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Intelligent roll applications and case studies for better nip profiles and runnability

Abstract: *All paper makers want to improve production efficiency and paper profiles, reduce energy consumption and save costs. On today's demanding market, it is also crucial to provide the best possible customer satisfaction for end product users. The intelligent roll – "iRoll" product family has been developed to meet these goals and provides a solution for improving sheet quality, optimizing nip profiles and ensuring the highest possible end product runnability. The intelligent "iRoll" product family is a complete set of tools for controlling paper tension and nip profiles. Intelligent rolls can be utilized in all main processes and positions on paper machines. This innovative technology makes it possible to improve production efficiency and product quality by ensuring optimal runnability in all process phases. Intelligent roll technology offers cost savings through improved nip profiles, parent roll hardness profiles and tension profiles as well as the best possible product for printing and converting houses. This paper introduces the applications of intelligent roll technology in paper, board and tissuemaking and illustrates the benefits through example cases.*

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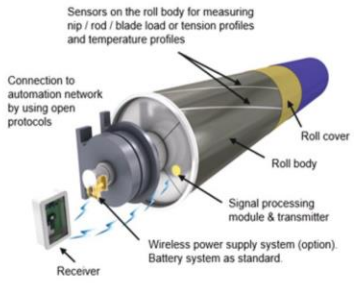
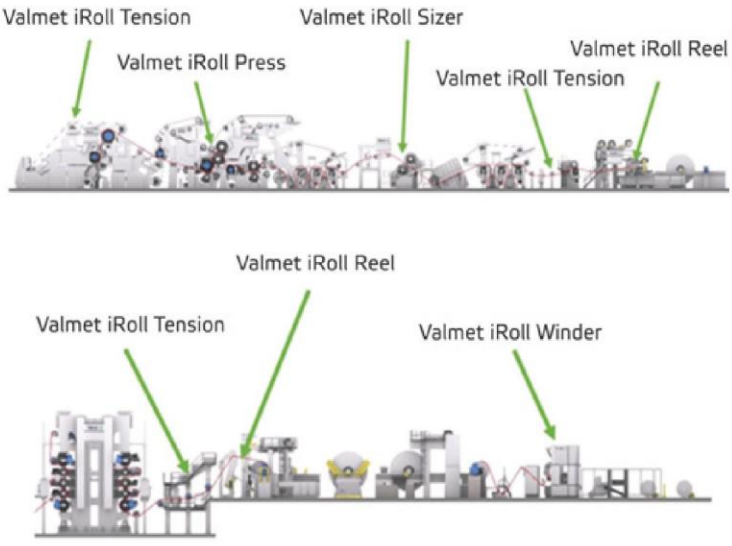
INTRODUCTION

The intelligent roll system – "iRoll", consists of high precision machined roll, force sensors mounted in helical pattern, roll covers, measurement electronics, digital radio transmission free from disturbances, and a receiver system that is connected to a user interface and the mill automation system. The specialty about "iRoll" is that layout changes or external measurement devices like scanners are not needed: intelligent roll is just like any other roll in the process and thus makes it possible to view how the press nip, sizer rod application, web tension or roll hardness profile is really effecting in the production line. Additional measurement devices often also cause error in the property that is being measured, which is not happening with intelligent roll. Intelligent rolls may be easily fitted to existing machinery and connected to mill automation systems through open protocols. Picture 1 illustrates the operation principle of "iRoll".



Picture 1: Intelligent roll – "iRoll", the operating principle.

The Intelligent roll technology creates new possibilities to optimize roll nips and the quality and runnability properties of the web. The intelligent roll for paper machine press sections – the "iRoll Press" is a tool for measuring profiles of press section nips during production. The intelligent roll for size presses - the "iRoll Sizer" enables to measure online size press nip load profile as well as the applicator rod loading profile and to obtain best possible profiling of the rod. The



Picture 2: intelligent roll technology enables measurements in various positions.

