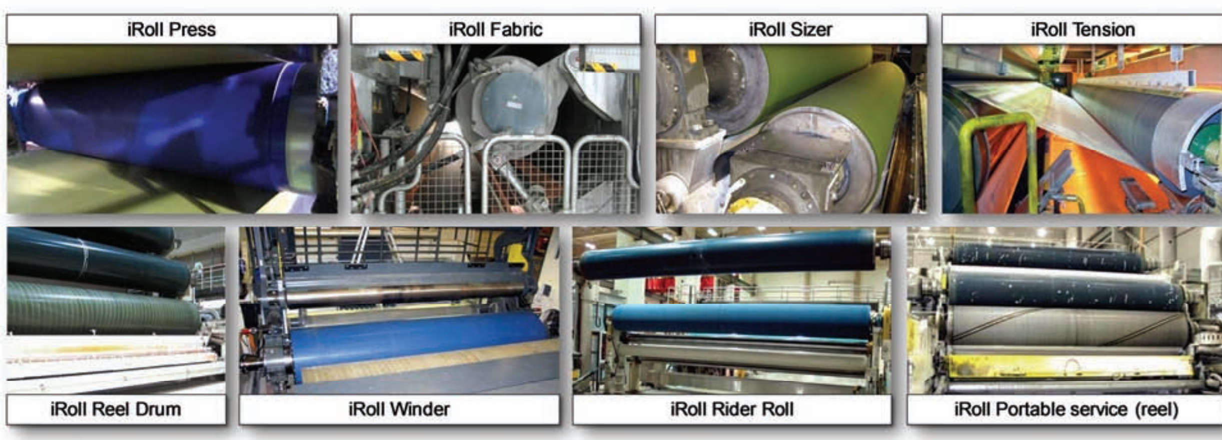


Figure 9. Examples of iRoll installations by machine section

iRoll Press

When used in the press section, iRoll measures the CD nip profile and MD nip load level from the press nips. Continuous full speed measurement is provided, with several profiles per second. Full configurability is available, from single nip applications to multiple nips in contact.

Full speed measurement with no delay allows for immediate actions. Thus, iRoll Press helps remove press nip skewness, optimize crowning and monitor the press roll cover condition, as well as monitor the condition of the press nip loading devices. Improved press nip loading with iRoll Press results in:

- More uniform moisture profile
    - Better sheet quality with less energy consumption
- Longer lifetime for felts and roll covers with no roll cover failures due to load peaks
    - Reduced costs and less downtime due to longer running periods
- Removal of factors that cause runnability issues in center nip presses
    - Fewer web breaks due to uniform sheet dryness
- Improved surface quality with smoothing presses

iRoll Press is suitable for all grades of paper, board and tissue. **Table 1** shows some iRoll Press results achieved at a few tissue producers.

Mill	Machine	Roll	Benefit
Tissue producer	DCT double nip machine, speed 1600 m/min	2nd press roll with blind drilled Valmet PU cover	Loading system suffered problems causing unexpected cover failures due to local cover overheating/overloading. With iRoll monitoring cover failures were eliminated.
Tissue producer	DCT double nip machine, speed 1900 m/min	2nd press roll with blind drilled and grooved Valmet PU cover	iRoll revealed clear under-crowning and nip skewness. Mill had suspected such but could not determine problem without iRoll. The problems contributed to felt compaction and paper web profile issues.
Tissue producer	DCT double nip machine, speed 2000 m/min	2nd press roll with blind drilled and grooved Valmet PU cover	Paper web profile problems were severe. iRoll indicated an over-crowning problem. Upon knowing the root cause, mill decided to grind new crowning to the roll immediately.

Table 1. Examples of results achieved with iRoll Press

Figure 10 shows an actual iRoll Press display of an under-crowned press nip. By monitoring iRoll Press in real-time, operators and maintenance personnel can take corrective actions such as adjusting nip and

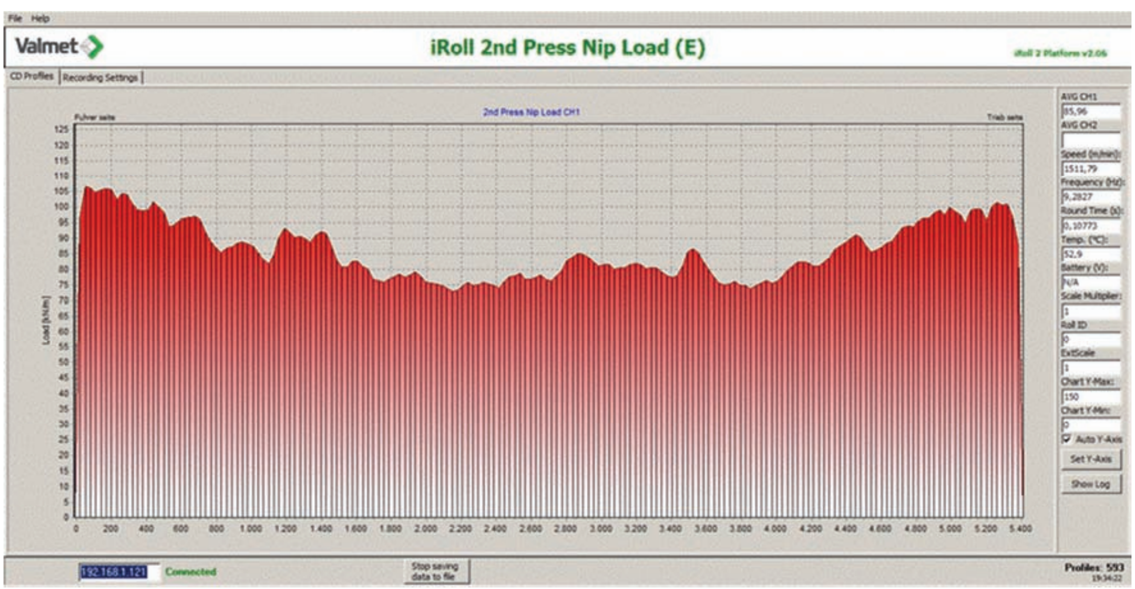


Figure 10. iRoll Press high resolution (200 databoxes) screen display of an under-crowned press nip

removing the skewness, checking the nip load controls and tuning them, and optimizing the crowning – all before any damage to rolls, roll covers or end product quality occur.

iRoll Fabric

iRoll Fabric measures the CD tension profile and MD tension level from wet end fabrics. It can be used at the wire and press sections. iRoll Fabric uses the same technology as Valmet's other iRoll products, with 200 databox wide profiles and typical accuracy of +/- 10 N/m and up to 10 profiles per second. **Figure 11** shows iRoll Fabric used for felt tension profile measurement in a press section.

