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LATEST TRENDS IN BLADE COATING

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INTRODUCTION

One of the most important trends in the paper and board industry, regardless of the paper grade is the continuous demand for better quality. Coating is one of the key areas, when paper and board quality is discussed. Increased production speed and wider machines mean growing requirements for coating machinery.

In figure 1 is shown the speed development of off-machine LWC coaters during the last 30 years. 1966 a coater was typically designed to run maximum 900 m/min and in reality the running speed was max. 600m/min. Three decades later

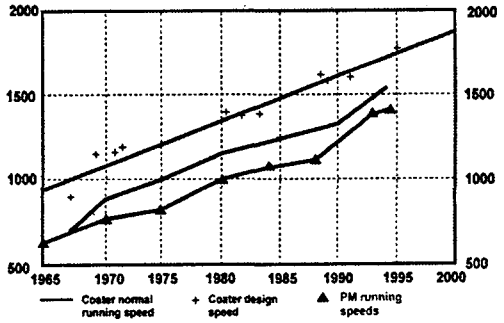

Figure 1. Speed development of off-machine LWC coaters and base paper PM's.

valmet's design speed for off-coaters is 1800m/min and fastest LWC coaters achieve speed of 1600m/min in normal production.

Logically pilot coaters can run faster than production machines.

According to Valmet's experience the speed of pilot coaters is 300-700m/min higher than full scale production machines. Recently Finnish Pulp and Paper Research Institute run with their short dwell pilot coater 2503m/min applying 7 g/m² coating on one side. The pilot machine has been supplied by Valmet and equipped with Opiblade coating head. We estimate that new generation coaters will be able to achieve the speed 2500 m/min also under normal production conditions before year 2010.

In addition to speeding way to increase production and improve productivity of coating, is to build wider machines. Traditionally woodfree papers have been produced with narrower and slower machines than woodcontaining grades, but

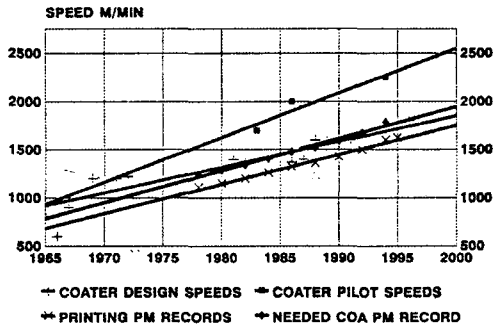

Figure 2. The speed development of Valmet coaters.

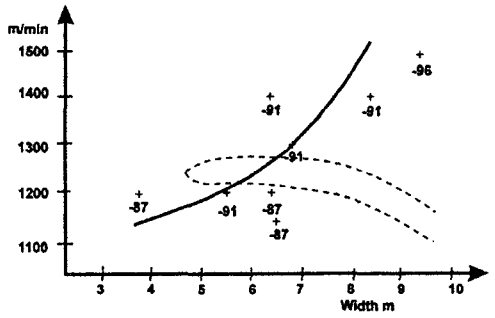

Figure 3. New coated woodfree lines start-ups in Europe 1986-1996.

also this has been changing at least in Europe. In figure 3 can be seen that ten years ago widest off-coaters for WFC grades were 6,5 m wide and designed for maximum speed 1200m/min. The biggest coater ever built for woodfree grades will soon be in full scale production in Germany. Nordland Papier's coater is 9,5 m wide and is designed for speed of 1500m/min.

Becaues of increased speeds and wider coaters, special attention has been paid to developing coating stations. Runnability and efficiency of coaters have been managed to keep on the good level by developing new blade coating techniques.

NEW GENERATION SHORT DWELL COATING HEAD-OPTIBLADE

Short dwell time coating technology was developed in 1970's, when woodcontaining coated papergrades required better runnability than the conventional applicator roll technology coaters could provide. A rapid growth of LWC capacity in Europe and America during the 1980's meant breakthrough of short dwell coaters. In the figure 4 can be seen the expansion of short dwell coaters during the period 1975-1995. Peak years of investments in LWC production capacity were 1983-1990.

Typically the factor limiting speed increase on a short dwell coater is quality deterioration due to short dwell streaks.

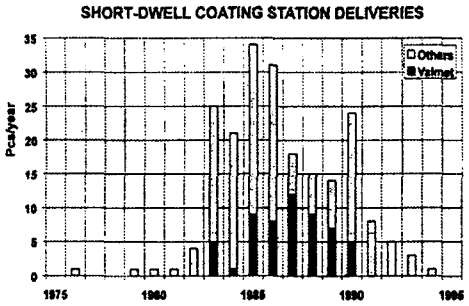

Figure 4. Short dwell coating head start-ups 1975-1995.