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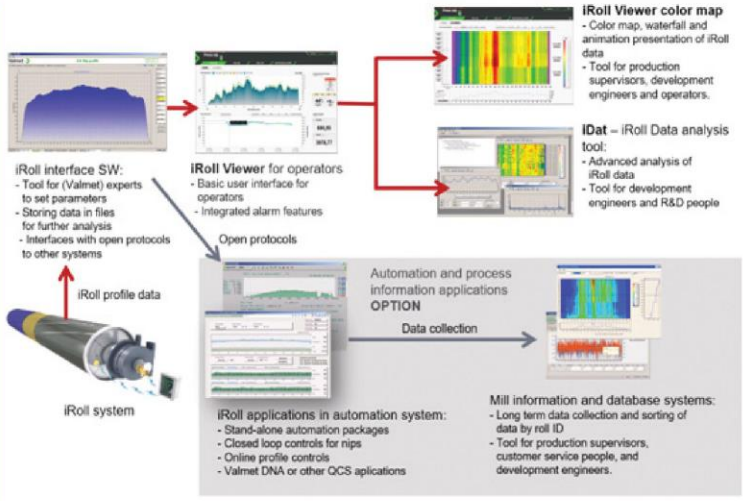
intelligent roll for reeling - the"iRoll Reel"is a tool for measuring parent roll hardness profile online - and also reeling nip load profile. The intelligent roll for web properties - the "iRoll Tension"is a tool for measuring web tension profiles online without any separate scanning devices. Tension profile measurement can also be used for wire and felt profile measurement.The "iRoll Reel" and "iRoll Tension" bring also a possibility for online control of roll hardness profile and web tension profile.Intelligent roll for winding processes – the "iRoll Winder" enables online measurement of the nip loading in the winder nip and customer roll set hardness profiles. Intelligent roll technology enables also temporary nip profile, process and runnability analysis measurements by using tape-mounted sensors. This so-called "iRoll Portable" enables roll profile, nip load profile and tension profile analysis as a service. The "iRoll Portable" brings a way to obtain cost savings through improved efficiency and helps the maintenance personnel tackle difficult problems without investments. Picture 2 illustrates the different applications of the intelligent roll technology.

The experiences of using intelligent roll technology have been positive and paper makers have experienced significantly improved machine runnability. After installing an intelligent roll, e.g. 50% fewer wet end breaks per day, 40% improvement in the coat weight 2-sigma value, 2% more production due less reeling waste are examples of the results this technology has achieved. The practical experiences of intelligent roll technology are presented in more detailed way in the experimental part of this paper.

Besides of the actual measurement technology, it is crucial also to have a dedicated tool set for processing of the measurement data. For "iRoll", there is an extensive software platform available, with tools to illustrate the profiles to users, drawing waterfall diagram color maps and also for deeper analysis of the data, e.g. spectral analysis. The open data transfer protocols of the intelligent roll system also enable to gather the data in process information systems and for automatic profile controls as a part of a QCS system. Picture 3 illustrates the software tools that are commonly used with intelligent roll data.



Picture 3: iRoll software tool set with applications for user interfacesand data analysis.

IMPLEMENTATIONS OF INTELLIGENT ROLL TECHNOLOGY

Intelligent roll for press section to improve nip and moisture profiles

Paper machine press section nip profiles are an essential factor for efficiency of the whole paper making line. Uneven press nip loading can result in reduced capacity due web breaks and increased drying costs due poor moisture profile. It can also cause increased costs by uneven felt compacting & quick wearing of roll covers, or even damages.These press nip load profile and runnability issues can be detected by using theintelligent rollin a press nip position. The "iRoll Press"provides a high resolution nip profile readings that reveal the roll nip load variations in CD & MD, possible nip skewness and actual nip load. it also enables to optimize crowns and to tune up nip loading devices. Improved press nip loading results in energy savings and better product quality by more uniform moisture profile. It also reduces costs by longer life time for felts and roll covers, while load peaks are avoided. With better moisture profile also less web breaks can be expected. In tissue presses the online measurement enables to detect the yankee cylinder pressure and temperature effect to the profile and to tune these up.On all wet pressing processes, enhancing dewatering efficiency is important, too. Optimizing the nip load level can help achieve this goal. Picture 4 illustrates an intelligent roll installed on a tissue machine press section 2nd nip position.

Picture 4: "iRoll Press" at a tissue machine press section.

