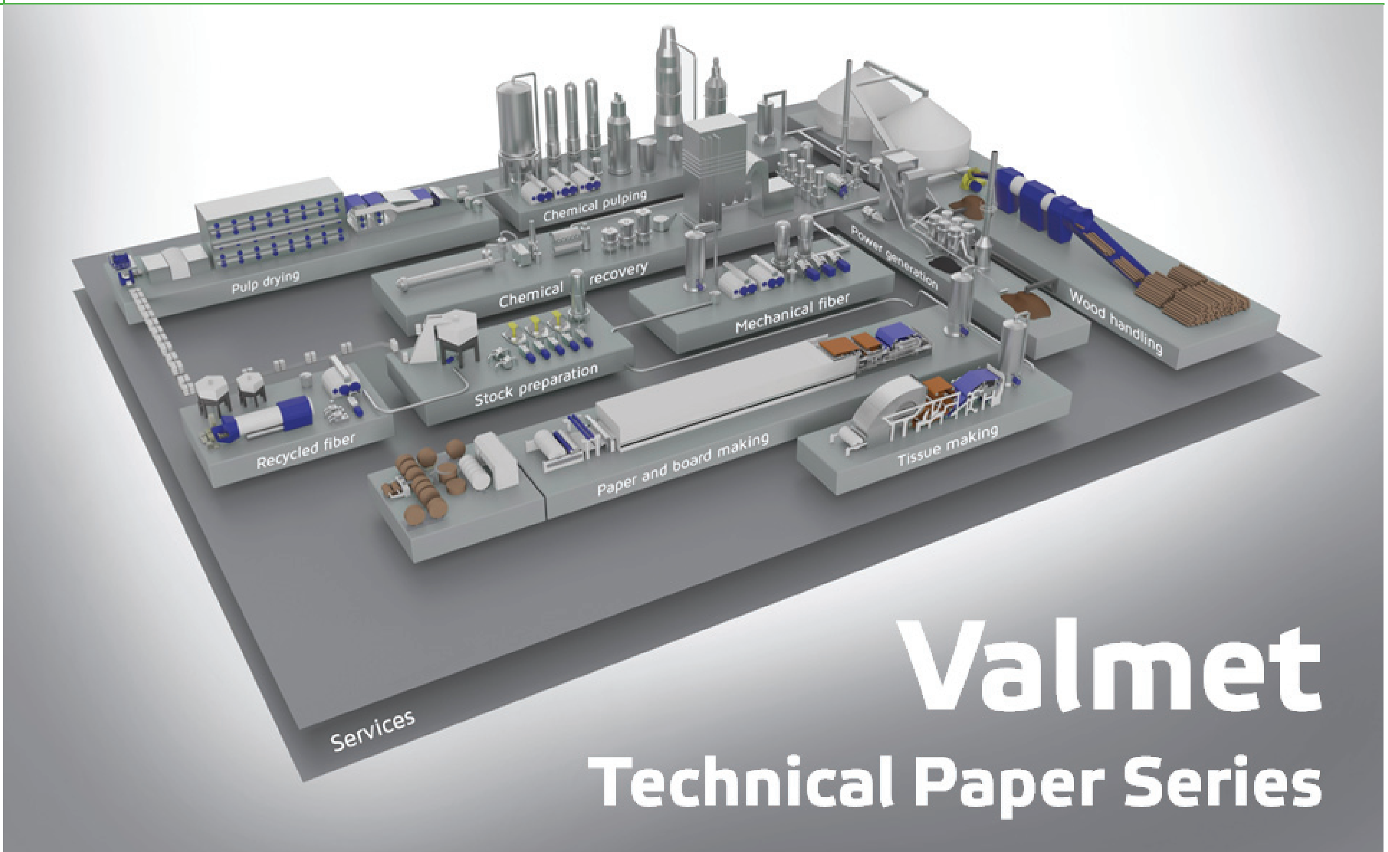


# Sizing & Coating Challenges/Solutions

## Executive Summary

There are many challenges when it comes to the processes of coating and sizing. Foremost among these are issues related to coat weight variation and sizer nip load profile.

Coat weight variations can be difficult to detect and their root causes hard to identify. It is important to solve them because they may cause unexplained problems elsewhere. With sizer nip load profile issues the cause-and-effect relationship is typically easier to detect, but many times difficult to solve. Root causes are identified and explained in this paper, as is a new novel technology for online load and profile measurement.

Consumables at the coater and sizer areas play an important role in maintaining product end quality and improving machine performance. Hard-coated blades deliver the best possible surface and longer lifetimes for high-quality paper and board grades. Insert rod beds for sizers bring savings and better runnability. Case studies are provided.

## Why do we need coating?

Why do we need coating? By coating the paper surface with coating color we want to influence certain characteristics related to how the paper can be further processed and what the end product looks like. The most important parameters affected by coating (**Figure 1**) are the visual properties such as printability, smoothness, gloss and brightness.

Printability improves significantly with coating as the ink does not penetrate the paper's fibers and spread out. Better smoothness is achieved when the coating fills in the valleys of the base sheet, and a smoother surface is easier to print on. The smoothness correlates with the gloss potential, which is ultimately a combination of coating method, coating color recipe and the calendaring concept and treatment.

| Mechanical properties | Visual properties | Runnability |
|---|---|---|
| Strength properties | Smoothness | Stiffness ratio |
| Stiffness | Printability | Profiles |
| Surface strength | Gloss | Dimensional stability |
| | Brightness | Curling tendency |
| | Surface cleanliness | Z-strength |
| | | Glue absorption |

***Figure 1. Key parameters affected by coating***

Other affected parameters include the mechanical properties and runnability related parameters where the profile related issues are the most common in everyday papermaking. We will concentrate on profile related issues in this paper.

## Coating methods and related challenges

The coating methods can be divided into to three basic groups (**Figure 2**) based on the application method: blade coaters, film transfer coaters and the most recent technology - curtain coaters. Blade coaters can be divided into categories based on the coating application method used.

