Solutions for High Quality LWC Paper

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ABSTRACT

The know-how described here spans from furnish components to the final printing surface of LWC paper. LWC lines with products, proces know-how and automation from fibres manufacturing to the roll wrapping line are given. Extensive project support for a board range of products, Process development packages, Furnish studies pilot trials from furnish to printing Continuous support for LWC paper quality and mill production efficiency are discussed. Those lines represent about 9 million t/a of LWC paper capacity in all with 20 mechanical pulping lines, 29 paper machines, 25 coaters, 26 calenders and 24 winders for those LWC lines. .

INTRODUCTION

The key words that describe the global paper Industry today are consolidation and competition. This means that fewer players control more of the business. As a result, the paper industry has to concentrate on cost-effectiveness. Coated grades are value-added grades and tolerate price pressures better than standard grades. However, the long-term real prices of coated grades are going downward. In a situation of declining prices, high-cost paper producers cannot stay in business. In the current competitive situation, technology is more important than ever in developing market-oriented paper grades. The right technology allows LWC production lines to operate efficiently and produce high-quality LWC from various raw materials at the lowest possible total investment and production costs. In order to be successful in this challenging world, papermakers need to have four different matters in good shape : furnish, process, automation, and machinery. LWC papermaking must be understood as an integrated whole from the wood material and mechanical pulp plant up to the wrapping process of the coated and calendred paper.

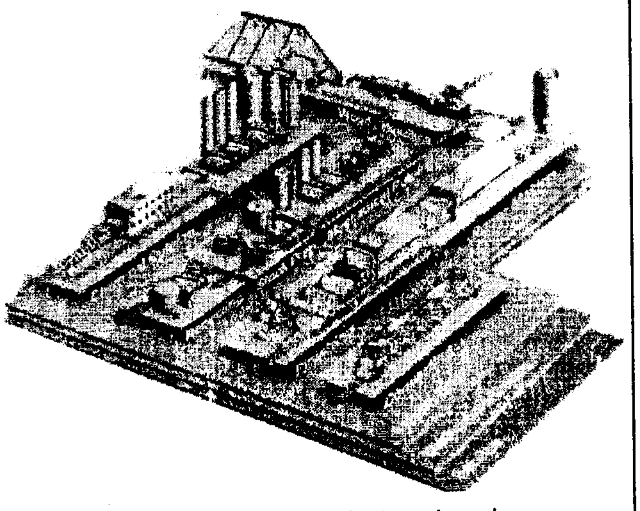


Fig. 1 New range of products and services

High-Quality LWC for Today's Printing Processes

When discussing LWC paper, we have to understand the paper technological requirements set by printers and publishers. The critical quality characteristics for high-quality LWC offset are:

- formation
- internal bond/blistering tendency
- printed gloss
- fibre puff
- paper gloss
- opacity/brightness
- stiffness / bulk
- fluting (waviness)

For rotogravure LWC, the main quality characteristics are

- PPS smoothness/surface topography
- compressibility/bulk
- micro-scale absorption evenness

In addition to the quality characteristics mentioned above, LWC paper has to have guaranteed press room runnability. LWC papers are mainly used for different types of magazines, catalogues, inserts, and marketing and sales promotion materials. In many cases the appearance of the paper surface plays a very important role. The printer places more importance on runnability properties, while the publisher is looking more at surface properties, such as the gloss-bringhtness relationship, for example. The end consumer of the paper- the reader-likes stiffness and opacity in paper, the paper must feel good in hand. In order to ensure good runnability of the printing press and paper machine line, paper must have certain strength characteristics. Papermakers can typically monitor strength properties by measuring MD tensile strength and CD tear strength. The furnish and paper machine line have a big effect on the strength properties of paper and the amount of defects. A limited number of defects (holes, edge cuts, creasing, etc.) will yield good runnability of the paper machine and printing machine.

Metso Paper Solutions from Furnish to the Final LWC Printing Surface

In the new paper processing technologies and services (Fig. 1), every subprocess has an effect on the final LWC printing surface and on press room runnability. These subprocesses/raw materials for LWC are:

Available fibre supply (wood species, recycled fibre)

- Chosen mechanical pulping process
- Furnish mix
- Headbox
- Former
- Press section
- Predrying
- Precalendering
- Coating head/coating colour
- Coating drying
- Final calendering
- Winding

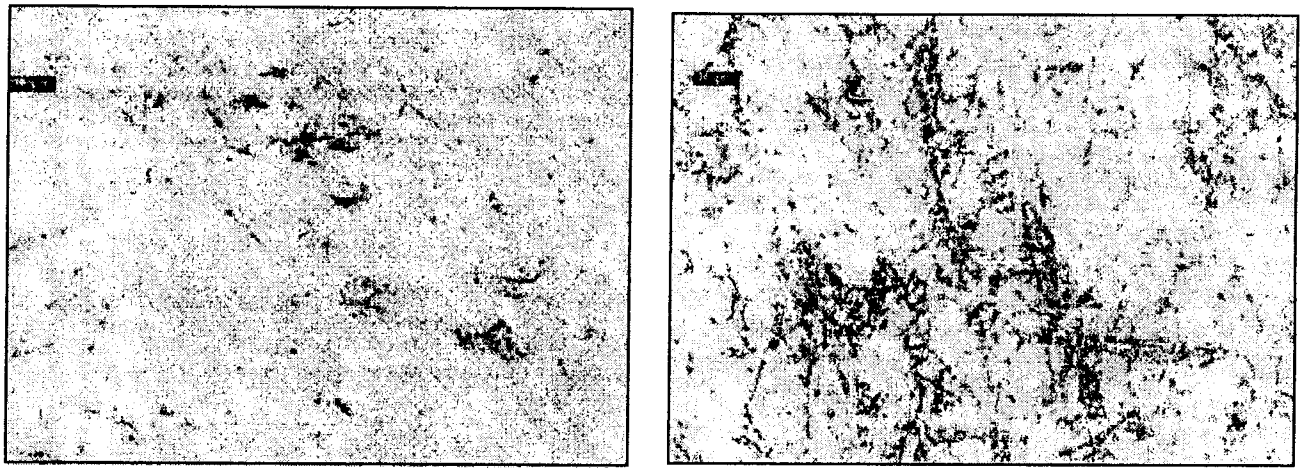
These subprocesses/raw materials must be optimized through a comprehensive papermaking process approach. Only this type of an approach allows LWC production lines to operate efficiently and produce high-quality LWC from various raw materials at the lowest possible total investment and production costs.

Available Fibre Supply

What type of pulp composition (in terms of fibre length and coarseness distribution) is best suited for LWC base stock? How to balance the amount of long fibre (needed for strength) and the amount of fines (needed for bonding and sheet structure)? The answers to these questions are typically given by a comprehensive furnish study, starting with laboratory-made hand sheets to screen for the best furnish compositions. At the end of the study, a full-scale papermaking line trial is executed. In the line trial, LWC paper is made by Metso's papermaking/finishing pilot plants, all the way from the selected furnish to finished printing rolls. This study provides mill personnel a target in selecting wood species/recycled fibre and adjusting pulping and refining conditions to suit LWC paper.