Intelligent roll for sizers to improve runnability and sizing/coatingprofile

Uneven size press nip loading causes runnability issues such as web fluttering, wrinkles and web breaks. These result in lost production and quality problems due to uneven film transfer. Improper applicator rod or blade loading causes also issues such as: quality losses due to uneven coat weight profile as well as energy and broke increase due to poor moisture profile. Increased maintenance costs may also occur because of uneven and quick wearing of roll covers and rods or blades. The "iRoll Sizer" enables to measure online the size press or film coater applicator rod loading profile and to obtain best possible profiling of the rod. With optimal rod profiling the coat weight profile errors may be dropped down even with manual profiling. Automatic profiling tools may also be used as part of the system but they are not a necessity. Besides the rod profile measurement, "iRoll Sizer" also enables to measure the sizer nip load profile online. This enables to prevent skewed nip loading and to do roll maintenance exactly on right time when the roll covers are worn out. By optimal sizer nip loading the film sizer press runnability can be improved as the wrinkling and fluttering issues are removed. Picture 5 illustrates

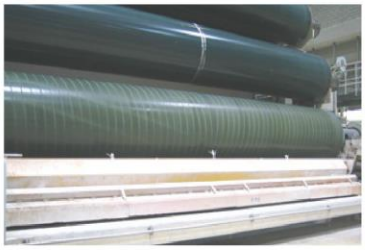
Picture 5: "iRoll Sizer" system ready to measure size press nip and applicator rod profiles online.

an intelligent roll installed on a size press bottom roll position.

Intelligent roll at reel for parent roll hardness profile measurement and control

Intelligent roll as a reel drum brings a new system of online nip force profile measurements, providing valuable information about paper web properties. The nip profile measured at a reel has a straight correlation with the hardness profile of the paper roll. Traditionally the parent roll hardness profile has been measured manually to overcome issues due in-accurate and unreliable caliper and gloss profile measurements. With "iRoll Reel" the hardness profile measurement can be done online. This application has been proven effective to reduce broke in paper machines. E.g. issues due parent roll hardness profile variation causing baggy areas, air bubble wrinkling, cracks, corrugations in parent rolls, crepe wrinkles, telescoping and bad visual outlook of the customer rolls could be overcome.

The high resolution of the profile measurement is based on the nature of roll building: since thousands of paper layers are reeled on top of each other in the parent roll, the thickness variations are cumulated and multiplied, making big shapes in the paper roll. Intelligent roll-based quality and roll hardness measurement has superior measurement accuracy when compared to alternative measurements such as caliper, back tenders' friend, etc. Due to this, it is possible to replace the old manual parent roll hardness measurements as well as scanner-basedcaliper profile measurements. Paper CD-profile online control with "iRoll" measurement is usually implemented by using calender zone controlled rolls or induction profilers as actuators. Also coat weight and base paper basis weight profiling can be used for the purpose. Picture 6 illustrates an intelligent roll being used as a reeling cylinder on a paper machine reel.



Picture 6: The "iRoll reel drum" installed in a paper machine reel.

Portable iRoll for process analyses and maintenance services

Portable intelligent roll technology brings a new online analysis service for paper, board, tissue makers and maintenance experts. This "iRoll Portable" analysis enables accessing the accuracy and benefits of the intelligent roll technology quickly and cost efficiently as a service without capital investments. The analysis includes the installation of intelligent roll sensors taped onto a roll surface and a signal-processing module with a transmitter attached to the roll head or shaft. The intelligent roll instruments provide a complete CD profile on each full turn of the roll. The measured profile information is transmitted with a wireless link via a receiver to a PC. The analysis package includes measurement and data collection for an agreed period, and expert analysis including recommendations for further nip or process development.

"iRoll Portable" has been utilized in more than 250 measurement cases globally for full range of paper makingprocesses. "iRoll Portable" tools enable to conduct process analysis and nip profile measurements throughout paper, board, tissue and pulp drying lines. Measurements at converting, printing, laminating and other similar processes are naturally possible too. "iRoll Portable" can be used at press nips, sizers, reels, winders, coaters and also for measuring paper and fabric tension profiles. Picture 7 illustrates the "iRoll Portable" sensors installed on a paper machine reel.

Picture 7: "iRoll Portable" sensors on a paper machine reel.