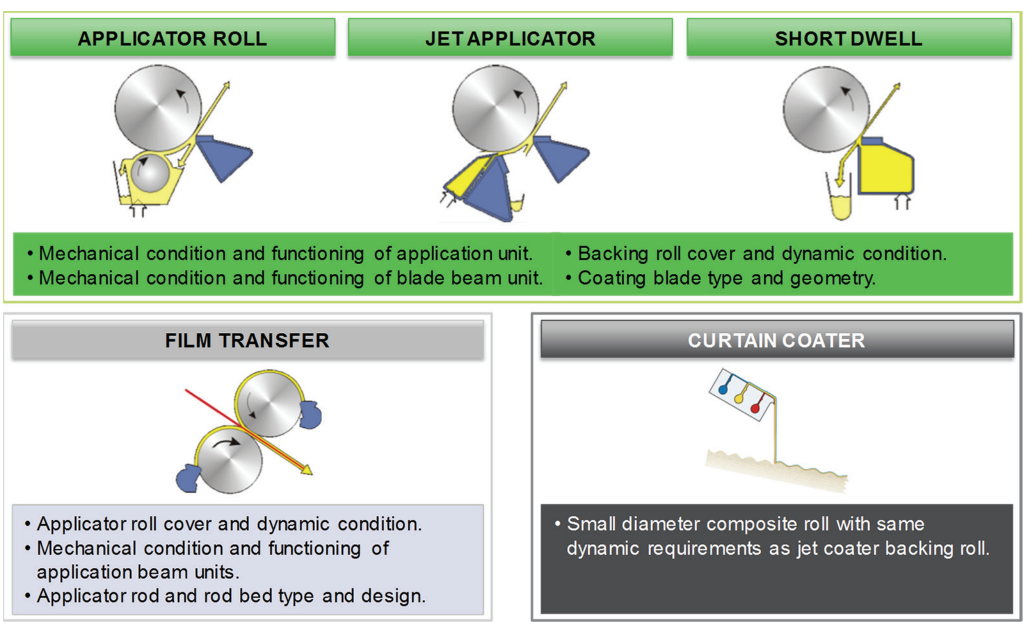


***Figure 2. Different coating station types and typical challenges***

 

Each coater group and its working principle differ in a fundamental way thus generating different types of challenges. In blade coating, both the application unit and the metering of the correct coat weight level are directly in contact with the paper surface, underlining the importance of their mechanical condition and functioning. The backing roll is on the other side of the paper and therefore not in direct contact with the coated surface. The dynamic condition and functioning of the backing roll are, however, still important.

The coating blade used for evening out and setting the coating layer once again directly affects the coated surface properties and uniformity and potentially directly affects the final quality. Thus the coating blade is one of the most important single consumable products on the machine line. In addition to the material composition issue, there are also several critical design parameters that directly affect the process.

With film transfer technology the coating layer is first evened out onto the roll surface and then transferred to the paper surface in the roll nip. This creates a critical requirement for the roll cover and dynamic functioning; an example of this being the nip load profile which we will review later. Of course, the mechanical functioning of the application beams is important, as well as the correct design of the applicator rods, that together with the roll cover properties and coating color parameters determine the coat weight level.

With the curtain coater there is no contacting element between the application/metering unit and the paper – thus providing the great runnability potential inherent in this coating application method. The basic coating function (e.g. with respect to profiles) is set during manufacture of the coating station. The small diameter composite roll under the web obeys strict dynamic behavior requirements as with other coating methods.

## Machine-direction (MD) coat weight variation

Machine-direction coat weight variation can be harmful in many ways. Oftentimes it is difficult to see with typical scanning methods and shows as a disturbance in the cross-direction (CD) coat weight profile.

Furthermore MD-variation can cause coating color waste as the coated quality is often optimized and adjusted in the worst case according to the poorest spot or, as in most cases, according to the average coat weight level. Similarly drying is optimized to the average coat weight level which might leave savings potential if the variation was reduced. Also the less coated areas may be over-dried leading to reduced strength properties.

The coat weight variations cause quality variations in the final product as many of the paper quality characteristics correlate with the coat weight level, such as gloss or smoothness of the paper. The higher variation may cause problems in achieving desired print density levels and therefore waste ink. Variations in strength and tension may increase the probability of web breaks.

As an example, **Table 1** presents some measured cases from three different machines. In these cases the machine-direction coat weight variation range was up to almost 7 g/m$^2$.

Valmet has undergone extensive R&D and performed dozens of analyses on different paper machines in order to identify, predict and eliminate possible coat weight variations.

| | Total Coat Weight | MD Coat Weight Variation | MC Coat Weight Min / Max | Speed (m/min) |
|---|---|---|---|---|
| A | 20 g/m$^2$ | 6.6 g/m$^2$ | 17-23 g/m$^2$ | 1400 |
| B | 20 g/m$^2$ | 4.3 g/m$^2$ | 18-22 g/m$^2$ | 1300 |
| C | 20 g/m$^2$ | 2.5 g/m$^2$ | 19-21 g/m$^2$ | 1300 |

*Table 1. Machine-direction coat weight variation from three machines*

## Causes of MD coat weight variation

What are the reasons for machine-direction coat weight variations?

Blade coating (**Figure 3**) is a highly sensitive process. The paper passes the blade tip in just a fraction of a second. A thin coating layer must be formed on the paper surface during this time.

The typical reason for coat weight variations is vibration in the coater area. The main causes are often either the runout of the backing roll, the blade beam vibration or the roll cover grinding.

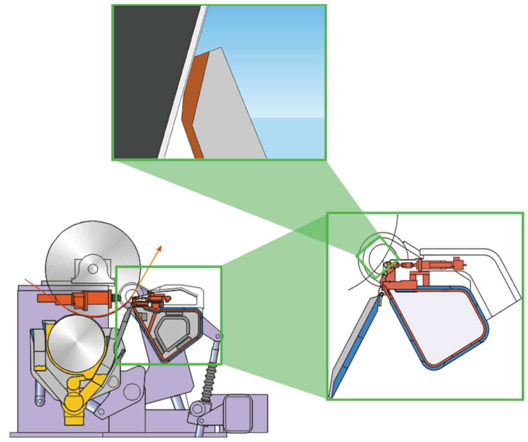

***Figure 3. Typical blade coater configuration***

### Runout of the backing roll

Runout of the backing roll (**Figure 4**) can be defined as the sum of center point movement (due to roll bending or roll imbalance) and the out-of-roundness (caused by material non-homogeneity in the roll shell). It is a roll structure related phenomenon.