Chosen Mechanical Pulping Process

GWD/PGW combined with a large amount of softwood kraft has traditionally been used as furnish for LWC. TMP and CTMP, with their good strength, are recently increasingly used as furnish for producing LWC paper. However, TMP and CTMP with a large amount of coarse fibres and a low fines content create challenges for coated paper quality. Relatively poor coating holdout and uniformity, as well as poor internal bond and paper formation, are typical with too coarse fibres. These drawbacks of refiner pulps have successfully been offset



80% Coverage

60% Coverage

Fig. 2 Effect of base paper porosity/openness on coating coverage through emphasized refining (to lower freeness). The biggest advantage of TMP is its lower reinforcing pulp (Kraft) demand in the paper furnish. Market pulps, GWD, CTMP and APMP, are available for making LWC paper. LWC base paper requires good tensile strength to avoid web breaks in coating and good stiffness and bonding strength to have good runnability in printing operations. At the same time, it also requires appropriate sheet structures for good coating holdout and uniformity. These requirements sometimes conflict with one another. The effect of base sheet porosity/openness on the coating result is shown in Fig. 2. SEM images of the coated paper surface are shown, where dark spots represent poorly covered areas. The images clearly show that the more open base paper structure of the coated paper made from coarse fibres results in less good coverage than lower freeness papers. This is due to (1) a higher degree of solids phase penetration into the base paper and a higher degree of fibre swelling and fibre rising (Fig. 3).

In the end, the specific mechanical pulp type selected for LWC paper production is very much a mill-specific decision. In addition to the established paper quality requirements, it depends at least on the following factors:

- share and price of chemical (kraft) pulp in the paper furnish
- specific energy consumption of mechanical pulp
- price and availability of raw materials and other utilities (wood, electricity, chemicals)
- initial and final brightness of mechanical pulp
- bleaching method and costs
- washing requirement and effluent load
- cost of effluent handling
- use of heat from possible heat recovery system
- investment cost
- other operational costs (manpower, pulp stones, refiner disks, maintenance)

Base Paper Properties

The right furnish mix gives the optimum composition for LWC base paper that helps meet the following partly conflicting requirements:

- Uniformity (profiles, basis weight residual variation, formation, fibre orientation etc.)
- Minimum coating penetration
- Smooth surface before precalender or coating
- Appropriate tensile strength
- Good internal bond strength
- Good folding resistance

Coating penetration becomes more important as the base paper basis weight is lowered or coarser mechanical pulp is used. The penetration of coating occurs when large-sized pores (or pinholes) are present at the surface. For any given coating method, fibre coverage depends strongly on the total coat weight, amount of coating penetration, surface roughness, and the compressibility of the base paper (2). Among the most important factors influencing the paper and print quality of coated paper is the filler content of the base paper. Studies have shown the importance of high filler content in film-coated grades for good paper and print quality. Filler content affects the rising of fibres and the dimensional stability of base paper. Increased filler content reduces fibre-to-fibre contact which reduces hygroexpansion and swelling pressure during water contact, Increased filler content will also reduce the expansion of pre-calendered paper. Increased filler content reduces the pore volume, but increases water

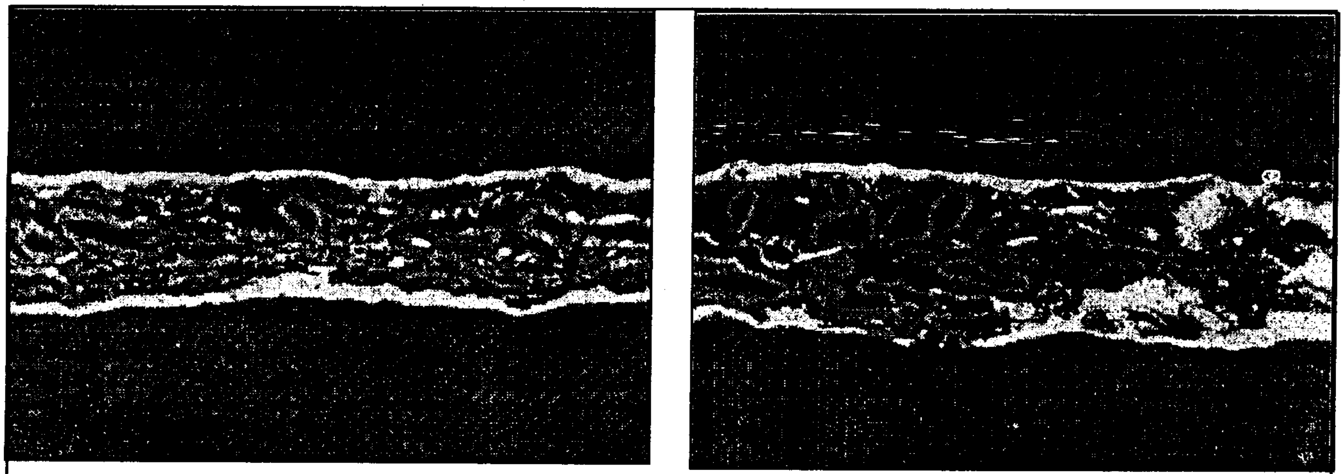

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Fig. 3 Effect of base paper porosity/openness on coating penetration

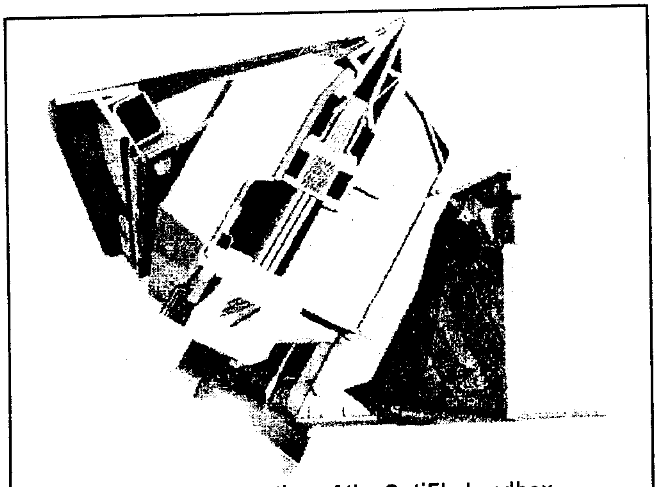


Fig. 4 Cross section of the OptiFlo headbox

penetration as a result due to a higher number of pores in the sheet (1).

Headbox

The headbox, together with the forming section, plays a major role in the production of high-quality LWC base paper, which in most cases means the overall uniformity of the paper structure. The former is responsible for smaller scale uniformity, where paper formation is measured. The headbox is primarily responsible for uniformity on larger scales, which can be divided into two parts: uniformity scales achieved through fluid mechanical operations of the headbox hydraulics, and scales above the operational capabilities of the quality control system, Accordingly, a high performance paper machine headbox should have two special characteristics: (1) robust hydraulic performance for stable production and (2) adaptability for varying production conditions.

LWC base paper uniformity fundamentally means even basis weight and fibre orientation distributions. The common quality measures used are basis weight profiles, basis weight residual variation, formation, and fibre orientation profiles. The absence of streakiness can be considered an additional quality measure reflecting small-scale fibre orientation uniformity. All solid particles like fibres, fines and fillers, as well as chemicals, have to be evently disturbuted in the slice jet before final freezing into the structure of paper on the forming section. In the slice jet, uniformity also denotes the evenness of flow structures and properties. This requirement means the absence of coherent flow structures and distrubances that could affect the basis weight or create unwanted fiber orientation effects, such as streaks, by rearranging fibers.