When used for paper and process analysis purposes, the "iRoll Portable" is used for measuring parent roll hardness profiles, web tension profiles or fabric tension profiles during production. The target is then to obtain paper quality, runnability and parent roll hardness profile improvements by doing process response testing and tuning. When using "iRoll Portable" for improving nip profile, the tool is used during shut downs to analyze e.g. nip and rod profiles of sizer, or press nip profiles in dynamic conditions. "iRoll Portable" replaces traditional nip impression film and electronic blanket type of nip measurements, which have been only used in static conditions – creating error and un-reliability to the results. With "iRoll Portable" the rolls are rotating during the measurement which shows the nip profiles in true running conditions. Illustrating the profiles with online graphs and color maps enables quick and precise online tuning actions.

This paper presents later an example case of using "iRoll Portable" technology. It describes the 200th "iRoll Portable" case that concentratedon improving tissue machine moisture profiles, runnability and press nip profiles with dynamic nip profile measurements.

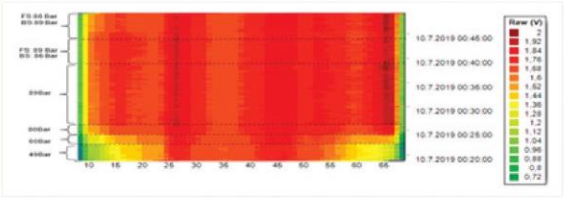
EXPERIENCES AND RESULTS AS CASE EXAMPLES

A case of using "iRollPortable Press" on a writing, printing and copy papermachine: N R Agarwal PM5in Sarigam, Gujarat, India

N R Agarwal'sUnit 5 wanted to optimize the wet pressing performance of its bi-nip press section by improving moisture profiles and reducing web breaks. Mill also wanted to increase the machine speed but was unsure whether the press section would be able to handle dewatering at higher speeds. The dewatering capacity of the press was unknown, because the actual loading in the press section was unclear. This made the optimization and speeding up of the machine even more challenging. The trial-and-error method is always available for a speed increase, but in today's competitive market, it is a slow and uncertain way to proceed.

The mill used "iRoll" technology, including nip measurements and an "iRoll Portable Press" analysisto optimize the bi-nip press.

The nip measurements revealed a difference between the calculated and actual load in the press section. Based on the actual load and nip profile, it has been possible to optimize the press load



Picture 7. "iRoll Portable" nip profiles during load testing.

and roll cover crowning, thus improving runnability. Other results included an improvement of 1 percent in web dryness after the press and 1.5 percent after the bi-nip, as well as a 10-12 percent draw reduction after the bi-nip section.

With a correct picture of the nip profile, the mill can now optimize it. It has been possible to increase the machine speed to 950 meters per minute according to the initial goal. Web breaks in the press section have been reduced by 20-30 percent and roll build-up has improved.

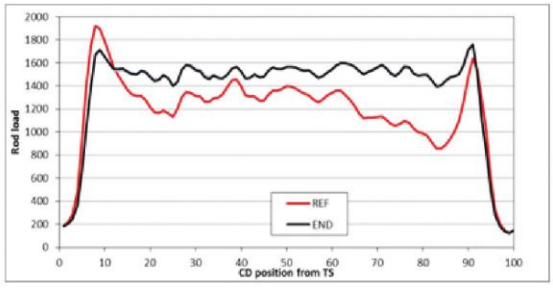
Now, the mill has a clear idea about the amount of water the press can handle with various grammages and speeds.

A case study of using "iRoll Sizer" on a book paper machine: StoraEnso Anjalankoski PM2, Finland

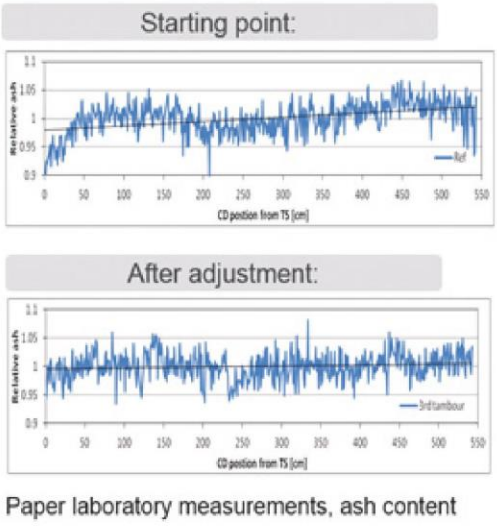
Stora Enso Anjalankoski PM2 in Finland produces coated book and printing papers.After the modernization made in 2009 the line had been suffering from runnability difficulties at theSpeedSizer. The problems were resulting from in-accurate sizer nip loading. According to production management the fluttering and wrinkling of the web edges were a problem. Situation had been most difficult with coatedgrades and after grade changes. Also the coat weight profiles of lightweight coated grades with 5-8g/m2 coating per side had been in need of improvement: profile variation needed to get better and the overall shape was skew.