They are 30-60mm wide, up th a meter long lighter or darker areas, that are clearly visible in through-light. The streaks are caused by coat weight variations. The fundamental cause to the streaks has been proven to be unstable CD-vortices in a short dwell chamber.

To overcome the streaking problem, Valmet has developed a new generation short dwell coating head OPTIBLADE. The new head is based on the sealing blade

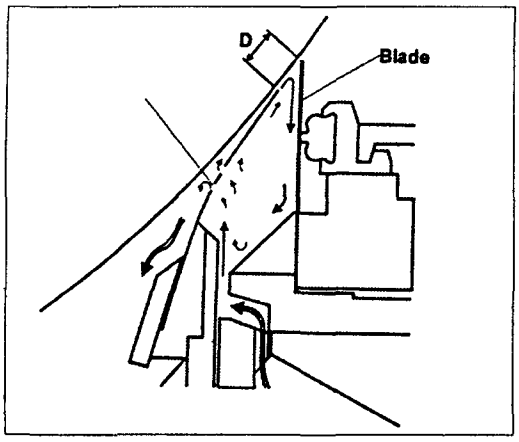

Figure 5. Optiblade operating principle.

technology developed for Valmet's film size press, Sym-sizer. The sealing blade throttle's recirculation from the application head significantly compared to standard short dwell application, which has an open gap retum. Pilot trials some three years ago showed that dwell distance had very big importance on streakiness and uniformity of the coating:the shortest dwell time proved to be the best. The sealing blade operates as a seal as well as a premetering and levelling device. The sealing blade holes leak colour from the application chamber to recirculation, but some of the colour will go back to the application chamber under the tip of the sealing blade.

Advantages of the premetering blade are that is seals off the air from the chamber, and that the acceleration distance of the color on the web from the sealing blade to the metering blade is the same in every spot in CD-direction. In an Optiblade the color is forced on the sheet by the sealing blade holes, which ensures a controlled wetting line without any tendency to sawtooth like line. The blade tip then further levels the preapplied liquid layer. For this reason also the impulse force of color against the final metering blade is quite even in CD-direction.

As the dwell distance in th chamber is short enough, the flows in the chamber cannot disturb the premetered layer. The short dwell distance has also another advantage : The contact length for paper to accelerate color in the application chamber is so short, that disturbing vortices are not formed to the extent they form in short dwells.

PRODUCTION EXPERIENCES OF OPTIBLADE

Production experiences referred to in this paper are from Kymmene Lappeenranta Coater #2, which will be referred to as LPR C2 from here onwards. This machine is a very good example of new technology constantly being applied to meet emerging demands.

When the line was built in 1981, LPR C2 was furnished with standard roll applicator units. Production of Pm^2 line was soon dedicated to rotogravure grades and problems arose when special rotogravure pigments, particularly talc, had to be added into the color formulations. Therefore roll applicator units were replaced with short dwell units in 1983 to improve the runnability of very difficult rotogravure colors-the major problem with these colors was low dynamic water retention.

The units served well for a certain time, but the incapability of short dwell units to

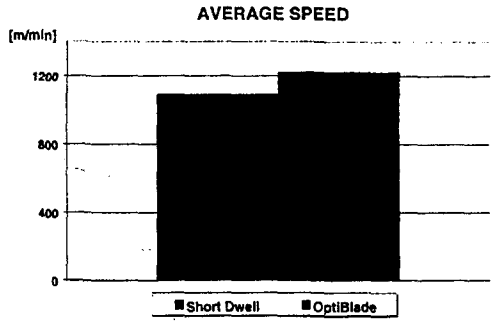

Figure 6. Average speed on Kaukas LPR C2 before and after Optiblade rebuild.

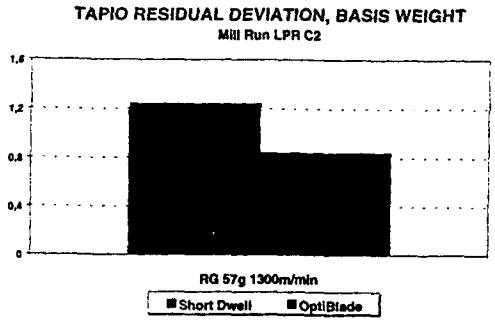

Figure 7. Tapio Residual Deviation, basis weight. Kaukas LPR C2, Rotogravure LWC, 57g/m², 1300m/min. Short dwell-Optiblade comparison.

apply higher coat weights made it necessary to replace the short dwells with the so-called combi units i.e. with units with roll applicator and short dwell mode. Currently as machine speeds are increasing, short dwells and roll applicator are both showing their limitations so that a replacement has been looked for. The target is to have a better coating result with speeds up to 1600m/min.

Optiblade units were installed on LPR C2 coater in November 1994, and have been in operation ever since then. Average speed after the introduction of Optiblade coating heads has been so far over 100m/min higher than the speed used to be with short dwell heads(Fig. 6). The runnability of the coater has remained on the earlier good level in spite of the speed increase.