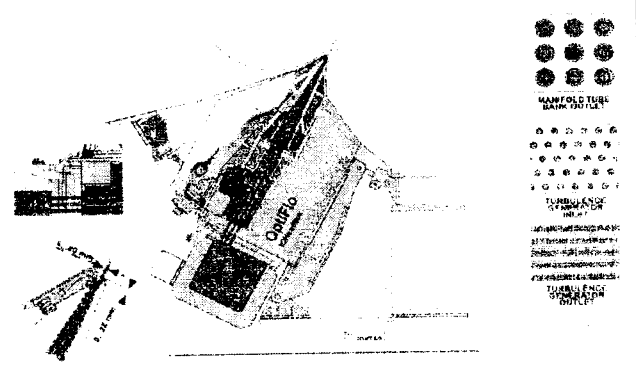


Fig. 5 OptiFlo hydraulics

Headbox hydraulics (Figs. 4 and 5) are strongly correlated with paper properties. Flow properties, especially structural ones, also influence paper structure. This raises the need to better understand the papermaking process from the viewpoint of headbox hydraulics and their linkages with paper structure. Understanding the interactions that link headbox hydraulics, slice jet properties and the forming process to the structure of paper and its functional properties of paper. In practice this means optimized headbox dimensioning and built in intelligence where the operating environment and the end product property targets have been carefully considered. The optimized design and dimensioning of Paper headbox solutions offer optimal concepts for each application (Fig. 6). The ability to achieve excellent CD profiles and the most uniform paper structures (Fig. 7) even in the most demanding paper production cases is based on longterm experience, innovative solutions and profound R&D. All these together assure the success of papermakers through improved paper quality and production efficiency.

Former

The top performance of various formers is limited to a given sppeed range, and the impact of higher running speeds on residual basis weight variation and paper quality has forced the updating of former designs (Fig. 8). Older former types can be rebuilt into later versions. Because of modular construction, a vertical or horizontal multifoil shoe former can easilty be rebuilt as an

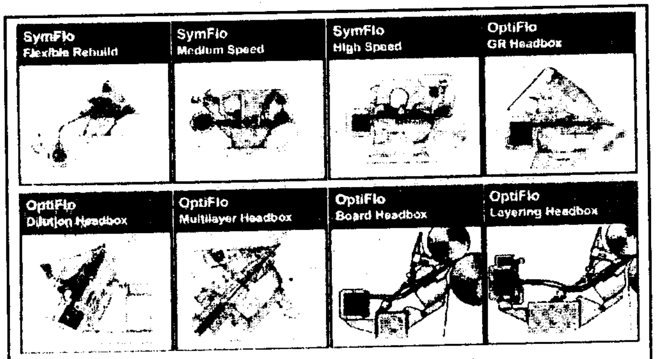


Fig. 6 The Paper headbox family

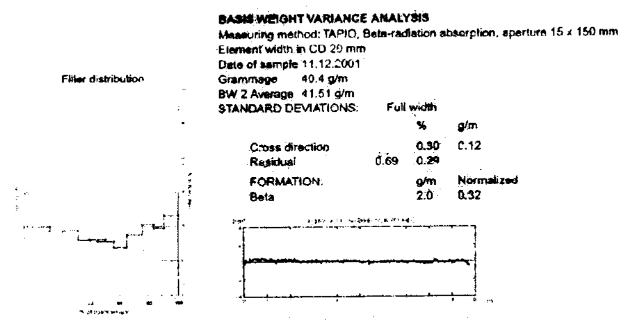


Fig. 7 Performance of the OptiFlo headbox : filler distribution and basis weight variation, A LWC case

OptiFormer with loadable blades, for example (3).

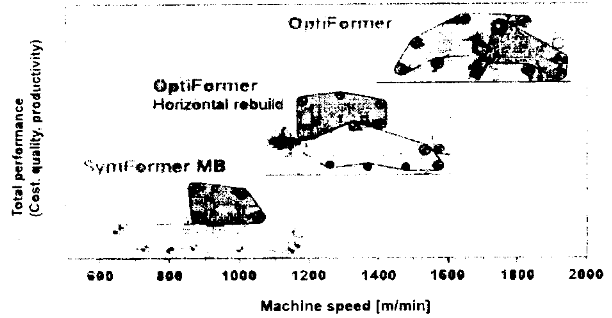


Fig. 8 Operating range for different formers

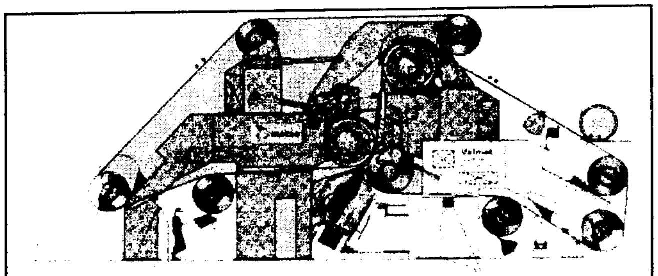


Fig. 9 OptiFormer with loadable blade module and OptiFlo

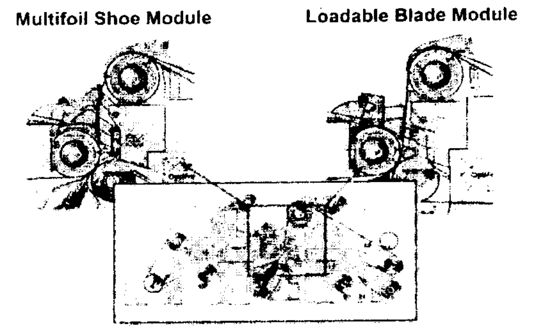


Fig. 10 Two different modules for OptiFormer

The target for OptiFormer development is to improve runnability, potential machine speed, and paper quality. To minimize shutdown times, the OptiFormer is designed to be easy and quick to maintain and keep clean. Its cantilever system and modularized layout make fabric replacement very fast, while excellent crane access makes the changing of rolls very easy. The OptiFormer has two different modules that are designed for different applications; a multifoil shoe module for SC and certain LWC grades, and a loadable blade module for newsprint, fine paper and LWC paper (Fig. 10). In both cases, initial dewatering takes place over an open forming roll under low drainage pressure (3). Drainage starts on the forming roll, whose wrap angle is optimized mainly on the basis of machine speed, furnish, and basis weight. Both surfaces of the paper web will filter at the same time in the forming roll area and the process retention rate becomes very high, which helps to keep the wet end clean. The next dewatering stage is the loadable blade zone. The loadable blade module is located as close to the forming roll as possible to minimize reflocculation time in the center layer of the web. The next dewatering element (3) is the multifoil shoe that can be used to control the properties of paper

	OptiFormer Vertical Concepts		OptiFormer Horizontal model	SymFormer MB
Process Parameters	Multifoil Shoe	Loadable Blades	Loadable Blades	Loadable Blades
Runnability	++	+++	++	+
Tonnage	++	+++	++	++
Dry content after former	++	+++	++	++
Quality Parameters				
Printability	++	+++	+++	+
Formation	++	++++	++++	+
Porosity	+++	++	++	++
Internal Bond	++	+++	+++	+
Oil absorbency	++	+++	+++	+
Printed gloss	++	+++	+++	+
Speed potential	2000 m/min	2000 m/min	max 1600 m/min	max 1300 m/min

Fig. 11 Detailed comparison of different former concepts

(e.g. formation, porosity, and filler distribution). Sophisticated forming yields good base paper for high-quality end product. The film coating method, which gives good runnability also at lower basis weights, is used in the case of fast all-online LWC machines. Good printability requires good raw material and formation of the base paper, as few big flocs (> 3 mm) as possible, and a closed surface structure (porosity, roughness, oil absorption, raw material distribution). LWC paper made with an OptiFormer featuring loadable blades has much fewer big flocs (>3mm), but has the same strength and surface properties as paper made using an OptiFormer with a multifoil shoe. Other paper properties that affect printability are filler coverage and the surface smoothness of paper (3).