A "iRollSizer" system was installed into the PM2 to solve the runnability problems and to increase the knowledge of the sizer nip behavior. With intelligent roll at size press, the nip load profile and loading level could be measured during the production. As the information of nip loading was available, the nip could now be tuned to assure symmetric loading and right load level. In case of runnability issues the changes in the nip loading could be seen immediately. This was a major improvement when comparing to earlier situation when the nip loading could only be measured in static conditions during a shut down.

Besides the nip load, also the applicator rod profile could be measured online with the intelligent roll. An optimization was done for bottom coat weight profile by straightening the applicator rod profile with manual spindles and using intelligent roll profile data. The overall 2-sigma variation of the coat weight profile was reduced by 40%. At the same time the coat weight profile skewness could be totally removed. These results were achieved by optimizing just the bottom rod loading profile by using the "iRoll Sizer" measurement as a reference. The profiling was done manually by tuning the rod profiling spindles. So besides the better runnability, also the improvement in the product quality was clear. Picture 8illustrates the improvement gained in the applicator rod profile by using the intelligent roll. Picture 9 illustrates the corresponding improvement in the coat weight profile.



Picture 8: Graphs above illustrate the online measured applicator rod load profile in N/m before (red) and after (black) optimization with "iRoll Sizer".



Picture 9: Graphs above illustrate the coat weight profile (ash content) from laboratory measurementbefore and after the optimization. Profile skewness could be removed and variation reduced significantly with intelligent roll. The online scanner measurement showed also 40% improvement in the coat weight 2-sigma value.

A case study of using "iRollPortable" and "iRoll Reel" on a specialty paper machine: Sappi Alfeld PM 2 in Germany

In 2013, the Sappi Alfeldmill converted its graphic paper machine, PM2, into what was probably the most sophisticated specialty paper machine ever built. An MG cylinder, an online coater, and an online multinipcalender are among the tools incorporated into the world's biggest specialty paper machine, which runs at up to 1,200m/min and has a production width of 5,150 mm.

The wide variety of grades presents additional challenges for process control and runnability. With the basis weight ranging from 50 to 180 g/m2, there are calendered, non-calendered, coated, uncoated, and one- and two-side-coated grades. Various other parameters needed to be optimized for high speed and efficiency, too.

After reaching the targets set for product properties and the highest quality on the market, Sappi Alfeld started to work on PM2's production efficiency. The idea was to have a large specialty paper machine that can cope with larger orders, provide top benchmark quality, feature the best possible cost

efficiency, and support the transition from plastic-based materials to paper-based ones.

The product mix in specialty paper production is diverse, with frequent grade changes. The variety of different products calls for a wide variety of process parameters, too. Material efficiency on the production line can easily fall due to profile- and runnability-related broke.This is a particular issue when reeling and winding higher-density paper grades that require more calendering impact.

Thus, multinip-calendered or soft-calendered grades create a set of challenges for profile controls. Dry end broke depends on parent roll hardness and diameter profiles. Bad profiles, such as hard roll edges or soft areas in the cross dimension, can lead to reeling, winding and runnability problems, resulting in high amounts of broke. Hard areas in parent roll CD hardness profiles can cause, for example, baggy areas, ridging or corrugation in parent rolls, and poor visual qualities in customer rolls. Typically, hard spots turn out baggy during unwinding.

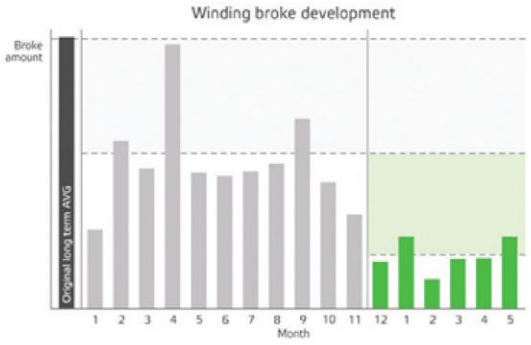
Sappi Alfeld set the quality standard high: only rolls with a perfect appearance and perfect profiles would be accepted. All rolls had to pass an inspection to verify that no baggy overstretched areas, wrinkles, finger streaks, or other hardness profile-related issues would end up being shipped.