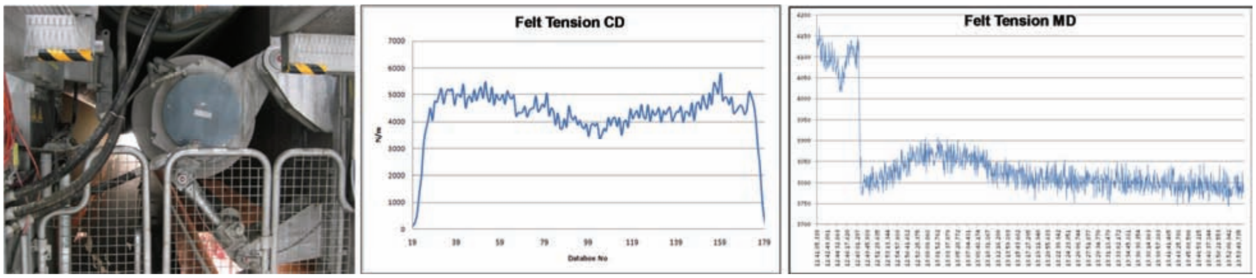


Figure 11. Press section fabric tension CD and MD measurement provided by iRoll Fabric

iRoll Sizer

Profiles in the sizing process are especially important and must be monitored. Improper sizer nip loading causes runnability problems, web fluttering, wrinkles, web breaks, profile and quality problems due to uneven film transfer, and uneven/quick wearing of roll covers. Poor sizer rod loading causes uneven coat weight profiles, errors in starch/moisture profiles, and uneven and quick wear of roll covers and rods.

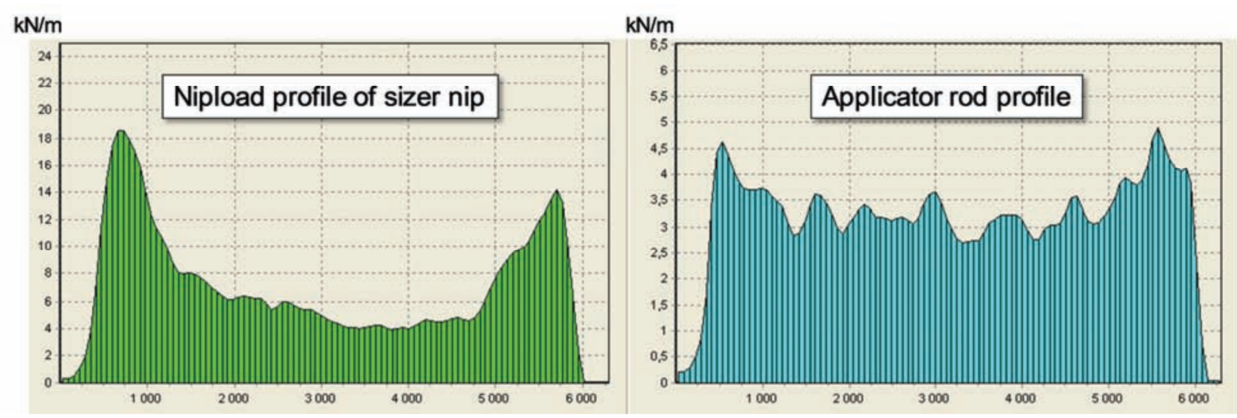


Figure 12. iRoll Sizer measures online both the nip load profile and applicator rod profile.

iRoll Sizer measures online the nip load, nip load profile, applicator rod load and applicator rod pressure profile (**Figure 12**). The profiles may be controlled automatically for rod profile and nip straightness. iRoll is based on Valmet's iRoll technology platform, and is available for polyurethane roll covers CoteFalcon and X-Mate X.

The iRoll Sizer example shown in **Figure 12** illustrates problems detectable in real-time with iRoll. The sizer nip load profile on the left shows that a small crowning value leads to a nip with much higher loading on the edges. Also, the sizer nip profile is clearly skewed which may cause wrinkling of the web.

The right graph shows an uneven applicator rod profile which will result in an uneven coat weight profile. In this case, if iRoll Sizer were tied to a process control system, the skewness and profile optimization can be handled automatically.

Figure 13 is an example of a problem occurring with a Voith Speed Sizer, on which iRoll Sizer was installed. The mill experienced coat weight profile variation with oblique profiles. It was impossible to adjust manually by using information from the coat weight profile scanner. The mill's target was to straighten the profiles and reduce variation. iRoll Sizer was installed on the bottom roll. Based on the iRoll measurement, it was determined that the bottom beam rod loading needed improvement. The spindles were adjusted manually based on the iRoll Sizer measurement.

As a result of spindle optimization, the coat weight 2-sigma was improved by 40% and coat weight profile skewness was straightened.

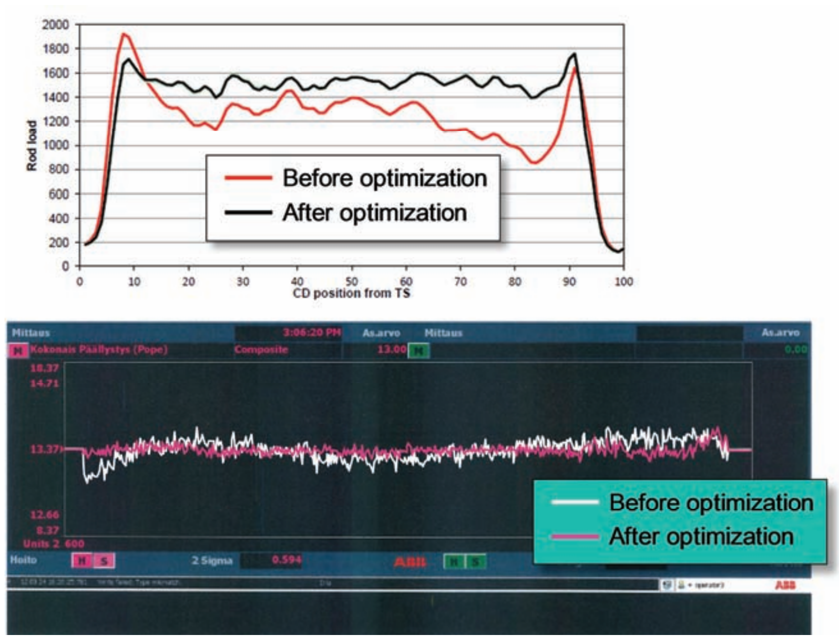


Figure 13. iRoll Sizer helped improve rod loading (top graph) and coat weight profiles (bottom graph) on a Voith Speed Sizer.