Many comparison tests have been made between multifoil shoe and loadable blade equipped OptiFormers for LWC paper. Results clearly show the same trend in paper properties with PGW, GW and TMP-based furnishes (Fig. 11). With the loadable blade concept formation is superior, evensidedness is improved, and dryness after the former is higher, which yields better sppeed potential and runnability. The pilot trial results in Fig. 12 show that loadable blades improve the formation of base paper compared to the multifoil shoe concept. Good formation can be accomplished with loadable blades by using lower headbox flow rates, which means higher headbox consistency. In this study headbox flow was 15% lower with the loadable blade concept than with the multifoil shoe concept. Lower headbox flow also has a positive effect on many paper properties, such as strength and porosity.

Press Section

The SymPress B concept with a SymBelt shoe press in the third press position has rapidly become the industry standard for LWC paper machines. In this concept, high dryness is achieved before the center roll release, thus guaranteeing superb runnability. It is applied to lower speed LWC machines for economic reasons. The SymPres B shoe press concept is also a good tool for rebuilding existing press because it gives 5%-7% more dryness compared to conventional roll presses. At the same time, paper quality, such as roughness twosidedness, oil absorption twosidedness and bulk remains at least at the same level or even improves compared to roll presses.

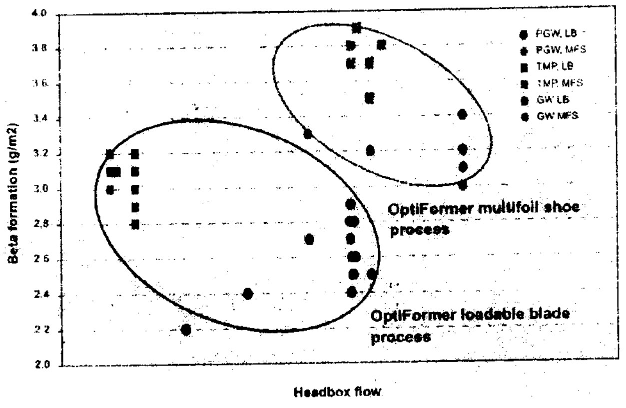


Fig. 12 The formation potential of the multifoil shoe and loadable blades

The high-performance OptiPress (Fig. 13) was developed to meet higher speed, quality and efficiency targets. The commonly known design features of the OptiPress are:

- No open draws
- No center rolls or related problems
- Full-width sheet threading
- Separately controlled nips

In operation these features have brought excellent efficiency, easy tail threading, and speed potential. The closed sheet transfer and streamlined web run concept minimize stresses on the wet paper web. OptiPress is therefore not sensitive to web defects, which sgnificantly cuts down on the number of web breaks for improved runnability. Experience with production machines shows that the first nip removes 75-90% of the total volume of water within the press section. After this it is easy to reach dryness of 46-48% with typical LWC furnish and running conditions. Special attention, of course, has to be paid to felt selection because only two nips are in use with heavy loading and water removal. With the transfer belt (instead of felt) in the bottom position, fabric geometry can be built to optimally control rewetting. The top felt can be seprarted immediately at the nip exit and rewetting is minimized. This is the key to good moisture profiles, which are a must for LWC line runnability and final quality consistency. The transfer belt concept gives the best moisture profiles for weeks and months. The

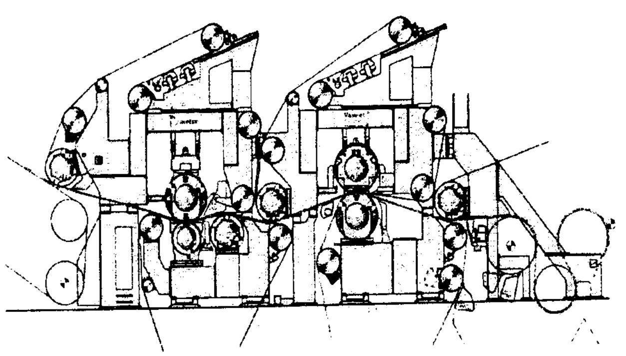


Fig. 12 OptiPress with Transbelt

same is not true of four-felt concepts, where felt properties change over time due to plugging and compression.

In terms of sheet roughness symmetry, the OptiPress gives better product than SymPress B. Typical values on pilot machines are 1.0-1.3, and on production machines 0.9-1.15 (TS/BS). Better figures cannot be reached with four felts (Fig. 14). In terms of oil absorbency (Fig. 15), equal dewatering plays a significant role in the last highly loaded nip. The bottom side of the paper sheet tends to get left more open. That can be reasonably compensated in the coating and calendering processes with LWC offset. With respect to other important LWC base paper quality parameters, the OptiPress with closed web transfer makes it possible to use limited draw between the press and dryer. This places less stress on the paper web and leads to good internal bond strength. The porosity of paper is also optimized through the speed difference between the press and dryer sections.

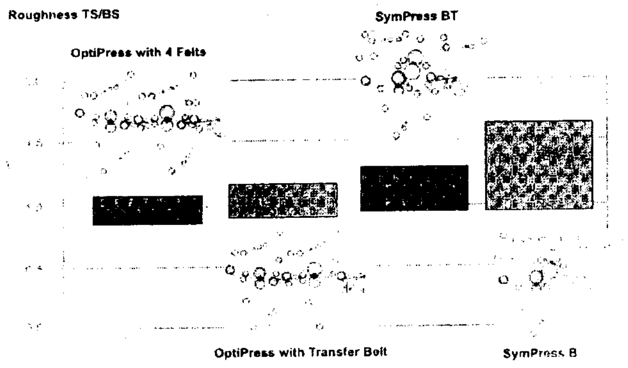


Fig. 14. Roughness comparison between different press concepts

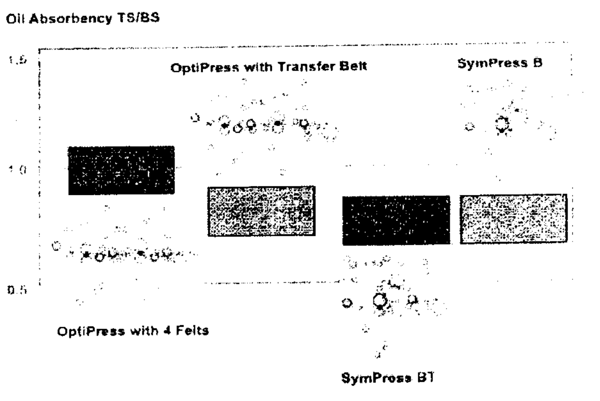


Fig. 15. Oil absorbency comparison between different press concepts

Predrying

Many of the desired properties that already exist in paper can be improved in the predrying section with proper web handling. The dryer geometry itself is single-tier drying, whose efficiency and good runnability properties are well known. The drying section is easier to build with internal fabric guiding rolls. The paper is also well protected against dirt that can deteriorate coating process runnability. If the length of the dryer section is limited, one option is to use impingement drying units that can shorten the dryer section without runnability or paper quality deterioration. External forces appearing at the paper machine disturb runnability in papermaking. Since most of these forces increase at the square of machine speed, their effect is impossible to ignore at the dryer section. The strongest appearance of these effects is concentrated at pocket areas of the dryer cylinder and rolls. Fig. 18 shows a schematic force distribution affecting the paper web. The conventional way of trying to improve runnability has been to increase the tension of the web starting from the press section and adding to it throughout the dryer section. However, it is generally known that increasing web tension normally has a negative influence on machine efficiency due to a higher susceptibility to web breaks. An obvious solution to the problem areas presented in (Fig. 19) is to create runnability components that create counter forces to stabilize the paper web. In the new HiRun blow box concept, shown in Fig. 20, the web release from the dryer cylinder is facilitated by means of a focused vacuum area. The key idea is to optimize the use of vacuum in the dryer section pocket by dividing the pocket into different zones that each have a different vacuum level. This means focusing much higher vacuum in the area of the opening dryer nip, while using smaller vacuum in other areas of the pocket. Thus the fabric deflection caused by the vacuum also remains small.

