Evolution of OptiConcept – Entering a New Era

Executive Summary

The OptiConcept launch in 1999 introduced groundbreaking technology in machine efficiency, availability and industrial design – all factors that have had a great impact on paper making and machine engineering since then.

Research and development at Valmet is a continuous and target-oriented process, combining innovations with results and experiences from production machines into new and more powerful and environmentally sound technologies. Acquisitions have yielded synergy benefits in this work. The paper making line of today is quite different from the one introduced ten years ago. Noteworthy is that all unit processes are also available for rebuilds and medium-capacity machines.

This paper provides an insight into the new unit processes of the line for woodfree uncoated paper. The features presented include the new headbox hydraulics and high-resolution dilution system for the creation of the most uniform slice jet. The shoe and blade gap former – with a shoe as the first initial dewatering element instead of a large forming roll – gives controllability and adjustability. Closed draw pressing combined with impingement drying maximizes speed and efficiency and optimizes bulk/roughness with lower press loads, which is especially important for all WFU producers.
Introduction

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This paper provides an insight into the new unit processes of a line for uncoated woodfree paper. The features presented include the new headbox hydraulics and high-resolution dilution system for the creation of the highly uniform slice jet. The shoe and blade gap former – with a shoe as the first initial dewatering element instead of a large forming roll – offers controllability and adjustability.

The new design has been particularly well applied in the press section through elimination of cantilevering beams and introduction of fabric installation units. The user-friendly design translates into improved availability of the entire wet end. Full-width threading through the dryer section enhances efficiency.

Closed draw pressing combined with impingement drying maximizes speed and efficiency and optimizes bulk/smoothness with lower press loads, which is especially important for all producers of woodfree uncoated paper. A single-tier configuration of the entire dryer section is made possible by impingement drying for curl control in the after-dryer section. Metal belt calendering introduces a way to achieve new high bulk grades.

The new reeling process enables one-level reeling on solid rails – no elevations are needed. The lower and robust design yields benefits in crane lifting height and building construction, as well as in building high quality parent rolls that maximize the material efficiency. The elimination of hydraulics reduces the amount of space required, and makes the machine, as well as the process, operator and maintenance friendly.

All these new features focus on improving paper quality and achieving higher efficiency, at a lower investment cost.

Quality requirements of woodfree uncoated paper

Good runnability in printing requires good paper profiles, dimensional stability and elimination of curl. With offset grades print quality is very important, and it is related mainly to formation, smoothness, density and optical properties. The raw material composition affects optical properties such as whiteness and opacity. Formation in turn is influenced by the headbox and the forming concept.

The caliper and smoothness levels remain fixed while bulk improvement through certain smoothness levels is often sought.

Figure 1. Quality requirements of uncoated woodfree paper
In principle, better bulk can be used to increase paper machine profitability by saving raw material costs or by getting a better price for the end product.

**Concept to promote raw material and energy savings**

Furnish fiber is a valuable raw material that all mills strive to save by replacing it with less expensive fillers. A state-of-the-art uncoated fine paper production line in Asia has been able to increase the paper filler content close to 30% from the grade-typical level of about 20%. This totals considerable savings of about 40 €/t.

This is made possible by the bulk and shoe-length optimized pressing process, combined with high press dry content and excellent pre-dryer section runnability. Production machines and pilot trials indicate that the 1st press of a double-nip shoe press section affects bulk more than the dry content.

This information is being used in the design of press configurations that are more profitable for papermakers and pay more attention to raw material or energy savings. These findings can also be used to control machine runnability by improving the dry content, wet strength, or density of the paper according to grade-specific requirements. The shoe press technique itself creates tools for reaching higher production speed, and the knowledge of the impact of the shoe design provides additional value.

The higher filler content brings significant energy savings in itself: a 10% increase in the filler content translates into 1% higher press dry content. And as the rule goes, the drying energy load reduces by 4% for each additional press dry content percentage-unit.

![Modern production line for uncoated woodfree paper, production speed 1,800 m/min](Image)

Our new machine solution was created ten years ago. Since its launch, it has had a great impact on papermaking thanks to its innovative features. During the years, the concept has strongly evolved and we are now able to reach the production speed of 1,800 m/min (5900 fpm) for uncoated woodfree grades.

**From flow structure to paper uniformity**

The new technology has made it possible to accurately measure the headbox flow structure and understand how it affects the slice jet quality and paper properties. The results have given tools to optimize the turbulence generator and slice channel area.

During the development process of the new headbox concept, MHI and Beloit technology of Concept IV and MJ flow design were extensively studied. According to the data good slice jet smoothness turned out to be the most important characteristic of Concept IV.
The new headbox creates a slice jet flow that is ideal for the shoe and blade gap formers as shown in Figure 3. The smooth jet and minimized free jet geometry with optimized turbulence level improves paper quality (formation, orientation, white spots and planar deviation targets).