iRoll Tension

The web tension profile on a papermachine is inherited by the rolls that are sent to a customer. Loose edges at the papermachine result in skewed profiles on the edge rolls, which are a typical source of customer reclamations. Improving the tension profile yields more saleable production and satisfied customers, as well as better runnability of the papermachine and downstream processes such as winding.

Web tension directly affects papermachine runnability. If the tension is too high, the sheet will break. If the tension is too low the sheet will flutter and wrinkle. Think of web tension as being best if maintained within a runnability margin as shown in **Figure 14**.

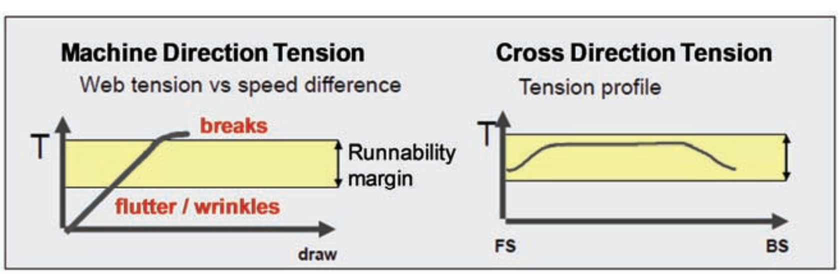


Figure 14. Web tension must be kept within a runnability margin.

The tension profile is a combination of the length profile, modulus of elasticity and distance differences such as alignments and spreading. Poor tension profiles cause slack edges, wrinkles, runnability problems, coater web shifting, poor roll edge quality, winding problems – and inevitably customer complaints. The tension profile can be affected by a multitude of factors, including: moisture profile, basis weight profile, caliper profile, drying, calendering, coating, fiber orientation angle, spreading and roll alignment.

Controlling the tension profile is not a new idea, having started in the 1980s. Much research was performed in the 1990s with Tenscan and IQTension, and methods of performing tension control were widely tested. Since that time tension profile control has been used in several mills to tackle the problem of loose web edges. The knowledge gathered during this research and testing has also been used to optimize moisture profile controls.

Valmet released iRoll Tension to accurately measure a tension profile without separate scanning measurement devices or layout modifications. With a typical sensitivity is +/- 1 N/m, iRoll Tension has subsequently been used in dozens of installations to improve machine and end product runnability, addressing the issues of slack edges, fluttering, wrinkling, web shifting, bagginess and web breaks (**Figure 15**).

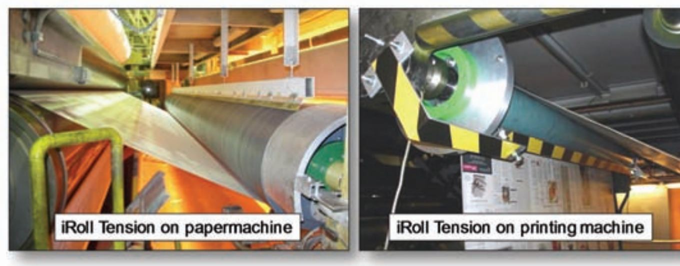


Figure 15. iRoll Tension improves runnability on the paper machine and downsteam processes.

Typically, the best actuator for controlling the tension profile is the press section steambox. The moisture profile at the press section has a large and permanent impact on the web tension profile, and this can be profiled with a steambox very effectively. Actuators at the dry end have a lower impact on the tension profile, but can also be used for profiling. These include moisturizers in or after the drying section, machine and soft calenders, and IR dryers with profiling.

When using the steambox for tension profile control, there will be some error with the moisture profile. This can be compensated for by using a moisturizer or IR dryers with profiling as these have a smaller effect on the tension profile – but a big effect on the moisture profile. The best actuator or combination of actuators is always situational. iRoll Portable may be used for tension profile measurement and response tests to determine and verify the best control concept.

Figure 16 (next page) shows the control concept and results achieved using iRoll Tension as the measurement device and the press section steambox as the control actuator. In this instance the tension profile and moisture profile control are in cascade. The moisture profile control is an internal loop and the tension profile is controlled by changing the moisture target.

In this case, the difference profile clearly shows the resulting change in tightness on both the TS and DS edges achieved with iRoll Tension based control. The tightening on the TS edge was 38% (~75 N/m) and valley was improved by 50% (~100 N/m) of the average force level of ~200 N/m. The result of the iRoll Tension and press steambox control concept was a significant improvement in the tension profile at this mill.

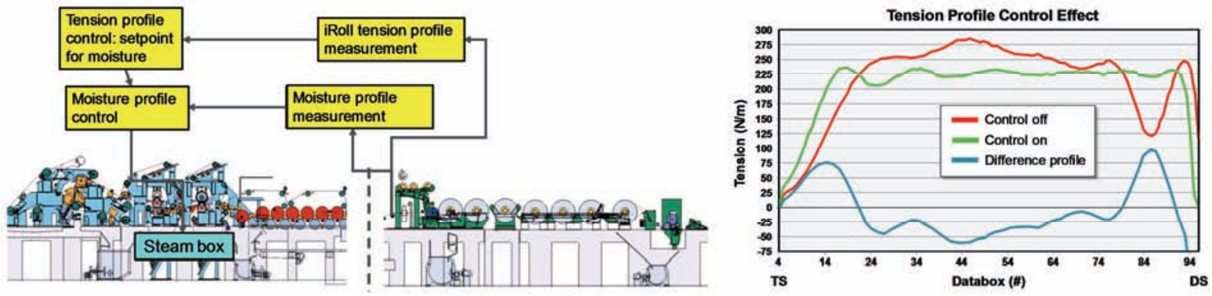


Figure 16. iRoll Tension online control example, using press steambox as actuator