Runout of the backing roll causes deviation in the distance between the blade and the paper which can be seen as MD coat weight variation. On relatively old and slow machines 100 µm can be considered as a limit for total runout. With faster and wider machines, the tolerance for runout is only at a 30-50 µm level.

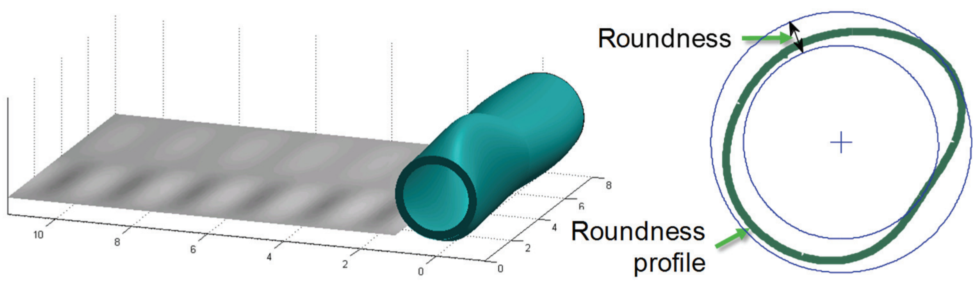


***Figure 4. Backing roll runout equals center point movement plus out-of-roundness.***

How much coat weight variation a certain runout causes depends on process conditions and coating color recipes. However, runout and coat weight variation have a linear correlation. Therefore, as an example, if it is possible to reduce the runout by 40 %, then the coat weight variation should also decrease by 40%.

### Blade beam vibration

Vibration of the blade beam (**Figure 5**) is another cause for periodic changes in the distance between the blade and the paper surface. These vibrations can be caused by the backing roll or other rolls in the neighborhood of the coating station. The most harmful vibrations force the beam to vibrate toward the backing roll.

Again, there is not a certain vibration level which must not be exceeded. Sometimes there may be vibrations of 1.5 mm/s without significant coat weight variation and

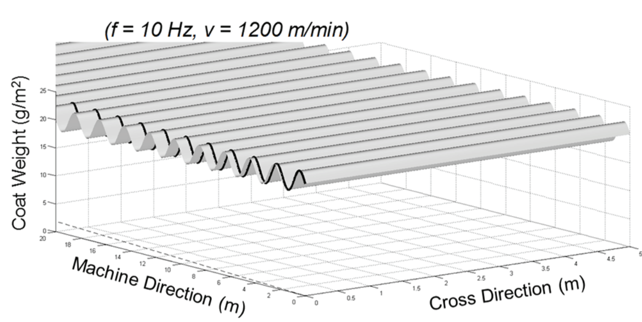


***Figure 5. Blade beam vibration changes the distance between the blade and paper surface.***

sometimes 0.8 mm/s vibrations are too much! Regardless, the tolerable vibration at the blade beam is much less than the limits set by vibration standards.

It is important to remember that blade beam vibration can occur at any speed level.

In **Figure 6** we see an example of how the blade beam vibration causing machine-direction variation in the coat weight levels actually affects the cross-direction coat weight profile measurement because the scanner is traversing across the web. It is then not precisely able to separate the machine-direction and cross-direction variations from each other.

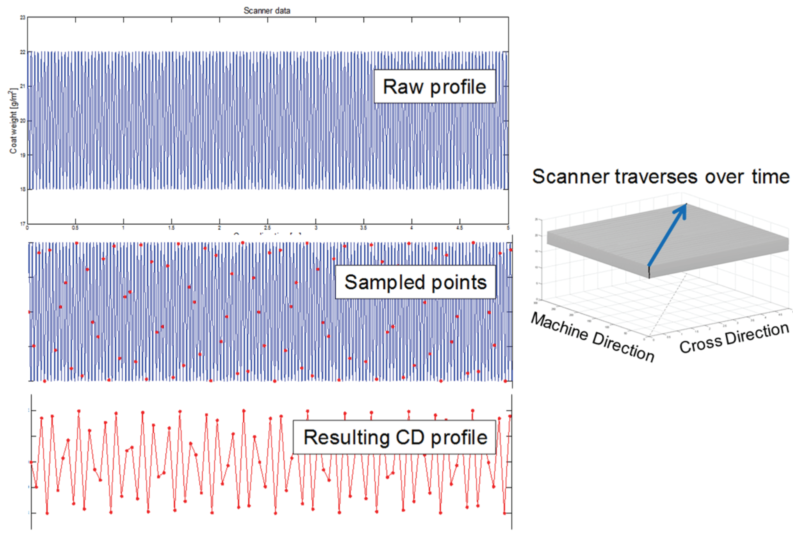


***Figure 6. Blade beam vibration causes MD-variation and affects the CD coat weight profile reported by scanner.***

The blue graph is the actual raw profile the scanner measures and the red dots are the sampled data, i.e. the data that is actually collected during the scanner traverse. So even though in this simplified example there is actually only MD-variation in the paper, the CD profile looks peaky.

## Roll cover grinding

**Figure 7** shows a case example of how MD-variation resulting from roll cover regrinding disturbs the CD profile measurement. The upper graph is sampled data the traversing on-line scanner has measured. The machine-direction variation appears to be cross-direction variation.