The compact headbox design enables the new turbulence generator dilution system with 30 mm actuator spacing. According to simulations this means 30 - 60 % better basis weight profiles.

There are more than fifty new headbox references, and the new headbox design will soon be in operation with the shoe and blade former.

**Improved initial dewatering with new stationary shoe**

Roll-and-blade forming has been the main gap forming process during the last twenty years of gap forming. The forming roll has been a key element in this type of formers. In shoe-and-blade gap forming the stationary shoe with an intelligent shoe construction replaces the forming roll as shown in Figure 4.

The shoe-and-blade design combines the good features of both the roll-and-blade, and blade formers. A shoe located as the first initial dewatering element behaves much like an open forming roll but the stationary shoe offers several benefits in initial dewatering.

The shoe performs vacuum-assisted non-pulsating initial dewatering. Studies have proven that the original philosophy of roll-and-blade technology, where gentle initial dewatering is combined with efficient blade dewatering, provides good retention with outstanding paper quality.

Both gap rolls have closed surfaces, which do not generate any misting. This provides excellent cleanliness of the shoe and headbox slice area thus having a significant positive impact on runnability and overall efficiency.

The controllability and adjustability of initial dewatering improves as it is possible to control the process better with the help of vacuum and the long shoe. Typically, the total dewatering in this area takes around 70 % of headbox flow but with the shoe we are able to change its range by 45 - 65 % with vacuum.

The length, open area and radius of the shoe are easy to customize in terms of capacity. The sheet is symmetric as dewatering is better controlled between the loadable blade suction area and the shoe.
The production machine results show good formation potential (Figure 5). Also, the headbox flow rates are lower than with the conventional technology. The lower headbox flow rates provide excellent porosity and internal strength. The tensile ratio control is easy because the shoe does not create as high a gap pressure as the forming roll.

The first shoe-and-blade gap former start-up in 2003 was a newsprint machine rebuild. An uncoated woodfree application followed in 2006. Several rebuilds and new line applications have started since then. The shoe-and-blade technology has been developed for hybrid formers as well, and it has produced excellent results on production machines.

**New press section design**

The R&D focus in the press section has been optimization of the shoe design, the transfer between the 1st and 2nd press nips and the new user-friendly design.

The correlation of the nip dwell time or the shoe length with paper bulk is interesting. Figure 6 shows the difference in bulk as the 1st press shoe is changed. There is a clear trend indicating that a shorter shoe in the 1st shoe press enables higher bulk. This can be seen in uncalendered base paper (see the starting points in the curves, top right corner).

It seems that the 1st press determines how the structure of the paper is compressed in subsequent pressing nips or in calendering. Approximately the same difference in bulk (at the same roughness level) that was found in base paper can be found in the calendered results.

The nip geometries have also been optimized, in practice this is done through a larger wrap with the 1st felt suction roll and higher draw levels between the 1st and 2nd press nips.

The biggest change is that the new press section has no cantilevering, which frees up space both on the drive side and inside of the machine, significantly improving the usability. It is worth noticing that these features can be applied to the entire wet end.
As shown in Figure 7, maintenance work and cleaning become significantly easier.

One of the main innovations is the felt installation unit, which enables fabric replacement without cantilevering. This solution facilitates installation and availability compared to earlier concepts.

**Impingement drying**

Impingement drying has been reviewed on several occasions during the last years. The concept has evolved during that period of time, and today it is a valid and highly effective solution on several production machines. The most impressive of these is the new twin impingement dryer section including a horizontal and a vertical run. Two new impingement dryers of this type will start in the near future (Figure 8).

The horizontal run increases the temperature of the sheet and the vertical continues the drying process. The dry content increase is around 6% and the sheet temperature around 30 °C (86 °F) higher before arriving at the first dryer cylinder compared to the conventional technology. This improves runnability at the first dryer cylinder and makes it possible to use higher steam pressures – both speed and efficiency are maximized.

Good runnability normally requires both a low draw from the press section to the dryer section and a high sheet dry content after the press section. Traditionally the problem has been that while high press loads are good for the paper dry content, they are not so good for the bulk, which tends to decrease at high press loads.

The bulk/smoothness ratio can be optimized by using the impingement drying concept with a horizontal and a vertical run. Lower press loads make paper bulky and the twin-impingement unit ensures good runnability at the dryer section by increasing the sheet dry content before the first dryer cylinder. The bulk savings potential of the impingement technology is great (Figure 9).
The same impingement application with a horizontal impingement run can be used for curl control (Figure 10). The improvement in after-dryer section runnability is considerable which has made it possible to apply a complete single-tier after-dryer section configuration.

The full width threading through the dryer section has been tested on a production machine, and the results are promising.