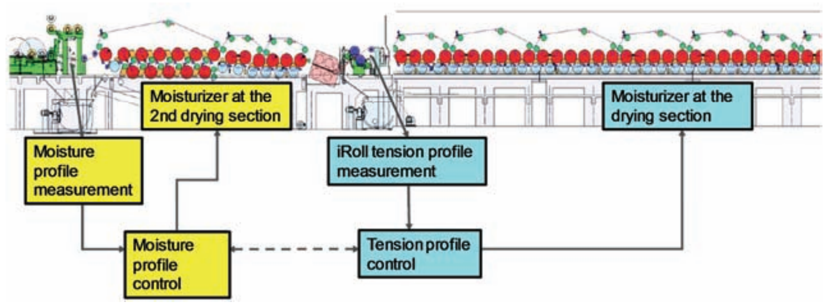


Figure 17. Concept used to control sizer runnability with tension profile control using iRoll Tension and VIB moisturizer

Another example of online iRoll Tension control is shown in **Figure 17**, at a mill where sizer runnability was a chronic problem.

In this mill, the tension profile was controlled with iRoll Tension by using the 1st dryer moisturizer. This provided a strong and permanent effect on the tension profile. The end product moisture profile was controlled with a 2nd dryer moisturizer which had a small effect on the tension profile but good effect on the end moisture. The tension and moisture profiles were simultaneously controlled to enable optimization of the system.

Figure 18 shows the results achieved with iRoll Tension online control. The upper left graph of iRoll Tension measured CD tension profile (dark plot) clearly shows that before the control was turned on, the profile exhibited loose web edges and skewness. At this point, the VIB actuators were not energized, therefore the corresponding VIB profile in the lower left graph is flat at zero.

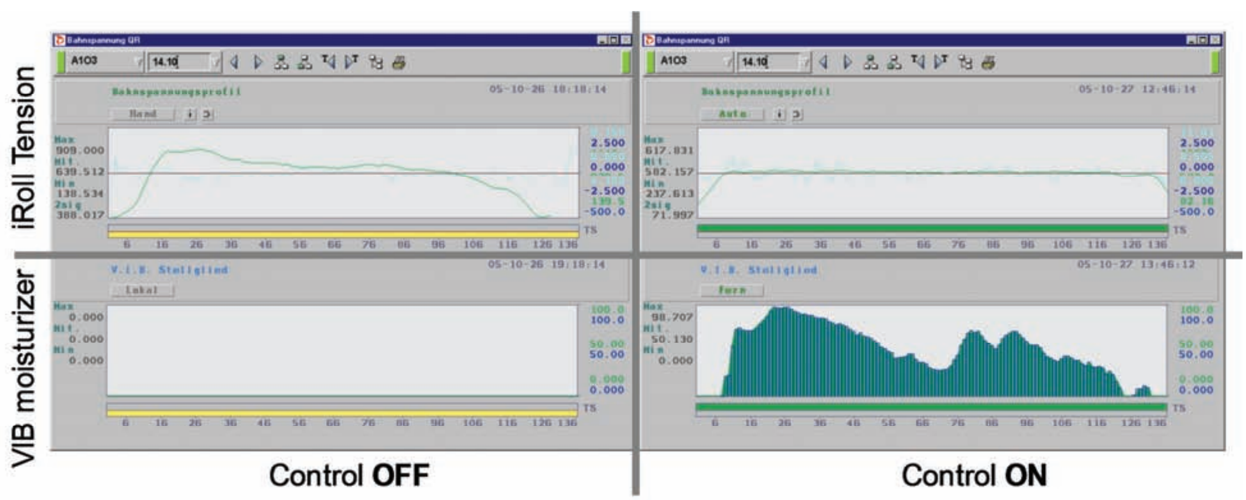


Figure 18. iRoll Tension profile measurement (upper graphs) and corresponding VIB moisturizer actuator control profile (lower graphs) with control off (left graphs) and on (right graphs).

Once control was turned on, as seen in the two right graphs in **Figure 18**, the tension profile (dark plot in upper right graph) shows the web edges have tightened and there is no longer any skewness. In the same graph, the moisture profile is shown in light blue, and has been kept within limits due to the 2nd moisturizer on the 2nd drying section. The VIB actuator control profile required to control the tension profile is shown in the bottom right graph, and represents the target profile of the 1st moisturizer.

iRoll Reel Drum and iRoll Rider Roll

The operating principle for the iRoll Reel Drum (and iRoll Rider Roll) is shown in **Figure 19**. The parent roll hardness profile is obtained when the sensor rotates through the nip, providing the fastest and most sensitive online profile measurement currently available. iRoll Portable uses the same principle when applied to the reel drum or rider roll.

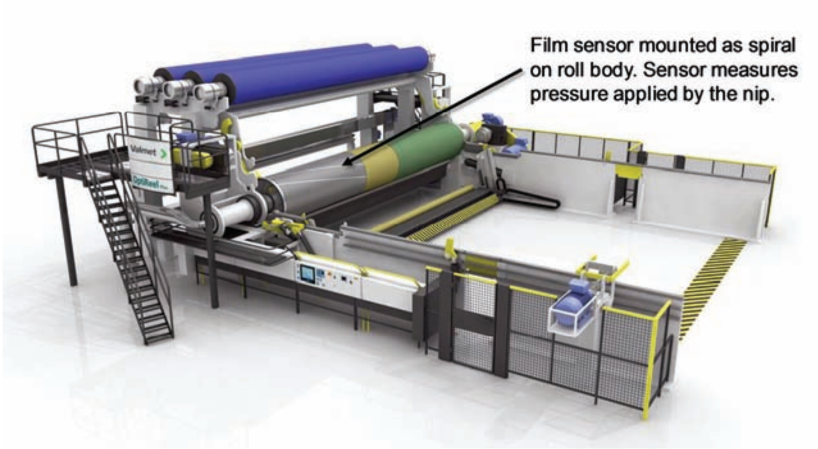


Figure 19. Principle of iRoll Reel Drum control

iRoll Reel Drum

The superior accuracy of iRoll Reel Drum is based on measuring from the parent roll. When reeling thousands of layers on top of each other into a roll, small thickness variations become large variations in roll hardness. These are easily measured with iRoll, providing accurate control, optimal roll structure, improved material efficiency and ultimately cost savings.