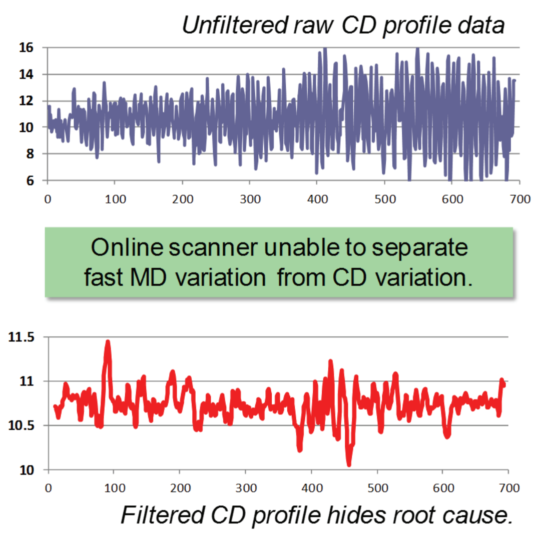


***Figure 7. Case example of cover regrinding producing MD-variation that disturbs CD profile measurement***

In practice the measurement raw data is of course then filtered as shown in the figure's lower graph, but while doing that some relevant data is always lost. (Note the different scaling in the pictures.)

The real root cause for the CD-variation in the picture is difficult to find and as a result, the CD actuators / profilers or coater blades are often blamed for the CD-variation.

## Analysis of MD-variation is required

Here is where Valmet can greatly assist the modern papermaker. As we have seen, the coat weight MD-variation is difficult to detect in practical everyday papermaking with the equipment in use. An analysis is often needed to detect the MD-variation level and causes. The Valmet approach involves verification by taking paper samples and analyzing the dynamic behavior of the blade station.

The possible runout of the backing rolls can be detected with a runout analysis that can be done on-site with a portable device that Valmet has developed for this purpose (**Figure 8**). Sophisticated mathematical analyses are often needed. The MD-variation analysis is typically a combination of these actions.

Finally and most importantly, action recommendations to resolve the coat weight variation are prioritized based on cost efficiency and effectiveness.

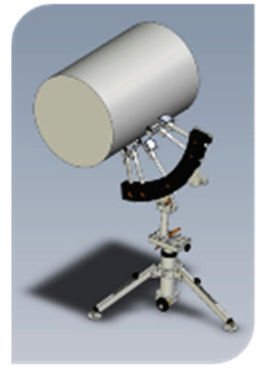

***Figure 8. Backing roll runout analysis onsite requires a portable device and sophisticated analysis.***

## Eliminating MD coat weight variation

When we know the source of the MD coat weight variation it is possible to remove it.

***Figure 9. Grinding of the backing roll eliminates runout.***

The easiest way to eliminate runout is via three dimensional grinding (**Figure 9**) where the dynamic behavior of the backing roll is optimized for a desired operating speed level. Also multiple plain balancings of the roll and modernization of the backing roll are sometimes needed, for example if the desired operating speed range needed is too large to be solved with 3D-grinding. The ultimate way is to replace the old backing roll with a new high-precision backing roll.

The easiest way to eliminate blade beam vibration is to avoid the critical speed areas where it occurs. Many times this is not an option and the full capacity of the machinery needs to be utilized and other actions are needed.

Depending on the original source for the vibration the action needed can vary: it may require balancing the rolls exciting the vibration outside the coater head or replacing them with new rolls. A dynamic dampener at the blade beam is a possibility especially when there are so many vibrating rolls that it is economically not possible to replace all of them.

With three dimensional grinding the dynamic behavior of the roll shell is taken into account proactively when grinding the roll cover (**Figure 10**). In simplified terms, a "negative" of the roll's running speed profile is ground so that at running speed the roll remains round. It is typically applicable for relatively narrow speed ranges only.

A new high-precision backing roll is designed to run through the speed range without any harmful deformations. As Valmet has been building fast coaters for years, we have developed suitable technology to handle the issue.

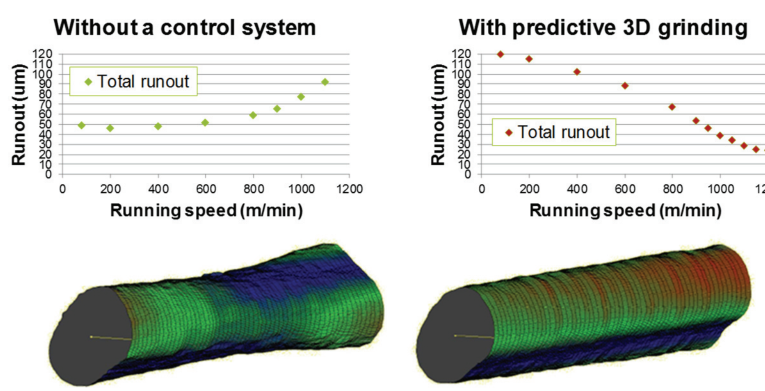


***Figure 10. Predictive 3D grinding reduces runout components in selected speed range***

**Figure 11** shows a case example from one mill, where runout of their conventional backing roll was a problem. As seen in the figure, with the new high-precision backing roll the dynamic runout remained at design level throughout the speed range.

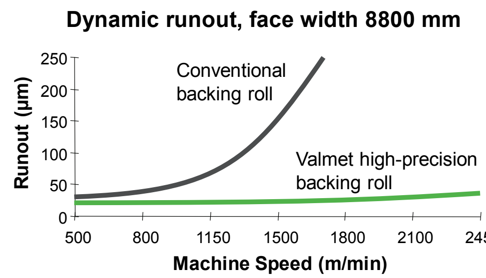


***Figure 11. Valmet high-precision backing roll reduces runout at higher speeds.***

## Sizer nip load profiles

Sizer coating technology is based on two running rolls forming a nip where the coating color or surface size is transferred to the paper surface. The nip load profile is very important as an uneven load profile can cause many problems, such as:

- Runnability issues (web fluttering and wrinkling)
- Profile issues
- Uneven wear of the covers
- Web breaks during startups (if the nip is closing unevenly)

Accurately measuring a nip load profile has traditionally been a challenge. Valmet has developed a technology to do this - called **iRoll**.