The uniformity of product is far better than with a Short Dwell coater due to the absence of Short Dwell streaks. This can be seen with the bare eye from a cross-machine sample on a light table. An off-line scanner, Tapio-analyzer, was used to quality the uniformity of the paper sheet.

Mill data from the same grade taken before and after the rebuild shows that residual deviation levels of caoted sheet's basis weight variation have come down significantly with the new Optiblade heads(Figure 7). The improvement has been over 30%. This is well in line with observation of increased uniformity in through-light.

OPTIBLADE coating heads have been tested on Valmet's pilot coater in Järvenpää, as well. The results are well in line with findings of full scale production. Test runs confirm, that OPTIBLADE's advantages are biggest at high speeds. When running 1600m/min with conventional short dwell head, the sheet

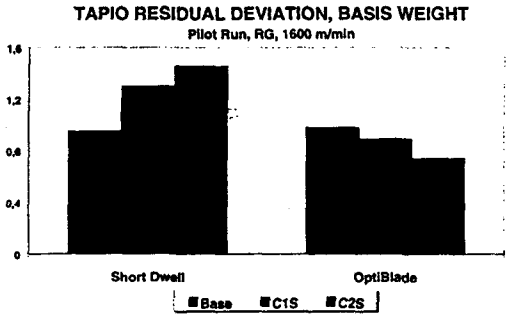

Figure 8. Tapio Residual Deviation, basis weight. Pilot trial run, Rotogravure, 1600m/min.

gets very streaky, but with OPTIBLADE the sheet has very good uniformity.

In addition to speed also coat weight range of conventional short dwell heads is limited. When targeting coat weights over 10g/m²/side, profiles start to deteriotate due to very low loading pressure of metering blade. Also short dwell streaks tend to be more visible when running with higher coat weights.

In order to study Optiblade's coatweight potential, a mill scale trial was made to increase coatweight beyond what is typically run with a short dwell. After controlled run at 10g/m² coatweight(Fig. 9a), a trial was made to increase the coatweight up to 13g/m². The profile did not deteriorate due to this increase(Fig 9 b). This indicates that the profies were surprisingly stable even at those high coatweights. Thus the potential for increasing coatweights from a profile point of view is a reality with Optiblade compared to short dwell. Actually since the Optiblades were installed, all grades previously run with applicator rolls have been switched to the new heads.

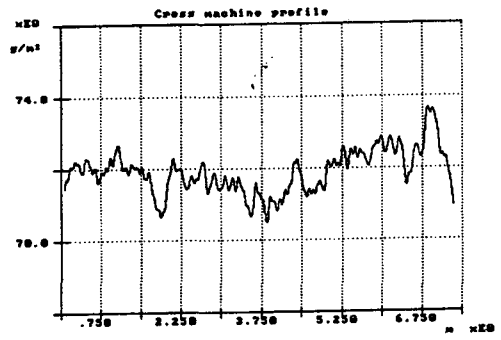

Figure 9 a. Tapio scanner basis weight profile, OPTIBLADE, Kaukas LPR C2, trial for precoationg CW 10/10g/m². 12 samples.

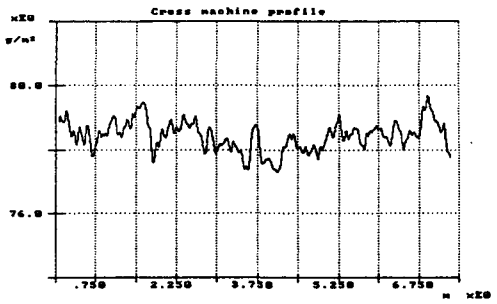

Figure 9 b. Tapio scanner basis weight profile, OPTIBLADE, Kaukas LPR C2, trial for precoating CW 13/13g/m². 12 samples.

As we can see in the above discussion, OPTIBLADE has a higher coat weight potential than short dwell if profiles are the limiting factor. If short dwell streaking is the limiting factor, then naturally OPTIBLADE which has been designed to eliminate streaks is going to reach higher coat weights. In overall coat weight profile behavior, OPTIBLADE is quite superior even to a well-constructed short dwell.

OPTICOAT TECHNOLOGY

Opticoat was developed as a solution to Short Dwell streaking tendency at high speeds by Valmet in 1988-1992. Basic idea was to remove the chamber turbulences next to the metering blade, which have been proven to be the root cause for short dwell streaks. This was done in Opticaot by separating the application and metering, and developing a blade premetered application unit capable of high speeds.