**Efficient nip control in film sizing**

Film sizing was probably the biggest innovation of the 1990s. It significantly improved fine paper machine runnability and efficiency.

The main task of the film size press is to ensure trouble-free and wrinkle-free operation - at a high speed. The know-how and expertise gained from more than 200 film size press deliveries has been utilized in the continuous development of the sizing concept, in order to fine-tune the structure and dimension of the nip rolls correctly. The efficient nip control system ensures accurate nip load control and even nip closing, which is essential for a wrinkle-free sheet run through the sizing section.

**Metal belt calendering**

In the production of uncoated fine paper metal belt calendering provides exceptional quality improvement. The first metal belt calender started in 2006 and now there are several metal belt calenders in operation on uncoated and coated board lines. The first metal belt calender for uncoated fine paper started in 2010.

The metal belt calendering process is based on a one-meter-long calendering zone formed between a heated metal belt and a heated thermo roll (Figure 11). The extended dwell time and high thermal energy input of the calendering zone effectively plasticize the sheet surface. Only light pressure is needed for calendering due to this thermal plasticization of the sheet.

Metal belt calendering thus permits a significantly higher bulk compared to the conventional calendering methods. For glossy coated paper and board grades the metal belt calender is used as a precalender before coating, whereas for uncoated grades the metal belt calender is the final calender.
Several pilot trials have demonstrated the benefits of metal belt calendering for both uncoated and coated fine paper grades. For uncoated fine paper, the metal belt final calender gives higher bulk and stiffness values than the soft nip calender, which make it possible to reduce the grammage or increase the filler content. Metal belt calendered paper has given excellent results also in printing tests. For example, there is less roughening during printing of metal belt calendered paper, which means that the smoothness and bulk values of unprinted paper can be higher. The printing quality is still the same or better for high-bulk metal belt calendered paper as for soft nip calendered paper (Figure 12).

**One level reeling without hydraulics**

The long-term, intensive research of the reeling processes has led to the development of OptiReel Linear, the one-level reeling concept (Figure 13). The main focus has been on the optimization of the parent roll structure with minimum waste, cost-efficiency and user-friendly design.
Reeling technology contributes to the profitability of a paper making line by creating higher material efficiency and capacity in terms of reduced spool and surface waste and better throughput in the finishing area through maximized parent roll diameters.

The parent roll size has a remarkable effect on overall material efficiency and capacity in the finishing area. A reel producing 2,500 mm (98.4 in.) parent rolls may leave as much as 1,500 m (4921 ft) (2.6%) of waste on every spool. By installing the new one-level reeling concept and new spools it is possible to increase the parent roll size to 3,700 mm (145.7 in.) and reduce the spool waste to 200 m (656 ft) (around 0.1%) on each roll. In this case, the application of the reeling concept and new spools improves material efficiency by 2.5%.

The smooth one-level reeling concept on solid rails gives significant benefits in terms of operating and maintenance. There are no elevations from storage to primary or from primary to rails. This permits larger parent rolls.

Reeling is stable throughout the parent roll – there are no load or drive changes from the primary to the secondary because the parent roll is wound using the same reeling carriage from start to finish of the new one-level reel concept.

The lower crane lifting height and the simplified controls – such as elimination of the hydraulics – contribute to lower investment costs, space savings and easier maintenance.

The parent roll structure and high turn-up efficiency are ensured by nip force control during turn-up. This concept gives plenty of time for primary winding as sequence limits have been eliminated. The nip force measurement and nip operation are secured by electronic control.

**Conclusions**

The new concept for uncoated woodfree production contains innovations combined with the best features of proven solutions. Together these improve paper quality and help to achieve higher production and cost efficiency. Flexibility is essential, and therefore the unit processes are applicable for rebuilds as well as medium-capacity production lines as well.

The machine wet end yields improved formation through higher headbox consistencies and a wider operating window for tensile ratio compared to conventional solutions. Also, profiles are improved with the new dilution system. The stationary shoe of the shoe-and-blade gap former gives superior paper symmetry and improves gap and headbox area cleanliness.

The bulk yield from the two-nip shoe press section, the impingement drying unit with a horizontal and vertical run, the metal belt calender and the new one-level reel can be used to increase paper machine profitability by saving raw material costs. Alternatively, it can be used to improve profitability through a higher end product price. The horizontal impingement drying unit gives a tool for better curl control. The impingement technology is a runnability asset in itself.

The new machine design takes efficiency, usability, cleanliness and good working environment to an entirely new level.

The one-level reeling concept guarantees a stable reeling process, and elimination of the hydraulics saves maintenance time and energy.

The new design is based on quality-yielding yet energy-efficient and environmentally sound technology. It is a step towards an entirely new view of what paper or board production could be in the future.
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.