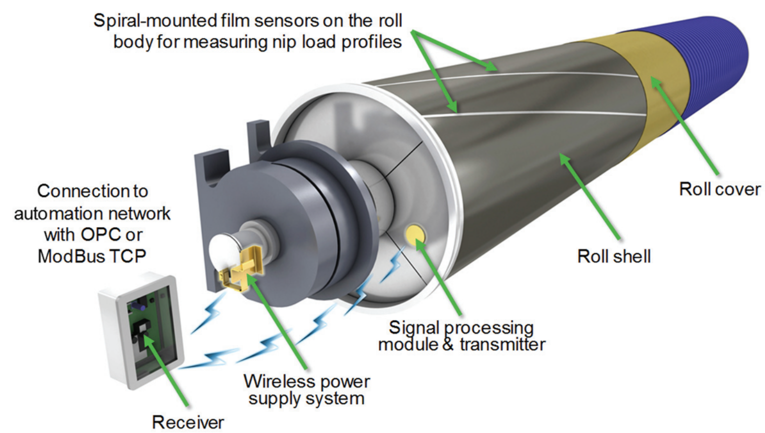


***Figure 12. iRoll technology uses spiral sensors under the roll cover that measure nip load as they pass through the nip.***

The basic idea (**Figure 12**) is that a sensor is mounted on the roll body under the cover and the sensor measures the pressures applied by the nip, web or fabric. As the sensor is mounted in a spiral fashion, the profile can be measured. The data is then sent wirelessly with a signal transmitter to a receiver that gathers and processes all the data.

The iRoll product can be applied to various places in a machine line (**Figure 13**) to measure tension profiles and nip load profiles. The product family has products from wet-end to the winder, these include:

- **Valmet iRoll Reel** measures reel nip load profiles and also online roll .
- **Valmet iRoll Sizer** measures the nip load profile and applicator rod profile of a film sizer press.
- **Valmet iRoll Winder** measures end-product runnability and quality.
- **Valmet iRoll Tension** measures web and fabric tension profiles online.
- **Valmet iRoll Portable** for runnability analysis services.

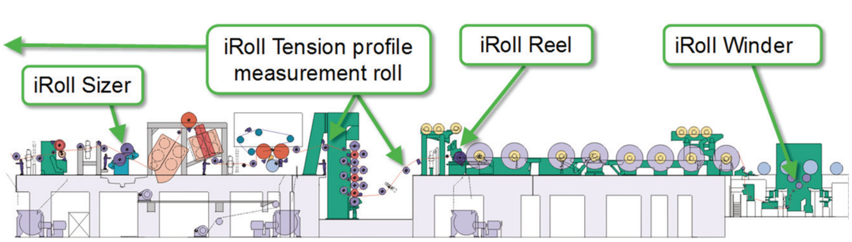


***Figure 13. The iRoll product may be used in various places to measure tension and nip load.***

With iRoll comes the possibility for adding online control of roll profile, web tension profile and nips.

A special product in this family is Valmet iRoll Portable which is used for runnability analysis services. In a Valmet iRoll Portable analysis the sensors are mounted on the top of the cover for short term analysis use and the same analysis results can be obtained as in a permanent installation. No changes in the machine are needed and it doesn't adversely affect normal production. Valmet iRoll Portable has been used to conduct over 100 analyses so far.

## iRoll for sizers – Valmet iRoll Sizer

Valmet has recently broadened the use of iRoll technology to include sizers. With the iRoll sensors mounted under the cover as in the roll in **Figure 12**, the same iRoll benefits can be obtained as elsewhere on the machine. This means not just the measurement of nip load and nip load profile, but also the applicator rod load and load profiles can be measured.

At the moment Valmet iRoll Sizer is available for polyurethane covers.

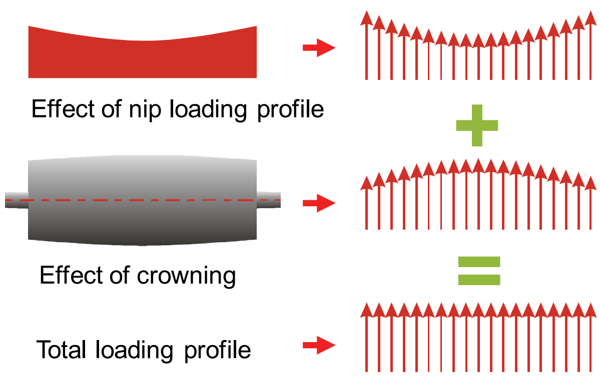


***Figure 14. Traditional optimization of the nip load profile***

## Optimization of the nip load profile

Regarding how the optimization of the nip load profile has traditionally been made (**Figure 14**), the effect of the roll weights and nip loading profiles is first calculated. After this a suitable crowning of the rolls is designed. As a result a certain total loading profile is achieved.

In real life the total loading profile is not as straight as it is in this simplified picture shown in **Figure 14.** The problem is that the actual exact dynamic nip load profile is not known. The static nip load profile can be measured with nip paper measurement, but this does not necessarily provide the actual profile in dynamic conditions at running speed. Also the necessary corrective actions regarding crowning have been based on these static measurements and/or experience-based knowledge based on the runnability of the sizer (i.e. trial and error).

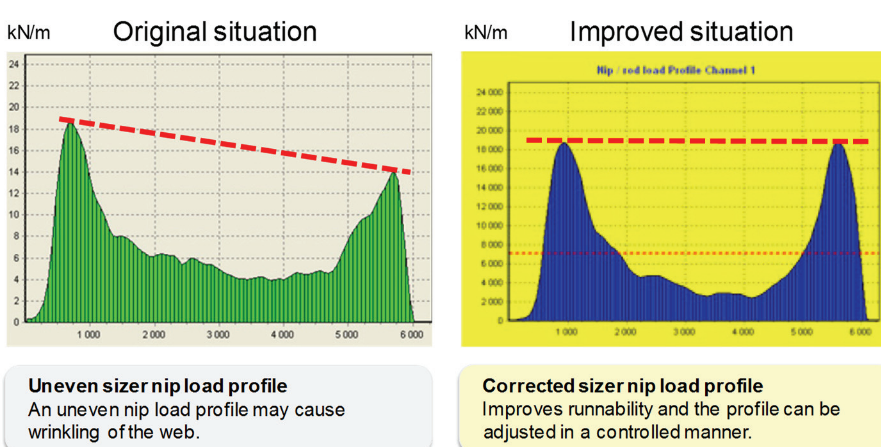


***Figure 15. Case example of coated woodfree machine using Valmet iRoll Sizer to measure nip loads online***

Using iRoll at the sizer measures the nip load profile in dynamic conditions **at running speed**. For example uneven loading can be easily detected and corrected with on-line feedback of corrective measures. In the example seen in **Figure 15** the uneven nip load shown on the left has been corrected in the righthand picture and runnability subsequently improved.