At first look, the coupling of web stabilization and air flows to the properties of base paper is not self-evident. However, understanding the entirety of the physical environment of web handling in open draws one can see that there are two options for stabilizing the web:

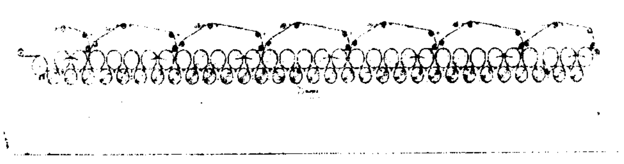


Fig. 16. Single-tier drying section with internal fabric guide rolls

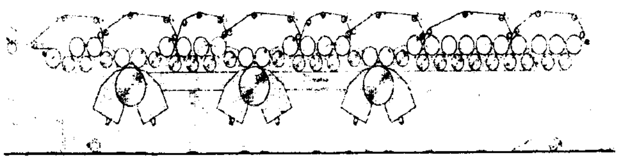


Fig. 17. Single-tier drying with impingement drying units

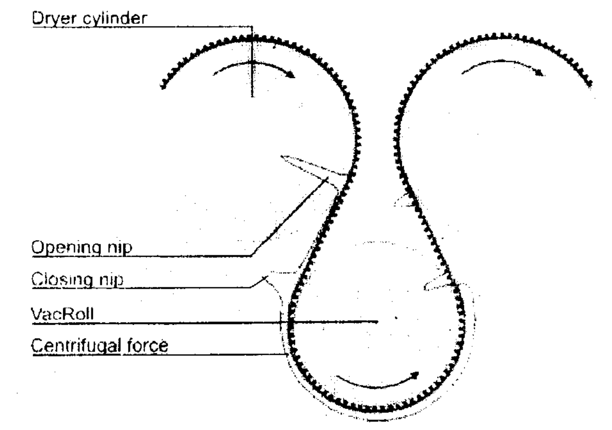


Fig. 18. Problem areas and force component distribution impacting the web in single-tier paper drying

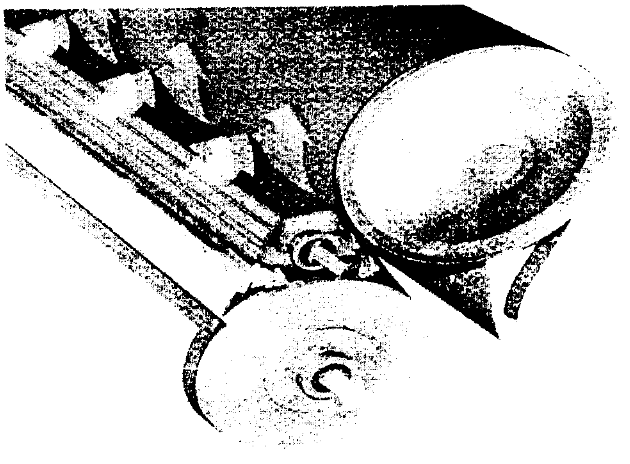


Fig. 20. HiRun blow box

1. Using the web's own elastoplastic features through straining to control the forces disturbing runnability (normal way)
2. Using external means and devices for web stabilization

The main benefit in supporting web transfer is the ability to separate web stabilization and web straining from each other. The connection between stabilizing the web and the properties of base paper is now apparent. Supporting the web in the press section and further on the dryer section facilitates reducing the MD strain traditionally used for web stabilization. Since straining is no longer dependent on web stabilization, straining can be used for optimizing the base paper properties. As an example, the following paper property results were obtained with dried LWC base paper. Figs. 21 and 24 represent one example of trial results with certain specific wet end and furnish paprameters. For this reason, data points have been indexed in each figure based on the MD result obtained at the maximum straining level (hollow circular dot). The development of the tensile strength of dry LWC base paper is presented in (Fig. 21). Due to lower straining, tensile strength is also decreasing, which is usually considered to be a consequence of more crimped fibres. However, with increasing CD strength the CD tensile modulus is also increasing, which results in more isotropic tensile properties in paper. If we compare the behaviour of tensile strength to that of the modulus of elasticity, it is very much the same. In Fig. 22 we can see that the decrease in MD elasticity is almost 20%, which means a more elastic web and lower tension peaks around holes and other web defects during straining. The simultaneous increase of the CD modulus gives a lower MD/CD ratio, and thus more uniform paper properties.

One of the most significant results can be seen in Fig. 23. The decrease of MD straining increases significantly MD strain at break (65%) giving substantially higher strain potential to paper. This property is very important especially in on-line coating and calendering where the base paper must have certain

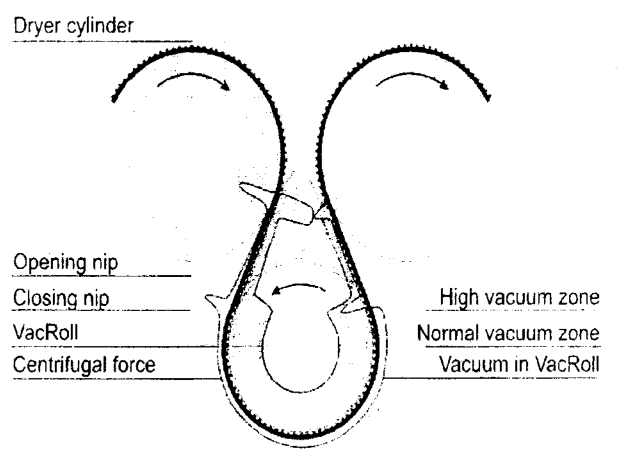


Fig. 19. Principle of focused counter forces to stabilize the web

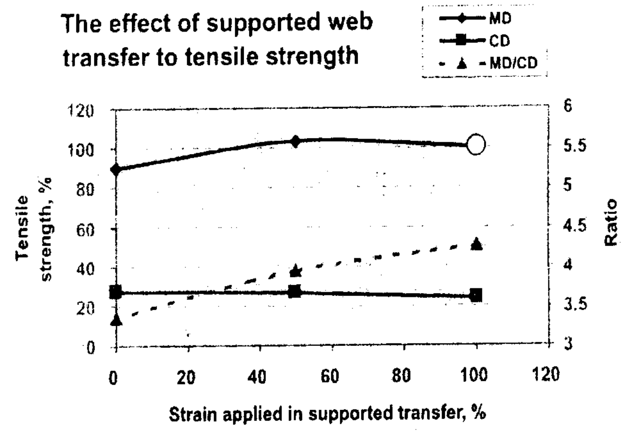


Fig. 21. Relative Tensile strength development with first straining supported web transfer

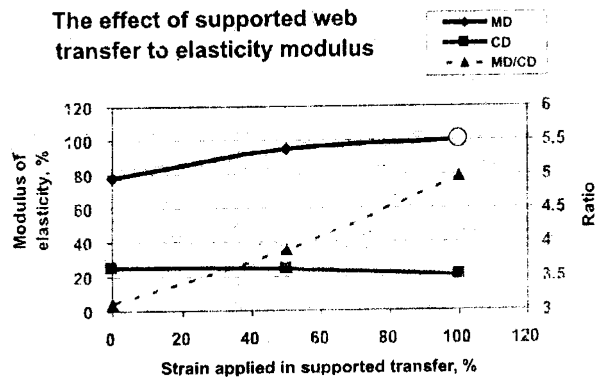


Fig. 22. Relative modulus of elasticity development with first straining in supported web transfer

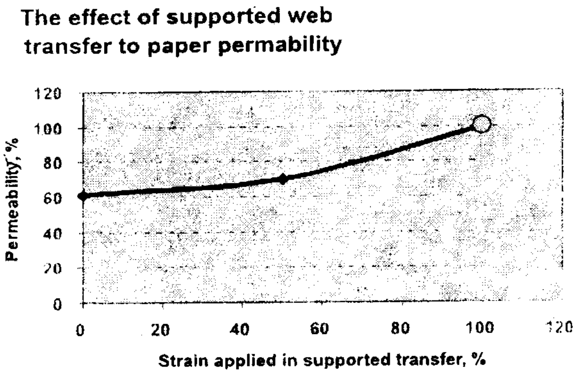


Fig. 24. Relative porosity development with first straining in supported wbe transfer

strength properties, Therefore, all extra straining of the base paper should be avoided in order to get the best possible runnability and efficiency in the downstream processes. Finally, the decrease of MD strain has a big effect on base paper permeability (Fig. 24).