After continued development there is now available two different type of Opticoat coating technology(Fig 10):

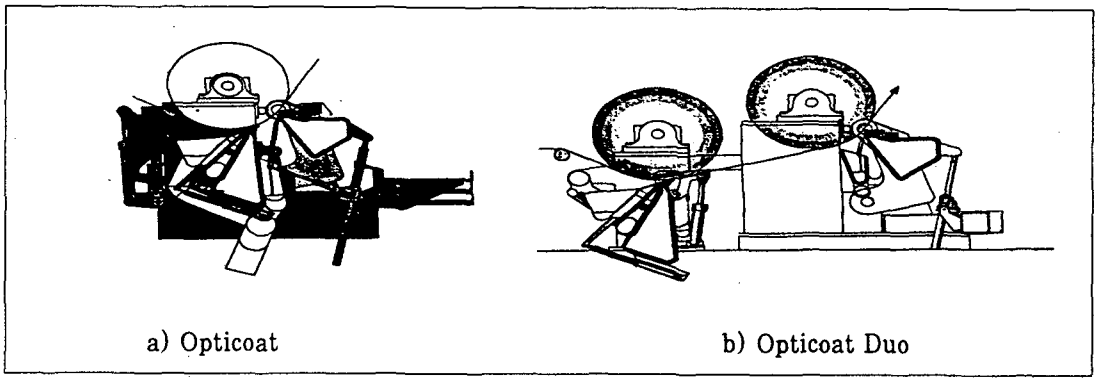

Figure 10. Opticoat coating heads.

-OPTICOAT
-OPTICOAT DUO

The alternatives-both Opticoat and Opticoat Duo-serve partly different purposes in the field of blade application.

OPTICOAT

Opticoat consists of a nozzle applicator for premetering and the Autoblade metering beam for coatweight control. This combination offers the best tecnology for many applications. Special features of the new Opticoat includes variable application dwell time, air and dirty free color feed and the most accurate constant tip angle control of blade beam.

Design of applicator beam

Coating color is supplied to the nozzle beam through a semiconical manifold. In the manifold there is a flow-through, which exhausts air effectively and evens out the cross supply profile, fig 11. This technology is proven in number of applications. This color feed system in unsensitive for color formulations and properties. It is distributing color evenly

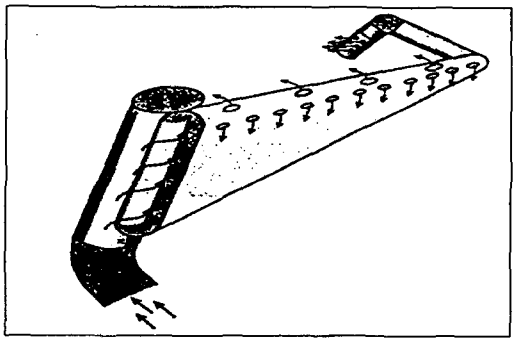

Figure 11. The supply manifold of opticoat beam.

for the full width of the machine.

The nozzle beam supply channels are optimized by means of pressure reducing and collision-turbulence zones. Because of this and the semiconical manifold, coating color application profile is very even in all running conditions. Even applicated coating profile is the base for good final coatweight profile, too.

The design of applicator nozzle can be a new jet-type, fig 12, or also a blade type. fig. 19. In the jet type nozzle coating color is applied onto the sheet surface through a narrow gap. The nozzle is directed to the web running direction. The contact angle of the jet flow can be adjusted according to the coating conditions, f.eg. machine speed

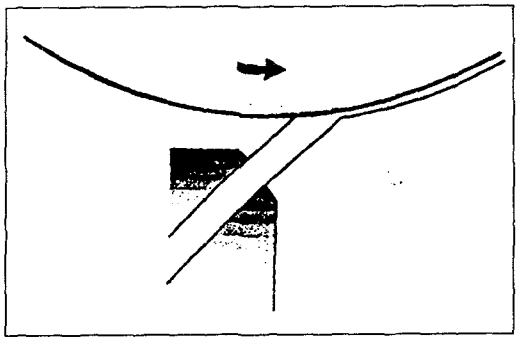

Figure 12. Principle of Opticoat jet application.

and color properties. The nozzle geometry has been optimized considering high speed, prevention of air problems like skipping or craters, and operation hospitality. The application gives streakfree and high quality coating even at the speed of 1800m/min.

The application beam can be turned 90° to the washing position and the supply chamber can be fully opened for easy washing. It is thus possible to wash the supply channels quick and easily and dry color build-ups can't block the nozzle gap

Optimum quality of coating

The applicated amount of coating color ie jet flow amount is adjusted by feed pumping rate of coating color. The jet flow speed shall be high enough to avoid skip coating and craters, but low enough to prevent exessive color application. It is the optimized nozzle design that guarantees a perfect surface quality of coating even at high speeds.

The dwell time, i.e. the distance from the nozzle to the blade doctoring area, influences the degree of color absorption into the base sheet. The longer the dwell time the stronger the absorption of water and coating color. With Opticoat the dwell time can be adjusted according to process requirements. With long dwell time quality of coating surface is better, it is easy to get high coatweights and the coating profiles are better. With short dwell time it is easy to get coatweights and runnability is good also with very low weights of paper.