On the other hand, hardness profile variations – especially with lighter basis weight grades – tended to cause these issues, leading to broke and reductions in overall material efficiency. The strict quality requirements led to relatively high levels of winding broke – with a consequent negative impact on PM2's overall profitability.

To tackle this challenge, the mill first tuned the headbox and added oscillation to the reelbut with a relatively small effect. Online thickness profile control for calender profiling did not give optimal results, so the focus shifted to the reel hardness profile.

The mill used the available tools to improve and stabilize the hardness profiles at the PM2 reel. This was done by regularly observing hardness profiles on all grades. Optimized profile targets for the pre- and multinipcalenders improved the hardness profile. An"iRoll Portable" analysiswas used to further fine-tune the profiles.

These manual actions decreased winding broke by 46% from the original levels. The improvement was clear – but still not sufficient. To get better results, an upgrade to the control system was needed.



Picture 10. Development of winder profile reject, showing manual actions enhanced by "iRoll Portable" and further with online hardness profile control. Manual actions could cut the amount of reject by almost half. A further 64% reduction from the manually optimized level was obtained with online hardness profile control. This equals an 80% total reduction compared with the original levels.

The final phase was carried out by adding an "iRoll Reel" with a soft ValmetReel Drum Cover RSto the PM2 reel. The"iRoll" hardness profile signal was connected to the Valmet IQ CD Controls multivariable profile control system. The "iRoll" hardness profile was used as an input in the controllers to obtain a good hardness profile, rather than using thickness profile control alone. The sophisticated multivariable controller also made it possible to combine several inputs and outputs, with optimized weight for each. This allows the use of different control strategies for different grades.

As a result of the iRoll hardness profile control with multivariable controller and optimal control strategy for each grade on PM2, winder broke fell by 80% compared with the original figures. This was a remarkable improvement compared with the earlier levels and in production line profitability.

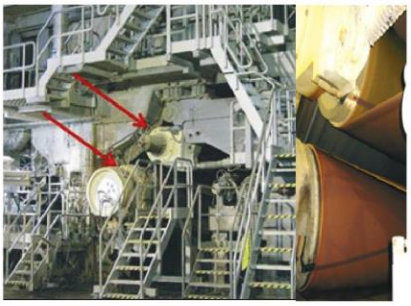
"iRoll" technology has allowed the mill to meet the requirements for high speed, top product quality, a wide product mix, and excellent material efficiency all at once, resulting in an excellent payback for the investment.

A case study of using "iRoll Portable"at a tissue machine, targeting to improved moisture profiles, runnability and betterpress nip profiles

Good press nip profiles are crucial for tissue machine press nips. Uneven nip loading results in lower moisture content in low loading areas. Typically the issues in nip loading occur on web edges. Press nip profile is determined as a combination of press roll cover crowning, yankee cylinder crowning, roll bending, yankee cylinder pressure and temperature effect and cooling effect of the moist felt and the sheet. Determining the actual nip profile by using traditional methods, such as nip impression film, electrical nip measurement blanket, or theoretical calculations have been proven to be often in-accurate.

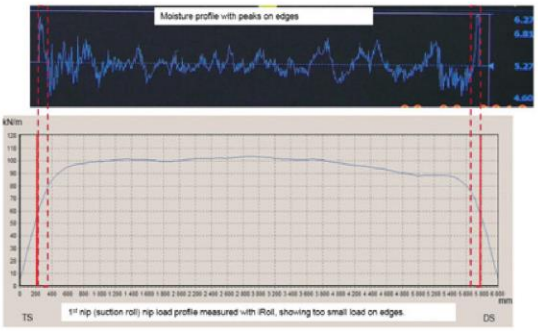
Customeroperating a tissue production line in Poland had been suffering wet sheet edges (about 20cm on both sides) due to un-even press nip profiles. Due the moisture peaks on edges the machine speed had had to be reduced or web width made narrower. These caused significant reduction in efficiency. Determining exactly right crowning for 1st and 2nd press nips had been found to be the key item. Nip films, electric nip measurement blankets and other kind of tools had been used in the past with no good success. Theoretical crowning calculations also gave poor results and non-optimal crowing recommendations.