Precalendering

Precalendering improves the print quality of blade and filmcoated paper, but does not always reduce the micro surface roughness of the coated product. Precalendering improves the coverage and coat weight uniformity of coated paper. The precalendering process also diminishes the pore radius and surface roughness. The lesser water and liquid penetration is a result of the reduced pore radius, where pressure penetration increases the difference between precalendered and not precalendered base papers (4). The effect of precalendering on the pore radius size distribution is similar to the effect of different filler contents. The precalendering of SGW/PGW papers reduces the total pore volume of the large pores (>2 μm) and increases the total pore volume of fine pores (>0.25>0.025) at the 10% filler level. At the 20% filler level there is no change in the pore volume of the finest pores. The precalendering of TMP papers reduces the pore volume of the largest pores and mid-sized pores as well, and consequently increases the amount of fine pores. The precalendering of TMP reduces the amount of the largest pores to a greater extent than a precalendering of SGW/PGW (4). It can be seen in (Fig. 26) that precalendering improves fiber coverage. The coating is prevented from penetrating into the base paper by closing the sheet structure (4).

Coating Process

LWC Line concepts

It is the coating area where the LWC line concepts start to differ. LWC manufacturing can be accomplised using one of three different concepts (Fig. 27).

- all off-machine
- traditional on-machine;
- all on-machine
- The 1986-2002 major projects for LWC and MFC world

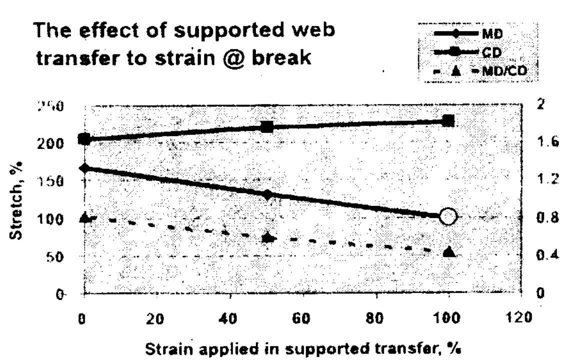


Fig. 23. Relative modulus of elasticity development with first straining in supported web transfer

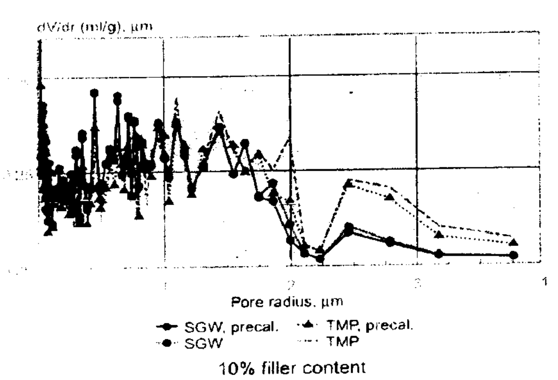


Fig. 25. Distributions of pore radius size for base papers, based on SGW/PGW and TMP

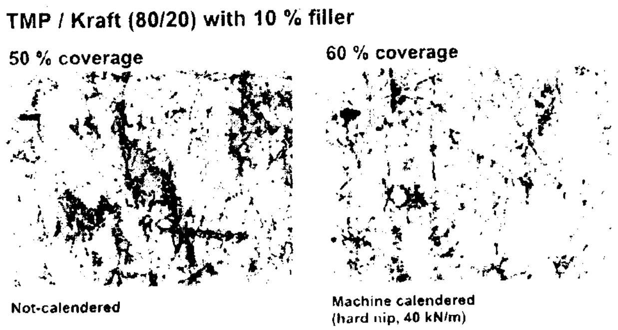


Fig. 26. Influence of calendering before coating

wide can be categorized as follows (Fig. 28).

- all off-machine 12
- traditional on-machine;
- separate calendering 12
- all on-machine 17

The all-off-machine concept (1980's) for LWC is no longer economically feasible,. Investment and operating costs are both too high. Concept development has therefore progresed from traditonal on-machine to the all on machine concept. The investment cost of a greenfield LWC line totals approximately EUR 500 million for a traditional on-machine concept with blade or film coating and off-machine multinip calendering. The all-on-machine concept reduces this investment cost by about 10%. In a rebuild case the all -on-machine concept gives 30%-40% savings in total project costs compared to the traditional on-machine concept with off-machine calendering.

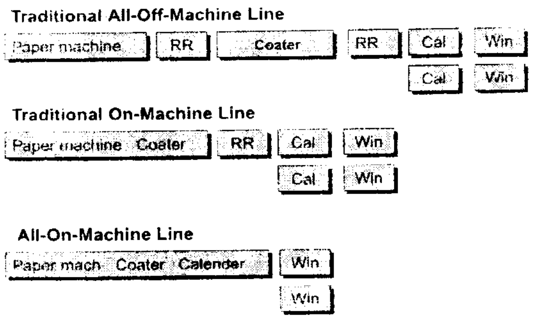


Fig. 27. LWC Line concepts

Coating Heads

Ten to fifteen years ago, practically all coaters were of the flooded nip or short dwell type. Today, there are several technical solutions that make it possible to better meet the quality targets of LWC. Increasing machine speeds have also increased the demands on coating technology. Today, the design speed of new LWC paper machines is already 2000 m/min and pilot coaters have exceeded 3000 m/min. In production, speeds in excess of 1800 m/min have been reached. There are today four types of coating heads available for LWC papers (Fig. 29). These are the OptiSpray, OptiSizer, Optiblade and OptiCoat Jet. OptiCoat jet is mainly feasible with basis weights over 65 g/m (MWC).

OptiBlade

Short dwell-type coaters have traditionally been used when coating LWC and even ULWC paper grades. The short contact time and application pressure of this type of coaters allow application of low coat weights with rather low mechanical stress. OtiBlade was developed to eliminate quality problems, such as "short-dwell streaks" or cross directional coat weight variations, at higher machine speeds. To achieve sufficient fibre coverage at low coat weights, blade coating stations run into restrictions due to an unevenly thick coating layer at a rather high blade load (2). Fibres rising through the coating layer, which causes deposits on the printing plates and reduces print gloss due to surface roughening, constitute another problem. As a result of increased machine speeds and the demand for low coat weights, the mechanical stress placed on the web naturally increases during a blade coating operation due to increased blade load. A reduced coating colour solids content reduces the blade load, but it also reduces fibre coverage and induces surface roughening (2). The OptimBlade coater (Fig. 30) features the benefit of giving better smoothness combined with the ability to run high coat weights. However, as mentioned earlier, a high solids content and a low coat weight are difficult to combine without added stress on the paper web (2).