It is important to remember that the nip load profile needs to be optimal - not straight!

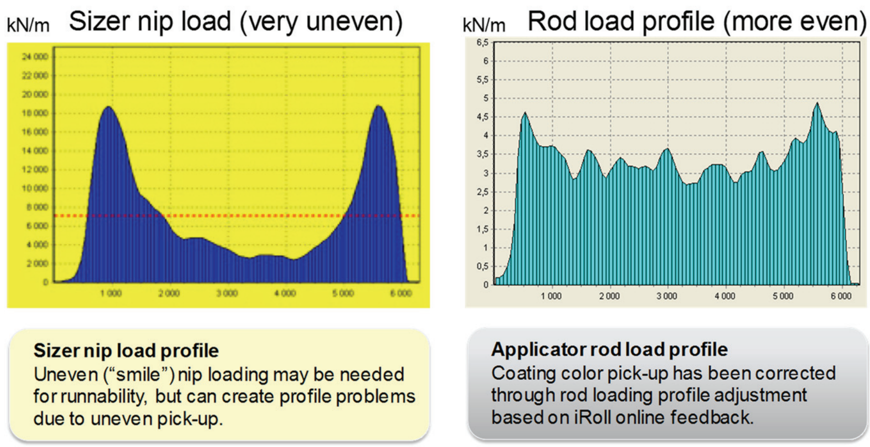


*Figure 16. Case example of coated woodfree machine using iRoll at the sizer to measure applicator rod load profile online, and take corrective action*

### Online measurement of the rod load profile

The uneven nip load profile required for good runnability of the sizer (**Figure 16**, left graph) causes uneven size or coating pick-up in the nip. iRoll also measures the applicator load profile (**Figure 16**, right graph) which helps especially if the profiler spindles are controlled manually.

The coat weight profiles can be corrected in a normal way with profiler adjustments as seen in the righthand graph of **Figure 16**, resulting in a good and even coat weight profile.

## Reducing costs with sizer and coater consumables

Given its role as a leading supplier and manufacturer of productive papermaking lines, Valmet's know-how covers the entire papermaking process. Therefore Valmet is able to supply high-quality innovative consumables for any coater or sizer in any part of the world.

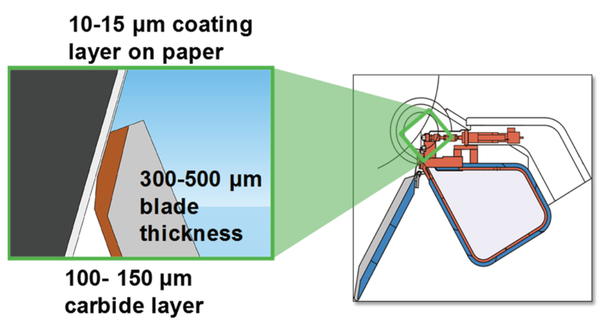


*Figure 17. Coater blades must leave a uniform layer at*

Long-term experience and know-how, together with OEM parts, provide a good starting point for paper and board mill success. Hard-coated blades deliver the best possible surface and longer lifetimes for high-quality paper and board grades. Insert rod beds for sizers bring savings and better runnability.

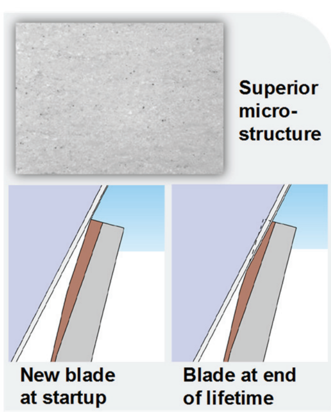


*Figure 18. Nano-scale powder provides superlative wear resistance.*

Coater blades play an important role in the paper or board making process, leaving a uniform layer of coating color on the paper/board surface for the desired coat weight (**Figure 17**). They have a huge effect on efficiency (both materials and time) and a major impact on final product quality.

### Valmet Coater Blade nC

Drawing on the most modern technology available, Valmet has introduced a very fine and dense tungsten carbide blade to the market. Its homogenous material ensures excellent coating quality also when worn. The nano-scale powder (**Figure 18**), sprayed with the latest technology, provides:

- Superior microstructure
- Improved wear resistance
- Low (compressive) stresses, resulting in a low tendency for micro-scale cracking

Development of the carbide blades has been rapid since Valmet acquired Pacific International in 2009.

## Case study: Specialty paper, woodfree, Europe

In this example, the target was to increase blade lifetime with no deterioration in printing quality. **Valmet Coater Blade nC** (previously known as PermaCote nC blade) was tested for the top coat. The equipment was an online Jagenberg Combi-Blade, running 4-11 g/m$^2$ coat weight at 400 m/min.

The new nanocarbide blade was an outstanding success. The startup was very good, with quite uniform profiles. Paper quality remained at a good level during testing, with no micro-scale streaks. Roughness and print quality were at target levels. The blade lifetime was 44 hours (including one sheet break).