The attainable coatweight range is 5-18g/m². With the automatic Coatmatic CD profiling device it is possible to increase the coatweight up to 20g/m².

Contrary to the applicator roll, short-dwell and blade premetering coaters

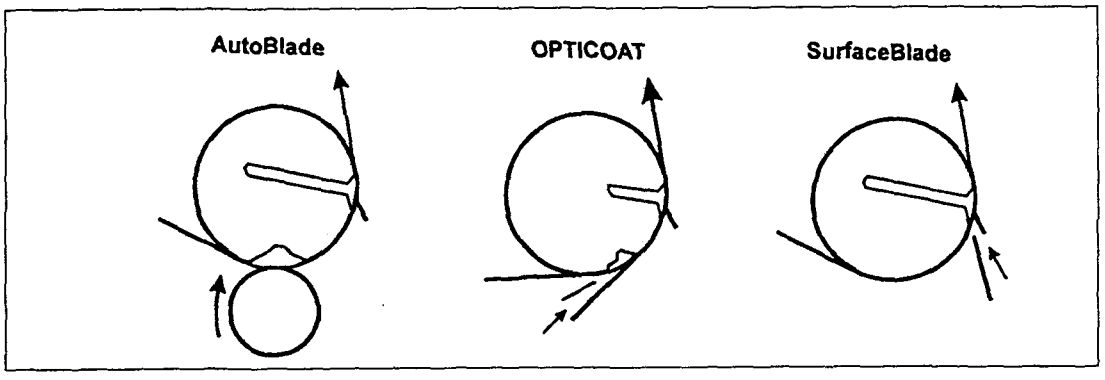

Figure 13. Loads acting on the paper with stations of various types.

Opticoat with jet applicator requires deaeration system in the machine circulation. Deaeration system and optimized nozzle design quarantee, that there is not skip coating in any speed up to 1800m/min.

Runnability

In terms of process technology there is difference between Opticoat and the other type of coating stations in the penetration of the coating colour.

Based on the loads acting on the paper(Fig. 13), the maximum pressure during application is lower with Opticoat than with the applicator roll or short-dwell systems, while the time under pressure is shorter.

With Opticoat, therefore, the amount of moisture absorbed by the base paper lies between those of the applicator roll and short dwell systems. Pressure-related penetration is negligible, since the pressure pulse, about 0,3 bar, caused by the jet flow acts on a span of only 1-2mm. Moistening caused by long dwell is of the same magnitude as in applicator roll coating. Total moistening in nozzle application is just slightly greater than in short-dwell coating.

Because there is less water absorption, the web strength under the doctoring blade is better with Opticoat than with the applicator roll. This makes the web better able to withstnad the forces under the final doctoring blade.

Since the Opticoat nozzle gives a well controlled, consistent and thinner layer of coating colour, the blade loads are lower than with the applicator roll. Lower blade loads strain the web less and improve runnability.

Special attention has been paid to edge area control. Edge dams anr easy to adjust and they guarantee straight, splashless, dry edges.

Coatweight control with Autoblade constant tip angle system

The Autoblade system for coatweight control is a concept that makes papermakers think of high-quality coating. With the help on Autoblade, Valmet has in just five years achieved number on status in blade coating world wide. To date, Valmet has sold more than 80 Autoblade systems for many grades and widths of machines. Special attention was given to achieving a good profile for the coated layer. The driving force behind the design was to supply state-of-the art technology that is also cost effective for narrow machine applications.

Autoblade produces paper surface quality that is more homogeneous than with conventional loading methods. The blade does not ride alternately on its heel and toe. The most distinct advantage of constant tip angle device lies in its far better adjustability and hence in the better CD and MD coatweight profies. The accuracy of the system keeps the blade angle within 0,1 dgr of the setting, which is necessary to maintain an accurate and repeatable coatweight.

A specified coatweight can be obtained with the Autoblade loading system in a much shorter time after an adjustment, a

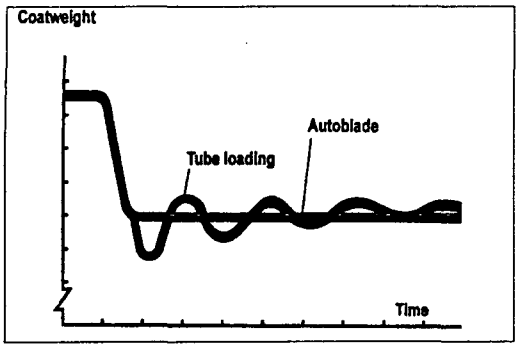

Figure 14. MD coatweight controllability with conventional and constant angle loading systems.