OptiSizer C2S

OptiSizer coating is today the main technology for LWC coating. This is because OptiSizer coating has quite a few advantages over blade coating technology: low investment cost, high production efficiency with low cost furnish, and good coating coverage. This is the main driving force behind the latest investments in LWC, where almost all are based on the OptiSizer technology Fig. 28. The OptiSizer technique is beneficial for coating LWC papers since it provides coating coverage at rather low coat weights (Fig. 31). At coat weights below 10 g/m^2 side, the quality of the Optisizer C2S coated paper is

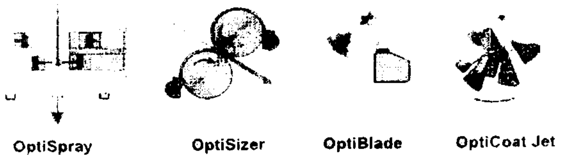


Fig. 29 Coating heads for LWC

competitive with OptiBlade in LWC offset. Above 10 g/m^2 side, the blade technique generally produces the smoothest surface. It is, however, possible to achieve proper coated LWC offset, and in the future LWC rotogravure paper qualities, with the OptiSizer C2S technique through sufficient process optimization. Both the coating color composition and the base paper sructure (including furnish) need to be optimized to reduce coating color penetration (2).

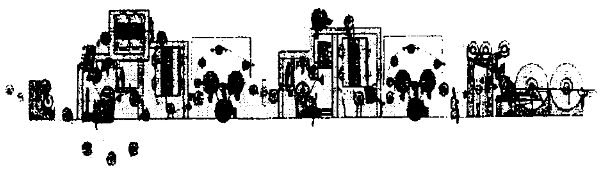


Fig. 30 Lay-out for OptiBlade or Opticoat Jet coating

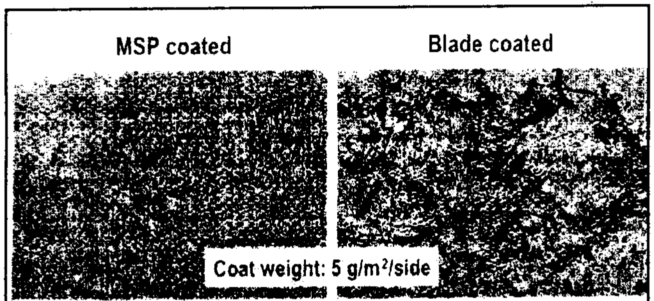


Fig. 31 OptiSizer C25 (left) and blade (right) coated UIWC Paper, where 28 g/m2 wood-containing base paper is coated with 5 g/m^2

The surface of the base paper needs to be closed to provide good coating coverage. A more open surface allows the coating to sink into the sheet and increases the coat weight needed to cover the surface (2). Qualitywise, it is feasible to produce LWC offset paper with a surface gloss of 55%-65% and a PPSs10 roughness of less than 1.5 mm. OptiSizer C2S coating also has quality advantages when brightness has to be increased by coating, or when very low coat weights below 8 g/m side are targeted. Contour type coating also has a low tendency toward mottled print as a result of an even coating layer thickness and coverage (2).

High process efficiency is achievable with OptiSizer C2S since the web is not in direct contact with the premetering device, which allows weaker paper webs to be coated. The Optisizer C2S coating process is also relatively insensitive to web defects and base paper variations. A difference of 50% in web breaks at the coating station, including blade changes at the coating station, can be calculated in favour of an OptiSizer C2S coating station. The improvement in overall paper machine line efficency can therefore be up to 2% -4% (2).

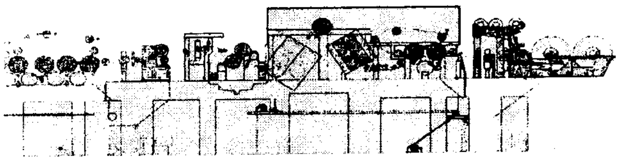


Fig. 32 The OptiSizer C25 concept with a contactless web turning air dryer

With the OptiSizer C2S concept, the paper web is coated simultaneously on both sides in one compact unit (Fig. 32). Rebuilds or news production lines are faced with less space restrictions when utilizing the OptiSizer C2S layout (inclined or horizontal configuration) compared to an OptiBlade layout (2).

OptiSpray

The new OptiSpray technique opens new opportunities for reaching LWC paper properties comparable to those produced by the OptiSizer at a reduced investment cost. The advantages come with the low application pressure where, for example, the OptiSizer technique requires a physically more closed surface to restrict the coating

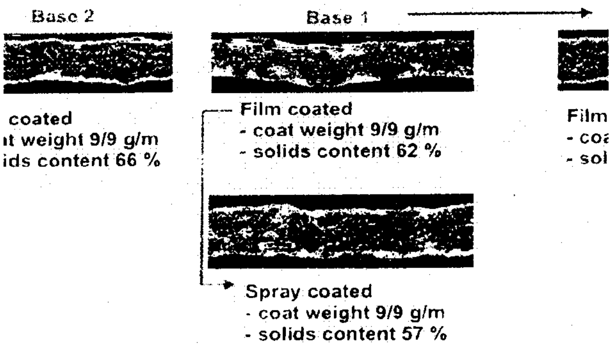


Fig. 33 The spray technique produces on extreme contour type of coating layer

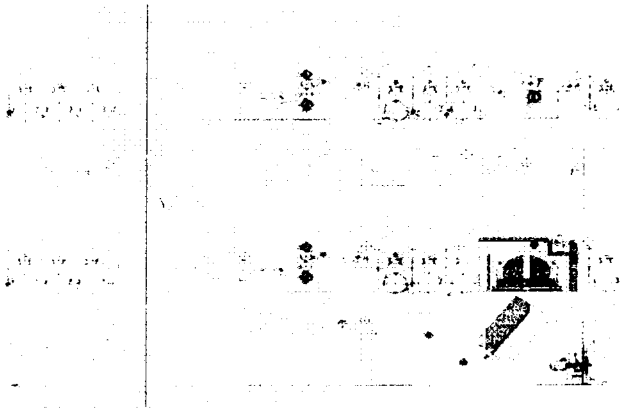


Fig. 34 A newsprint paper machine rebuild with the OptiSpray

	OptiSizer	OptiSpray
Formation bond/Blistering Tendency	better	better
Printed gloss	better (evenness)	~Equal (evenness)
Fibre Puff	better (coating coverage)	better (coating Coverage)
Paper gloss	~ equal	~ equal
Opacity/Brigthness	better	better
Surface strength	~ equal	~ equal
Stiffness/Bulk	equal	equal

Fig. 35 OptiSizer and OptiSpray quality compared to OptiBlade

colour from being pressed into the paper. This difference means that limited effort needs to be expended on changing the base paper furnish to reach targeted paper surface requires a denser furnish (e.g. lower pulp freeness and/or higher ash content) which, in turn, requires modifications in pulp preparation. Two approaches are illustrated in Fig. 33 for improving coating layer coverage and uniformity on the surface of paper. By reducing the freeness of the pulp and adding more filler (e.g. from base 1 to base 2), a more closed sheet was achieved with a more uniform coating layer. The same uniform coating layer. The same effect can be achieved by reducing the coating application pressure, which is the case when using the OptiSpray techinique. This example could make a rebuild from newsprint grade to a coated grade more cost-effective than earlier (5). A rebuild example of a newsprint paper machine is illustrated in Fig. 34, where the spray technique adds coating capabilities into the same machine space.