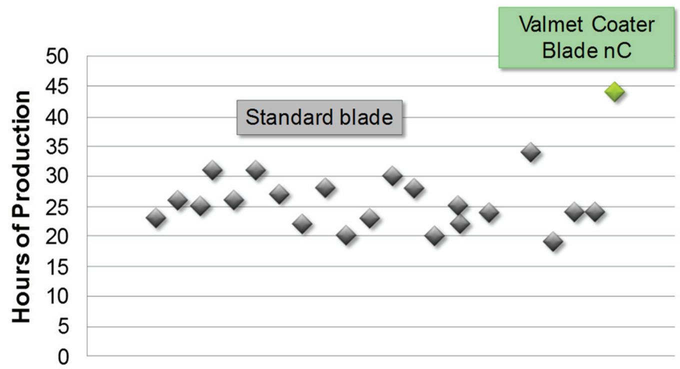


*Figure 19. Valmet Coater Blade nC nanocarbide blade yielded a 20% longer lifetime.*

Valmet's nanocarbide blade yielded a nearly 20% longer lifetime (**Figure 19**) than the best competing blade. End-product quality did not suffer even at the end of the blade's lifetime.

## Case study: Coated woodfree, Asia

At this mill the targets were to increase blade lifetime while simultaneously improving print quality. Valmet Coater Blade nC was tested for the top coat. The off-machine coater was an OptiCoat Jet, with a coat weight of 9-12 g/m$^2$ running at 1300 m/min. At the time of the test the existing blade had an average life of less than 20 hours, with an average PPS of 0.87-0.91.

Results were again excellent. With Valmet Coater Blade nC the blade lifetime on the 1$^{st}$ top coater was 26 hours and on the 2$^{nd}$ top coater was 22 hours. The PPS average on the 1$^{st}$ top coater was 0.83 and the 2$^{nd}$ top coater was 0.82.

This represents a typical test result from a high-speed off-coater - in this case print quality played as important a role as blade lifetime. Valmet's nanocarbide blade achieved both a longer lifetime and better printed paper quality than the competing blade.

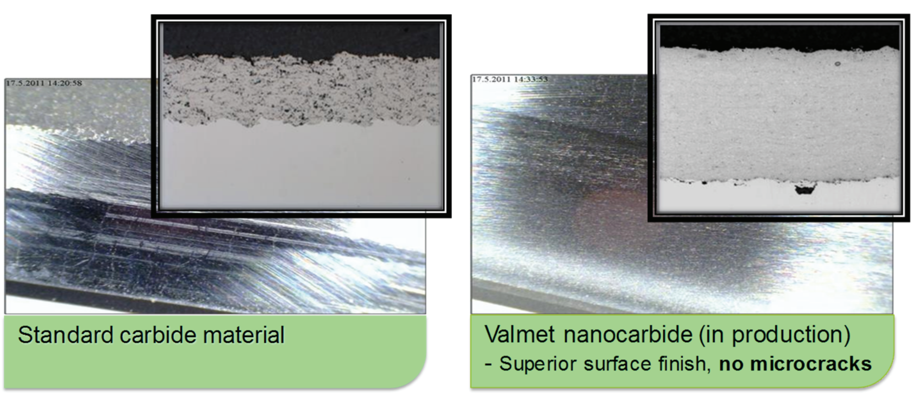


*Figure 20. Optical microscope images, competitor carbide vs. Valmet nanocarbide material*

## High-quality carbide saves money

Increasing the potential lifetime of coater blades will save mills money, both in consumables and paper/board broke. As shown in **Table 2**, on a WFC machine (130 gsm) with two coating heads running at 1400 m/min the savings were **€15,100/month.**

| | Standard Carbide | New Nano-carbide |
|---|---|---|
| *(Average blade lifetime improved **20%** with nanocarbide)* | | |
| Estimated blade cost / month | €10,500 | €8,400 |
| Monthly saleable paper lost at blade changes, speed ramps (€400/tonne, 5 km broke/change) | €13,000 | |
| Total cost / month | €23,500 | €8,400 |
| **Monthly savings with Nano-carbide** | **€15,100** | |

***Table 2. Monthly cost savings changing from carbide to nanocarbide (WFC machine, 130 gsm, with two coating heads, 1400 m/min). Values are based on the average nanocarbide blade lifetime increasing 20% when compared with standard carbide blade lifetime.***

## New cost-effective rod bed solution for sizers

The general targets for surface sizing and film coating consumables are clearly understood. Film quality and quantity targets must be met. When this is achieved simultaneously with good runnability and a long lifetime for consumables – the result is better cost-effectiveness. Now let's break down the targets one-by-one.

### Film quality

Good paper and board quality can only be achieved when there are no streaks or discontinuities in the film. Additionally there must be good coat weight and moisture profiles. It is important to minimize skipping, splashing and misting as this will lead to fewer breaks, longer regrinding intervals, better cleanliness and overall improved runnability.

### Film quantity

Coat weight targets must be achieved in film coating with good profiles. Size pickup targets in surface sizing must be met: if too little, dust/lint problems result; if too much, there is a loss of energy in drying and lower machine speeds result.

### Long lifetime - wear resistance

Fewer changes of consumables are desired as this leads to less work and better runnability. Longer consumable lifetimes also produce better cost-effectiveness due to the smaller amount of consumables used.

### Two-part rod bed

The latest innovation in sizer consumables is a two-part rod bed (**Figure 21**). The frame is made of a composite material while a smaller insert made of polyethylene serves as the wearing part.

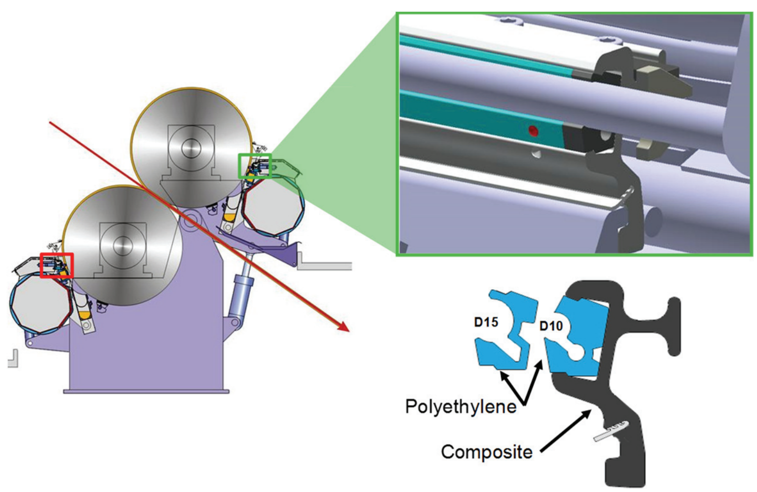


***Figure 21. New two-part rod bed uses composite frame and smaller polyethylene insert as wearing part.***

This novel solution offers several advantages over the conventional one-piece rod bed design. The results are less waste and better cost-effectiveness. The two-part rod bed is applicable for both smooth and grooved rods. (**Figure 21** shows a D10 rod bed in the two part holder.)