Figure 20 shows the results achieved on an LWC line using iRoll Reel Drum. This Beloit machine started up in the 1980s, with online coating. Since that time the speed has increased and is now in the 1300 to 1400 m/min range. The mill suffered from poor reeling efficiency. The reeling recipe with the old pope reel was impossible to tune, leading to reeling broke. Hard parent roll edges created air bagging and soft roll edges created glossy spots or crepe wrinkles in the parent roll bottom. iRoll Reel Drum was installed to improve efficiency. iRoll is now regularly used to optimize the reeling recipes and monitor roll hardness profiles (the profile can be adjusted with coat weight profiling).

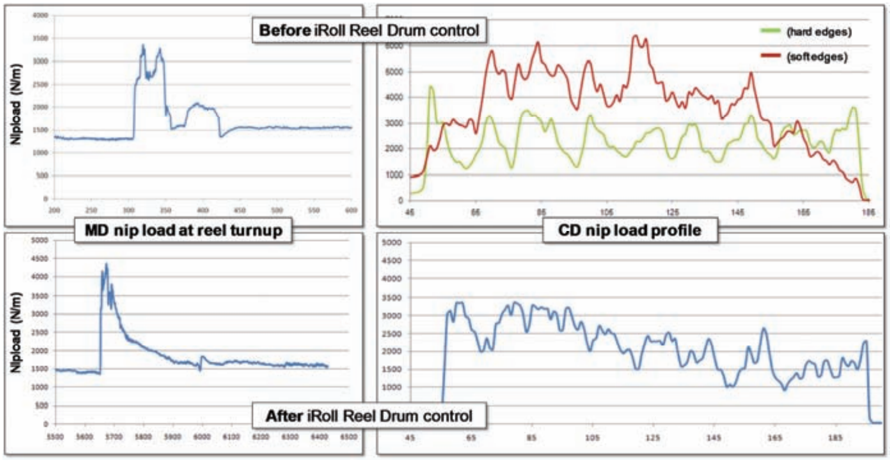


Figure 20. Results of reel nip load control optimization by using iRoll Reel Drum at an LWC mill

Before iRoll Reel Drum was taken into use the reeling broke ran about 1.25 tons/day, resulting in 235k€/year lost production. The reel turnup would produce broke due to discontinuities, as shown in the upper left graph (previous page). Examples of hard and soft edges are shown in the upper right graph.

After iRoll was taken into use, losses due to reeling broke dropped to 0.28 tons/day, or 32k€/year. The smoother reel turnup can be seen in **Figure 20**'s lower left graph. The post-iRoll nip load CD profile shown in the lower right graph is not perfect, but is good enough, providing tightness to the parent roll structure while allowing air to flow out from the roll. The mill realized annual savings from reeling broke reduction of over 200,000 euros, plus they were able to increase the machine speed.

iRoll Rider Roll

For calenders, controlling with scanning caliper measurement has been problematic. Non-functioning measurement often results in problems in quality control and thus poor parent roll hardness profiles, tension profile problems, runnability problems at the winder, and a large amount of waste and unnecessary work. In addition to the challenges of caliper measurement, gloss measurement or manual roll hardness measurements have been used with sub-optimal results to control calendering. Traditionally, roll profiles have been measured manually offline with e.g. a Schmidt hammer (**Figure 21**), because online measurement has not been available and a caliper scanner may be unreliable.

Figure 21. The Schmidt hammer test is typically used to measure roll hardness, but is a manual offline process.

iRoll Rider Roll addresses these difficulties and provides a solution. By measuring the profiles with iRoll, the profile measurement and calender control reliability, repeatability and accuracy are increased to a new, otherwise unachievable, level. iRoll measurement is also quick and reliable in the web edge areas. With iRoll the calender profiling may be controlled automatically using Sym roll zones or an induction profiler as actuators. The end result is that iRoll Rider Roll control assures the runnability of parent and customer rolls.

Figure 22 describes the iRoll Rider Roll control concept used at a WFC mill in 2009 to optimize dry end efficiency. The mill experienced excessive winder bottom broke at the winders due to parent roll hardness

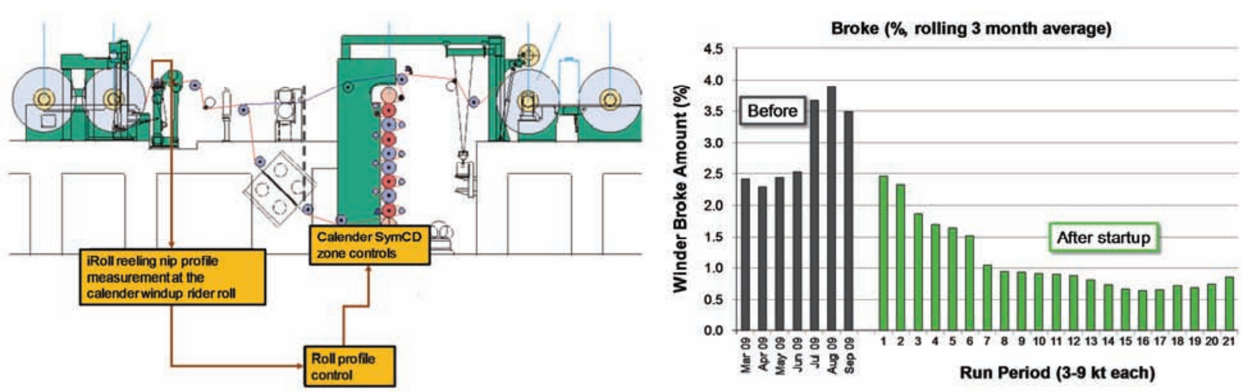


Figure 22. Offline supercalender control using iRoll Rider Roll improves winder efficiency at a WFC mill.

profile variation. iRoll Rider Roll and automatic profile control were installed at the offline calender to improve the hardness profiles.