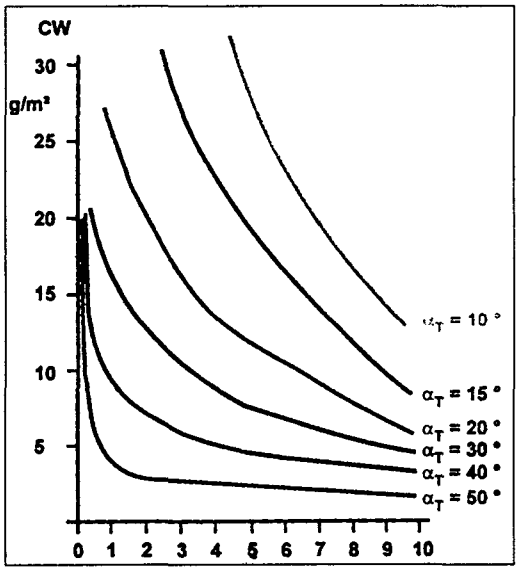

Figure 15. Coatweight as a function of blade load.

break or a blade change. Once reached, the coatweight is kept constant for a long period of time without any fluctuations, unlike the case with conventional(tube) loading system(Fig 14).

With Autoblade the doctor blade geometry is easily optimized for good runnability and high final product quality for all processes. A "Stiff-blade" running mode is employd under normal running

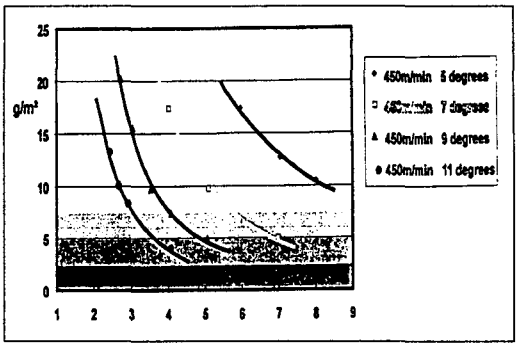

Figure 16. Coatweight as a function of blade load in Autoblade bentblade.

conditions(Fig. 15). This is the case at high speeds, too. It is a simple matter to change to a "bent blade" when required at low speeds of for runnability or quality reasons.(Fig 16)

The Autoblade head is also better equipped for low-angle coating(bent blade) than station that were not designed as constant tip angle devices. In normal bent blade systems only the beam angle is known. With Autoblade, the blade movements are precise and continuously measured and adjusted. This accurate control allows adjustment of loads as low as 0,05mm and angles as small as 0,01°. The real tip angle and its repeatability are also accurately controlled.

Coatmatic CD

The new Coatmatic CD coatweight profile control system can easily be installed on existing coating units or it can be an esentil part of new coating head. It consists of actuators, closed-loop control software and a user interface. The system is capable of improving coatweight profiles that are impaired by the operation of all parts of the process. Production experience

has shown that 2-sigma variations of the order of 3-4% can be attained even at high coatweights. After a blade change, the coatweight profile can be stabilized in 2 minutes on a modern full-width coater.

Coatmatic CD offers Opticoat users the following benefits:

- Uniform quality of coated paper in the cross-direction
- Improved coatweight profile even at high coatweights
- Less profile-related broke after start-up or grade change
- Permits profile corrections regardless of the reason variation
- Fewer blade changes
- Remote control of the blade loading control

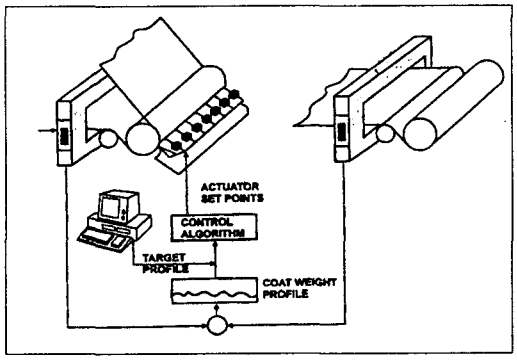

Figure 17. Principle of Coatmatic CD profiling system.

OPTICOAT DUO

Technology

When targeting still better quality of coated sheet it was found in pilot test

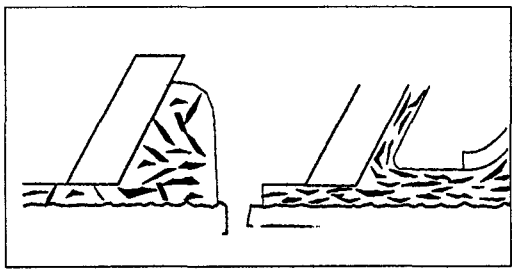

Figure 18. Pigment preorientation.