"iRoll Portable" measurements were utilized to finally determine the optimal crowning. These measurements were done with rolls rotating (dynamic conditions), wet felts in the machine and yankee cylinder in normal heat and pressure. Thus the dynamic measurements represented the profiles as close as possible to normal running conditions. Picture 11 illustrates the measurement positions at the press section.

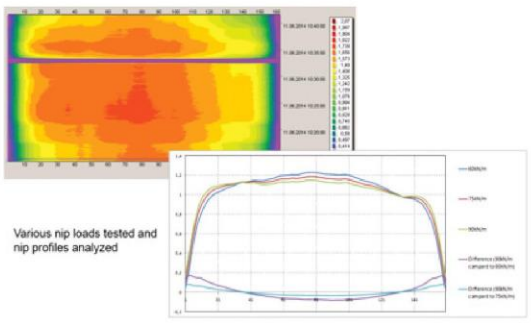


Picture 11. "iRoll Portable" systems installed on tissue machine press section 1st and 2nd nips to measure nip profiles in dynamic conditions.

Several nip loads and machine running parameters were tested during the measurement session. The "iRoll Portable" measurements revealed immediately how the nip profile looked: the center area was straight and did not need any correction. On the other hand, the edges had clearly too small loading. The loading dropped down sharply towards the edges. Picture 12 illustrates the moisture profile and corresponding suction press nip profile. Picture 13 illustrates examples of data gathered by dynamic nip profile measurements during loading tests.

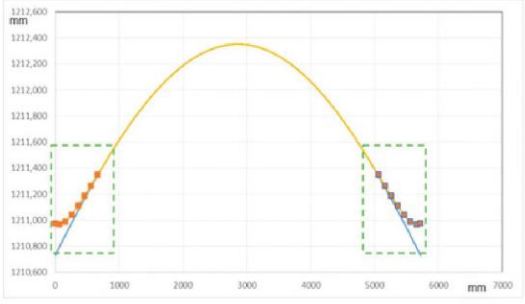


Picture 12: Moisture profile (upper graph) relation to press nip profile measured with "iRoll Portable". Wet peaks on edges caused by lower nip load and in-adequate dewatering on edge areas.



Picture 13: Examples of data gathered by using portable intelligent roll technology during the loading tests done with a press nip.

As a result of the measurements it was concluded that the standard single cosine curve crowning was not adequate to straighten the loading enough on edges. Thus a new optimized negative double crowning was recommended on the basis of measurement results.New crowning shape uses the modern way of adding a special crowning pattern to fix the loading issues on very edges. New grinding machines can do a freely chosen shapes along the roll CD-width. This incorporated with dynamic "iRoll Portable" measurements give a best possible result for nip loading. With the optimized crowning for both 1st and 2nd nip the nip loading can be straightened at the press improving the moisture profile and efficiency at the same time.Picture 14 illustrates the new optimized crowning curve. Result with improved crowning was that the dry content on edges increased by 3%, which reduced web breaks, gave potential for higher running speed and also decreased energy consumption in the yankee cylinder hood.



Picture 14: Optimized crowning curve determined on the basis of "iRoll Portable" measurements. The edge corrections are illustrated on both edges with a dotted

SUMMARY AND CONCLUSIONS

Intelligent roll technology – "iRoll" provides accurate online CD nip profile measurement and process control in press, sizer, coater, reel and winder applications, as well as sheet tension profile measurement throughout the papermaking line. Intelligent roll technology can be used to improve runnability and moisture profiles, reduce web breaks, optimizepress/size press nip profiles and obtain better parent roll hardness and tension profiles, all leading to optimal paper quality. This technology can be utilized on a covered roll as a permanent solution or as a temporary tool called "iRoll Portable". The latter provides the benefits of "iRoll" technology cost-efficiently by using temporarily installed sensors for dynamic nip profile measurement and process analysis purposes. Intelligent roll applications are available for all paper, board, tissue, pulp drying and finishing processes as well as to other industries such as printing and converting.

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