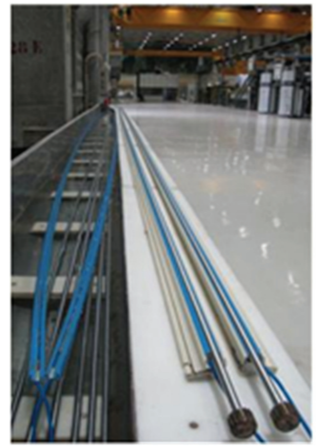

***Figure 22. Rigid composite rod bed frame makes it easy to handle and install.***

## Rigid composite frame

Thanks to the rigidity of the frame, the composite rod bed is easy to handle and install (**Figure 22**). No lifting support is needed.

A flexible (silicone) sealing lip keeps the sizer locking device (to which the frame is clamped) from getting dirty and stuck. The sealing lip can be removed and replaced when needed.

Experience has shown that a composite frame improves surface sizing moisture profiles in the edge areas by supporting the rod better.

## HDPE rod bed material in the insert

The high density polyethylene material in the insert has low friction properties and facilitates easy installation. The new rod bed system can easily handle possible changes in rod diameter (Ø10-15 or Ø18-20-25).

Low-friction material in the insert makes rod rotation stable and easy. This represents a very cost-effective solution. (NOTE: Composite rod beds should be used with Valmet rods to ensure proper fit.)

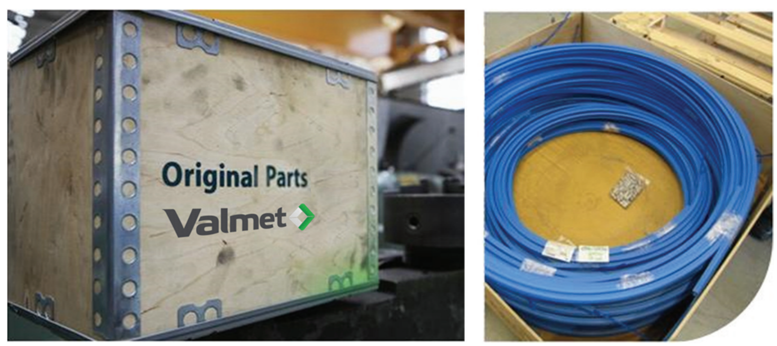


***Figure 23. Polyethylene rod bed inserts can be coiled for shipping.***

## Eco-efficient as well

The frame has a long service life; it can really only be destroyed by a very violent web break.

The lifetime of the insert is similar to that of conventional rod beds. This improves cost-effectiveness and reduces waste. Compared to conventional rod bed solutions, consumables cost decrease significantly.

***Figure 24. Size press using new two-part rod bed insert improved cost-effectiveness.***

If required, the insert can be coiled up for transportation (**Figure 23**), which saves shipping and packaging costs.

## Case study: Uncoated woodfree paper, Europe

This mill needed to raise size press productivity while minimizing related costs. The machine produced uncoated woodfree paper (UWF) in the 60-100 g/m$^2$ range at 1150 m/min speed.

The solution was to use Valmet's new composite insert rod bed (**Figure 24**). The insert rod bed solution has been providing better cost-effectiveness since 2009. Compared to conventional rod beds, consumables costs have decreased significantly.

## Case study: Finland mill

**Figure 25** shows the results of another case study of a mill in Finland that has been running the new composite insert rod bed. With conventional rod beds, annual costs exceeded €100,000. After taking the new insert rod beds into use, costs have dropped to below €20,000, representing an 80% annual cost savings.

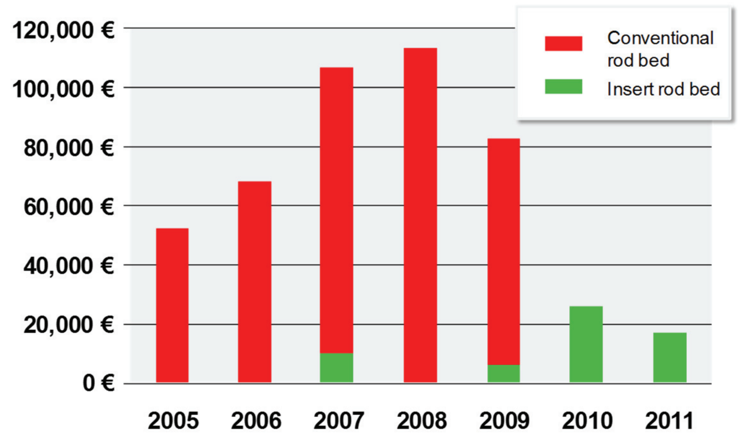


***Figure 25. Annual rod bed costs at Finnish mill, New two-part rod bed insert resulted in significant savings.***

## Summary

As has been demonstrated, sizing and coating present special challenges. Coat weight variations can be difficult to detect and their root causes difficult to identify. It is important to solve these issues because they may cause unexplained problems elsewhere. With sizer nip load profile issues the cause-and-effect relationship is typically easier to detect, but many times difficult to solve.

Paying attention to backing roll runout, blade beam vibration and cover grinding can reduce coat weight variation. Implementing the new iRoll online measurement technology can have a major positive effect on nip load and rod load profiles. Proper choice of coater blade and rod bed can significantly reduce annual operating costs.

Valmet has effective tools and the experience necessary to help mills solve coat weight variation, profile and cost-related problems. As the leading supplier and manufacturer of the most productive papermaking lines, Valmet is uniquely qualified to provide expert assistance in this area.

*This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers. Not all products and services are available in all geographic markets.*

*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.*