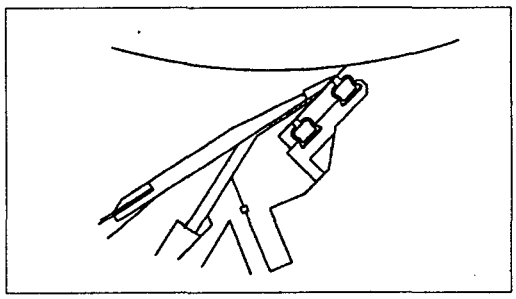

Figure 19. Opticoat Duo premetering beam with blade.

runs, that dwell distance between application and metering had a great effect. When increasing the dwell time double of the normal distance, the result was superior surface characteristics compared to conventional coating heads. Not only was the uniformity a lot better, but also printed quality and surface smoothness wer exceptionally high.

This was due to uniform premetered layer, long dwell-time and combining effect of premetering blade orienting the pigment particles.(Fig 18).

To make dwell time long enough two backing rolls are needed, one for application beam and the other for metering beam.(Fig. 10. b.).

This was first considered to be a threat, since there was no experience with such long dwell distances, but it turned to an

advantage in getting high coat weights and excellent coating uniformity and quality. Dwell times are relevant rather than distances anyway for sheet wetting, and on the fast machines that OCD will be used at, the dwell times will be moderate even with the long dwell distance.

There are many structural advantages of a coating head built on two backing rolls. The biggest one is that the application and metering blade beams do not interfere with each other in designing the head.

Quality

The reason for developing the OCD was to further improve the quality potential of Opticoat, with no limitations to optimise coating process control parameters. This was accomplished and we gained even more we had hoped with the OCD.

Skipfree coating at high speeds

Typical for blade premetered application technique is that application layer can be controlled a lot better than in an applicator roll system or a short dwell system. This leads to a superior control of difficult coating colors at high speeds. We have compared Opticoat applicator to an applicator roll a number of times in both trial runs and production, and found that coating colors, which cannot be run with other units at the speeds required can be run with Opticoat.

At our production reference max speed that could be run with applicator roll on sheet grades used to be 1100m/min on a 80g/m² sheet due to skipping. Now with OCD sheet grades can be run as fast as the drives and drying allow, i.e. 1230m/min, and there is no indication that the OCD would have any trouble running still considerably faster.

Uniform coated layer

With OCD for the first time the full preblade loading range can be utilised on a wide, fast production machine. This allows doctoring the application layer to a 100-150g/m² mirror-like surface, which will have no splashes or rides disturbing uniform penetration and final metering blade operation. This results in the most uniformly distributed coated surface we have ever been able to make on any coating head.

Better printed surface and gloss contrast

Due to pigment preorienting phenomenon a blde premetered applicator seems to

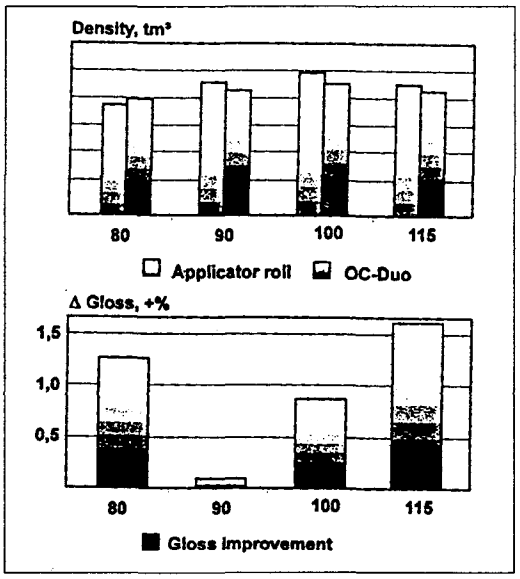

Figure 20. Coated sheet gloss of Opticoat Duo is better than applicator roll. A long term production comparison with different grammages.

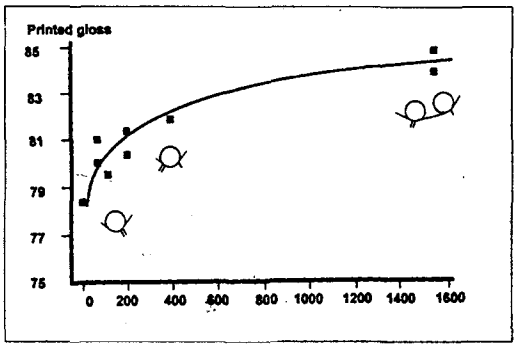

Figure 21. The effect of application dwell time on printed gloss. The longer the dwell time, the better printed properties.

make a smoother and glossier surface than other coating heads. The long dwell time of OCD further enhances this(Figure 20). The smooth application and long absorption time improves specially printed properties like visual uniformity, printed gloss and gloss contrast(Figure 21).

High coatweights easily achieved.