At this mill the broke from winder bottom wrinkles decreased from 3% to 0.7% with the iRoll Rider Roll measurement-enabled control, as demonstrated in the three month broke rolling average before and after iRoll startup shown in the graph. This produced an annual savings of over 5000 metric tons, or 4M€/yr.

iRoll Winder

With iRoll Winder, sensors are installed under the compliant winder drum cover, providing measurement of the nip load from the winding nip and online measurement of the hardness profile of customer rolls. This allows for better windup control at the winder, online condition monitoring of the winding nip, higher end product quality and runnability, and more saleable product.

iRoll Winder measures straight from the winding nip, showing the true winding nip load and all discontinuities that can cause problems during roll buildup. It enables tuning of winding recipes for best performance and removal or avoidance of all discontinuities. **Figure 23** shows an example of nip load measured with iRoll. The discontinuity at the moment the rider rolls open is clearly visible in the iRoll Winder display (highlighted area).

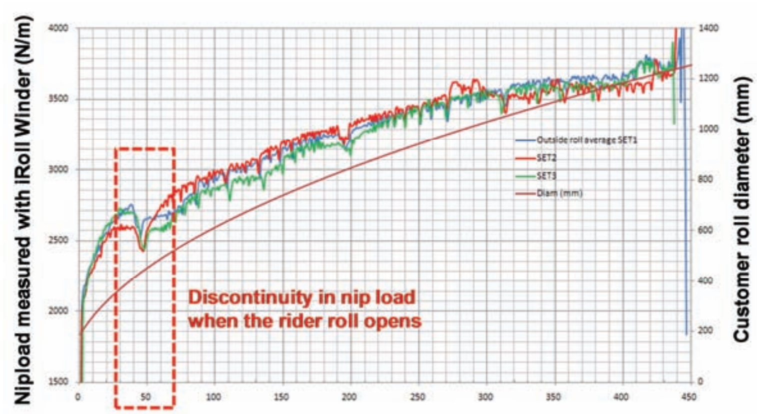


Figure 23. On-line condition monitoring of the winding nip with iRoll Winder provides instantaneous insight into winding irregularities.

The real-time information provided by iRoll Winder helps avoid nip load peaks and discontinuities in roll buildup, skewed nip profiles, breaks and broke. Monitoring the roll profiles and roll structure using iRoll Winder measurement enables tuning winding parameters to adapt to profile-related winding problems caused by earlier process stages, thus avoiding potential roll defects.

iRoll Winder provides totally new, online information about nip load evenness and wound roll profiles (i.e. paper web and parent reel profiles as seen in **Figure 24**). It also enables correctly-timed preventive maintenance actions.

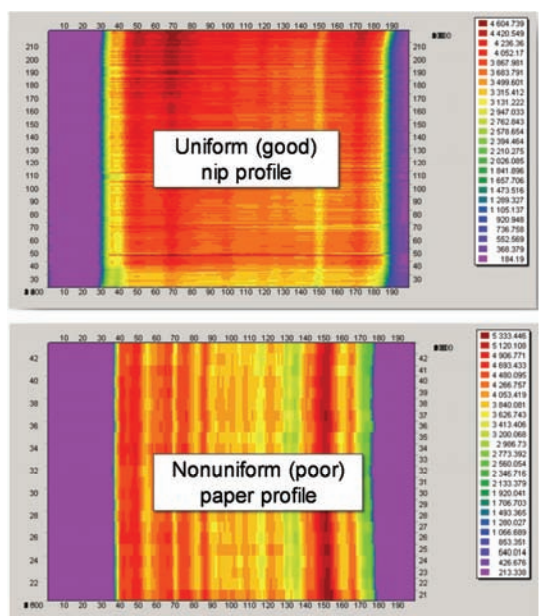


Figure 24. Good and bad profiles are easily seen in real-time with the iRoll Winder display.

iRoll technology features

The iRoll platform takes nip to the next level by having the best options chosen for each application. The continuous sensors are capable of measuring infinite disturbances in the CD profile – even capable of measuring the tension profile in a tissue web. The discrete sensors can withstand the harshest conditions, such as a shoe press. Both of these options provide the best sensitivity and CD resolution available today.

iRoll achieves higher measurement accuracy by optimizing the sensor placement for each application; measurement of the press nip vs. measuring the web tension profile require different approaches. iRoll utilizes high precision tooling with 3D controlled lathes. Sensors and equipment are pre-calibrated during the manufacturing process, as well as calibrated at the mill site.

The electronics are engineered to utilize fully integrated microprocessor, analog/digital and radio transmission – all embedded on a single integrated circuit. This results in extremely low power usage and the ability to run measurements at high speed, i.e. several profiles per second continuously. iRoll systems also have an induction power system which can replace the battery entirely. Signal processing algorithms run on embedded electronics and pre-process the data to remove errors from the signal, resulting in far higher resolution and accuracy than other systems can provide.

iRoll has proven integration with mill systems and interfaces to all major paper mill distributed control systems (DCS) using open protocols. Valmet papermaking and automation engineering expertise is available for iRoll users, to conduct bump tests and tuning of papermaking control loops and implement automatic profile controls. With iRoll, it's much more than just monitoring – it's controlling the end product to tight tolerances!

iRoll vs. scanner

(NOTE: the comparison data in this section is taken from real-world iRoll Portable studies at mills which were experiencing caliper-related problems. The iRoll studies were undertaken for a reason – the mills' caliper measurement would not perform as needed.)

There are four main issues with thickness scanner performance. These are:

1. Resolution is too low, in practice 1 micrometer or worse. The needed resolution should be at least 10x better. Quality Control System (QCS) suppliers sometimes state that they have better resolution but that is not true in reality.
2. Requires constant care. There is a constant need for cleaning, calibration and other maintenance and tuning. Without this the whole measurement concept fails to work. In practice, it's not possible to provide this constant service in a mill environment.
3. Caliper is not the right thing to measure. To assure good reel buildup and runnability, the primary parameter is the hardness/diameter profile. Thickness is only a secondary parameter that effects hardness and diameter.
4. Web breaks are caused by contacting caliper measurement scanners.

iRoll overcomes the issues stated above as it measures the hardness from a parent roll that has thousands of layers wound on top of one another.

iRoll vs. laser caliper scanner, case #1

Figure 25 illustrates a first example of comparing iRoll to a laser caliper scanner in a mill. The upper graph shows the average iRoll roll hardness profiles from the first parent roll (normalized). Calcoil control was off. The blue profile is from the parent roll bottom, the orange is from the halfway point, and the red profile was measured from the parent roll top. As you can see, the profile variation increases toward the parent roll top, as more layers accumulate on the parent roll. This explains why the top set is usually the most difficult to run at the winders. This also shows the importance of using the parent roll hardness profile instead of the caliper profile measurement, as the hardness truly reveals how the parent roll builds up,

The middle graph is the Parotester hardness profile measured on the top of the first roll of the supercalender. The Parotester and iRoll profiles show a similar shape, with hard areas at the edges and softness + variation in the center.