The long dwell distance results in a thickr filter cake forming before the final metering blade. This helps in getting high coatweights with still controllable final metering blade loads. Coatweights up to

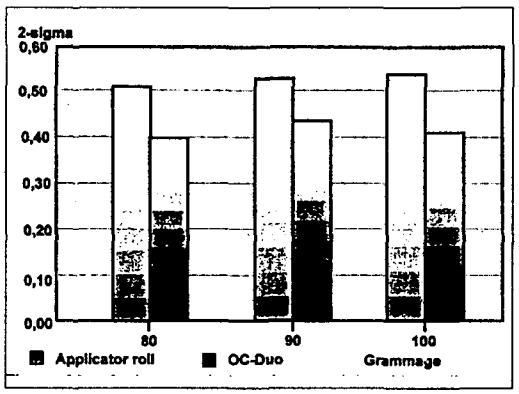

Figure 22. 2-sigma variation of coatweight with applicator roll coater and OCD with different grammages.

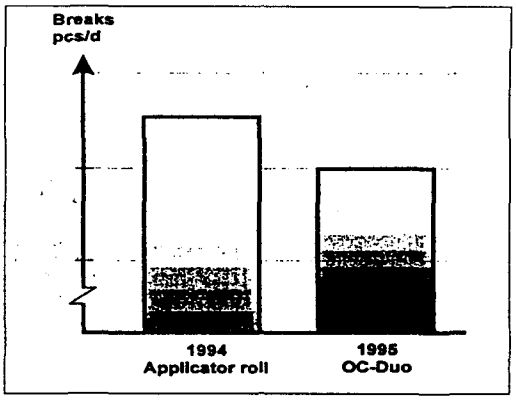

Figure 23. Breaks/day with applicator roll and OCD.

18g/m² can be run. Experience from production indicates, that smooth application improves also coatweight profiles, compared to application roll.

The other side of the coin is of course, that low coatweights will require more effort than with other coaters. There are a number of wasy to overcome this, formulation and base sheet changes, increased premetering and metering blade loads.

Runnability

We have run an OCD since march 1995 on a full scale production machine, where it replaced applicator roll heads. The break statistics show, that number of breaks on the coater so far is at the level of applicator roll coater or lower,

This proves, that the dwell distance and wetting the sheet is not actually most critical factor affecting runnability-no doubt the sheet moisture at final metering blade is now slightly higher than it used to be at the same speed.

The excellent tension control of the system reduces breaks. Sheet tension

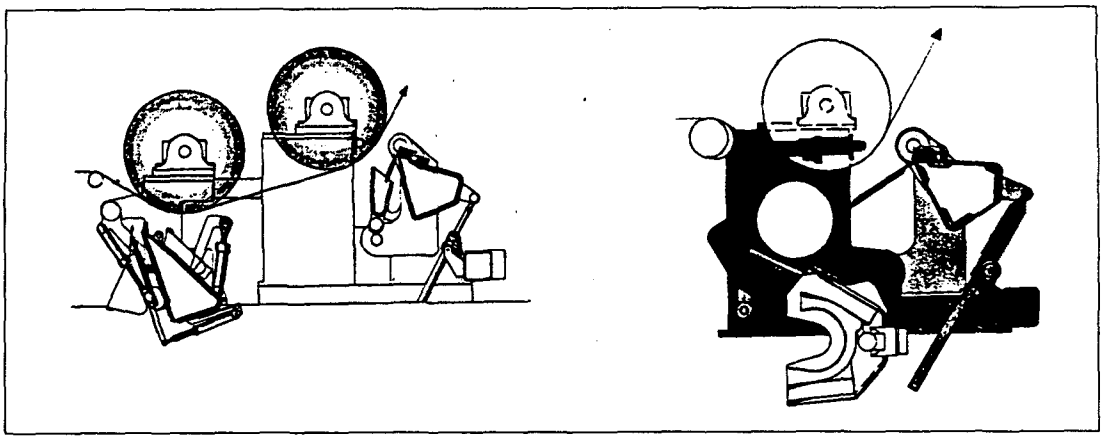

Figure 24. Opticoat Duo and Autoblade-applicator roll coating heads in washing position.

between backing rolls can be run low and thus the stress for paper is reduced. In addition the areas where we have improved the runnability is control of the edges of the sheet. Applicator roll edgewipes are more prone to deposits drying on them than OCD's.

Other notion has been, that break time has remained the same or decreased. This is coming from the fact that there are two rolls and an applicator system to be washed in both units. Actually OCD's first backing roll is easier to wash than applicator roll, because of the better ergonomy, and the same applies to the nozzle vs. applicator roll pan.

CONCLUSION

The new coating head Opticoat Duo developed by Valmet, Will set standards of sheet uniformity and printed quality at high coatweight, high speed coating. The coating method is excellent especially for woodcontaining MWC papers and woodfree papers for coatweights 9-20g/m².