The lower graph represents the caliper profile of the first supercalender roll as a color map. The caliper measurement has some hint of the high hardness/caliper on the supercalender's front side (to the right in the graph), but otherwise it does not tell the profile shape as the iRoll or Parotester does. Caliper profile scanner measurements are often unreliable and inaccurate, especially with multinip calendered paper grades. This seems to be the case as well for this supercalender. The caliper scanner measurement is incapable of measuring the profiles well enough to control the calender profiles and thus hardness profile measurement is recommended instead.

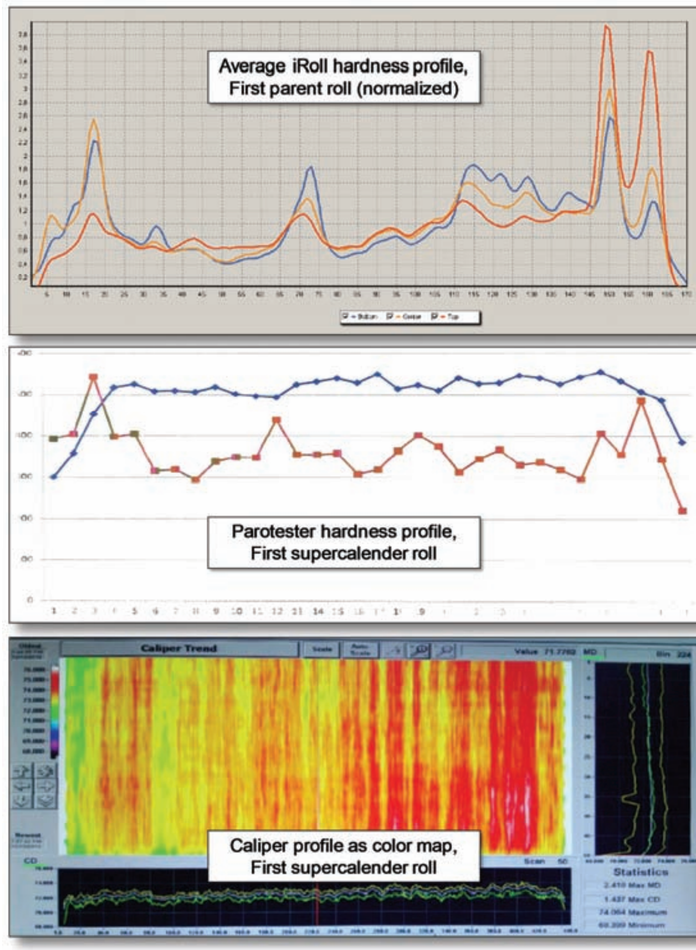


Figure 25. Comparison of iRoll to a laser caliper scanner (example #1)

iRoll vs. laser caliper scanner, case #2

In example 2, shown in **Figure 26** (next page), the upper graph shows the normalized average iRoll hardness profiles from the second test parent roll bump test on an off machine coater. Again, the profile variation increases toward the end of the roll. The bump test (light orange plot) shows a softer area (highlighted in red) and a harder area (highlighted in black).

The lower graphs are the caliper, top gloss and bottom gloss profiles reported from the laser scanner during the second roll bottom. Comparing the blue graph in the upper (iRoll) graph to the caliper graph reported by the scanner, we see that the scanner caliper profile does not show the hard bumps on the edges nor the variation in the center.

Gloss measurement isn't appropriate for control either, as the scanner gloss profiles show low gloss at the edges. These would require the calender nip loading to be reduced (via Calcoil) at the edges, which would cause the high hardness bumps to get even harder!

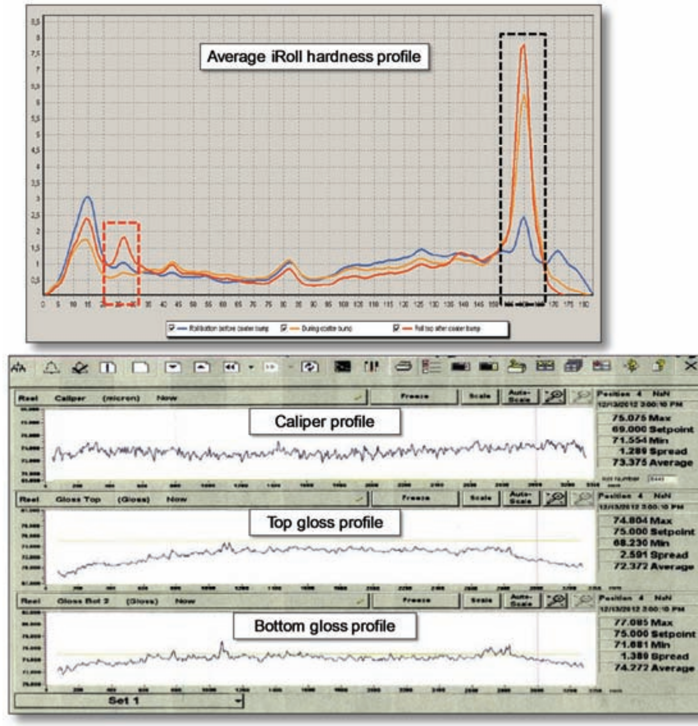


Figure 26. Comparison of iRoll to a laser caliper scanner (example #2)

Summary

Since its introduction in 2005 (**Figure 27**), iRoll has proven itself as a real-time, high-speed, accurate method of measuring critical CD and MD process profiles. By the end of 2014 over three dozen permanent iRoll installations will be running at mill sites around the world. At the time of writing of this paper (mid-2014) 180 iRoll portability runnability analyses and 20 iRoll Portable Lite analyses have been performed.

iRoll helps solve problems that cannot be addressed by other technology such as scanners. It allows papermakers to detect problems before roll covers and end product are damaged and take corrective action. iRoll is suitable for all grades, as well as polymer film and nonwovens and is now available for almost all locations on a machine line – if it's a roll, iRoll can measure it!

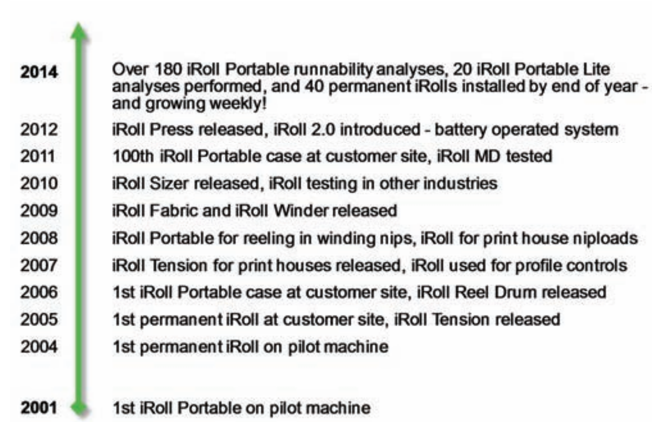


Figure 27. iRoll development started over a decade ago, and continues with new applications released regularly, across all grades and into other industries such as printing and laminating.

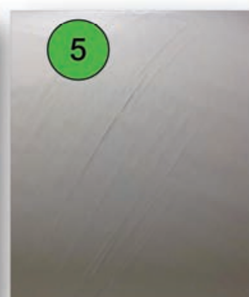
This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers.

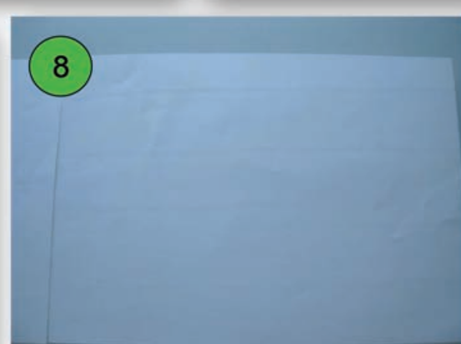
Valmet provides competitive technologies and services to the pulp, energy and paper industries. Valmet's pulp, paper and power professionals specialize in processes, machinery, equipment, services, paper machine clothing and filter fabrics. Our offering and experience cover the entire process life cycle including new production lines, rebuilds and services.

We are committed to moving our customers' performance forward.

Appendix: Reeling and runnability problems that may be tackled with iRoll Portable

1. Rope marking in customer roll hard areas
2. Length or roll profile related problem that is revealed at the next unwinding (a source for wrinkles and web breaks)
3. Bottom wrinkles in a customer roll caused by too soft of an edge area
4. Traditional crepe wrinkle due to too loose of a parent roll structure and bad roll profile
5. Wrinkling inside parent roll due to air bagging in the reeling nip. Air bag is caused by hard parent roll edges blocking the air flow out at the roll edges.
6. Baggy lanes in the sheet and corrugations on parent roll surface due to roll hardness profile variation
7. Loose web edge causing wrinkling when run into a nip
8. Worm trails that have marked a WFC sheet on parent roll bottom due to reeling issues





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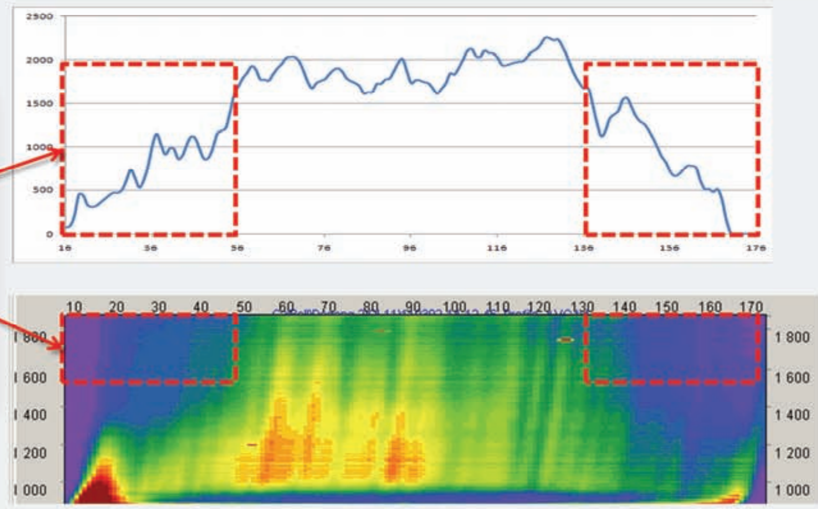
Appendix: Example of iRoll Portable solving bottom wrinkles at winder

- Bottom wrinkles due to too soft parent roll edges (especially WFC)
- Bottom wrinkles most often occur on top sets and edge positions.
- Usually the parent roll edges are the softest - especially on top.

Bottom wrinkle



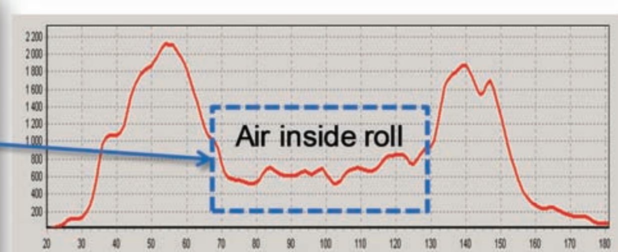
Parent roll hardness profiles reported by iRoll Portable

- **iRoll control assures uniform hardness profile and prevents wrinkles.**

Appendix: Example of iRoll Portable solving coated board roll telescoping

- Coated board roll telescoping due to too hard parent roll edges and air entrapment
- Hard parent roll edges block the air inside the roll, which reduces friction.
- Air inside the roll together with an uneven profile causes the web to shift and telescoping occurs.

Telescoping roll



iRoll hardness profile

- **iRoll control with compliant soft reel drum cover assures uniform hardness profile and prevents telescoping.**