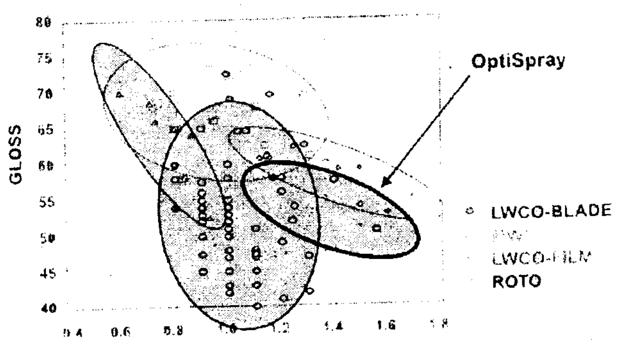


Fig. 36 The Smoothness-gloss combination with the three different coating methods

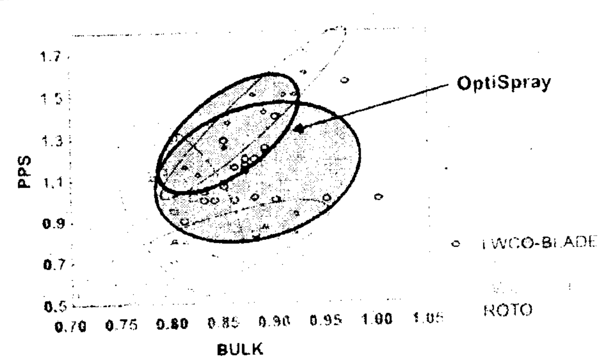


Fig. 37 The bulk-smoothness combination with the three different coating methods

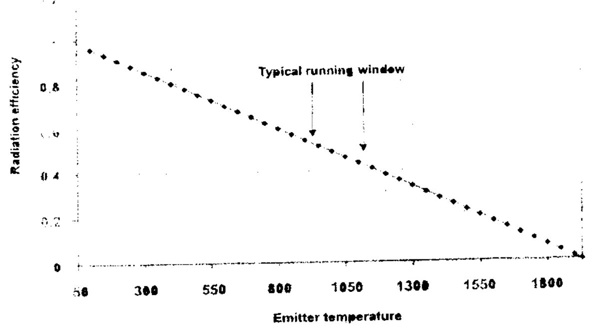


Fig. 38 Efficiency window for gas IR dryer

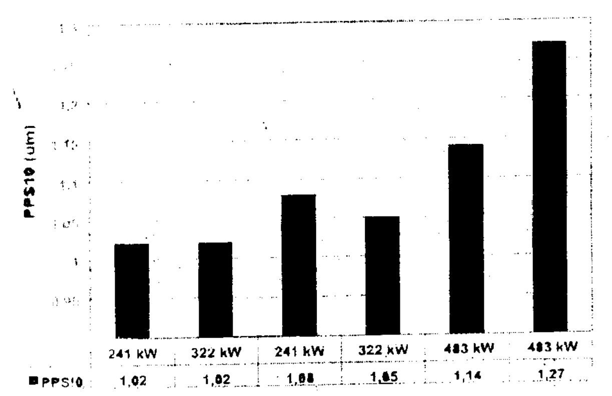


Fig. 39 Decreasing of smoothness because of fibre rising when increasing IR power in combined dryer, LWC, 10/gm^2

Quality Comparison Between Different Coating Methods

The OptiSizer and OptiSpray can achieve a surface gloss level comparable to OptiBlade-coated paper for LWC offset grades. There is, however, a diference in surface smoothness of roughly 0.2 -0.3 mm in favour of the OptiBlade coated sheet. The contour like coating produced with an OptiSizer and OptiSpray gives less brightness mottle and a visually more even surface than the OptiBlade-coated sheet. Fig. 35 presents LWC paper quality with OptiSizer and OptiSpray compared to

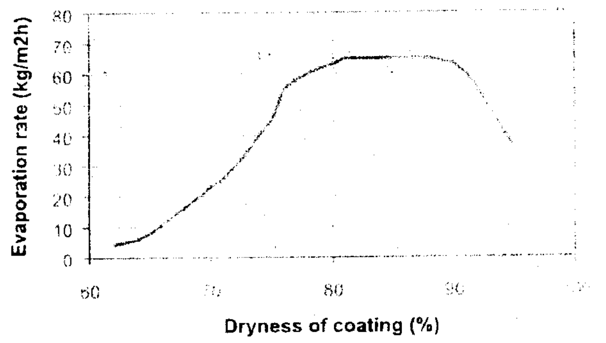


Fig. 40 Optimal drying strategy based on new all-high theory

OptiBlade. The general areas are presented (6) in Fig. 36 and 37.

Coating Drying

IR Dryers

Gas infrared dryers have replaced electrical IR dryers in coating drying solutions during the last couple of decades. The weak point of gas IR dryers is their poor energy economy . If 20°C combustion air and natural gas is heated to 1930°C in a gas combustion process, and this flame gives part of its energy content to a radiator whose temperature equals 1100°C, it is easy to see that the maximum radiation efficiency is only about 50% (Fig. 38). Part of this radiation (60%-80%) is absorbed into the web, part is reflected out to the machine hall (10%-20%), and one part is transmitted through the web (10%-20%). The maximum drying efficiency is then 40%. The high web temperatures associated with drying coated paper with IR dryers also cause such problems as fibre rising (7).

IR Air Combination Dryer

Because the energy efficiency of IR dryers is much lower than that of air or cylinder dryers, attempts have been made to combine the good features of IR and air drying. Some good combined dryer solutions are available on the market. Introducing more blowing nozzles into dryers has cured the weak points of IR dryers. One disadvantage is the fact that LWC paper that contains mechanical pulp (TMP, PGW, and SGW) suffers from severe fibre rising (7) when dried using a gas combination dryer (Fig. 39).

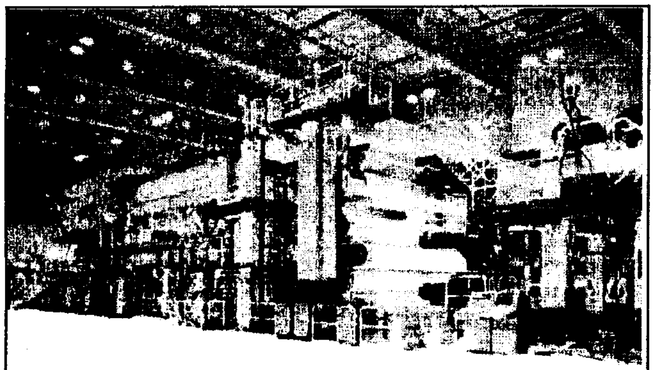


Fig. 41 On-line Optiload, UPM-Kymmene, Augsburg, Desing speed 1800 m/min

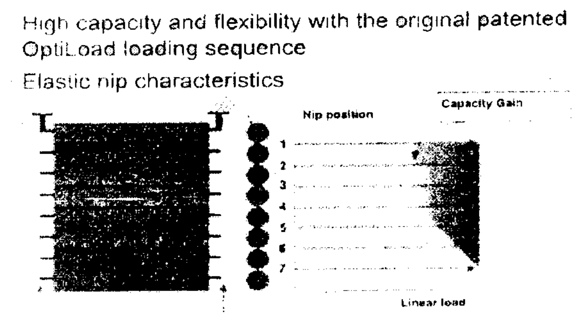


Fig. 42 The OptiLoad loading method

Air Drying

Air dryers used in LWC machines are air floatation dryers. In an air flotation dryer, the web is supported on both sides by air jets or air cushions. Special flotation nozzles constructions have been developed in order to maintain good web stability and efficient heat transfer. Two -sided air flotation dryers are always used in drying LWC paper webs because they have good and stable web runnability. That is why they can be used for all web speeds and basis weights. When using air drying, web temperature is not forced above the evaporation temperature like it is in IR drying. When drying coating with air dryers, a low web temperature makes dimension stability, fibre rising, and dusting easy to control. CD profiles are also more easily controlled when the web is cool (7). The efficiency of the Metso PowerDry dryers is over 60%, a lot higher than IR dryers.

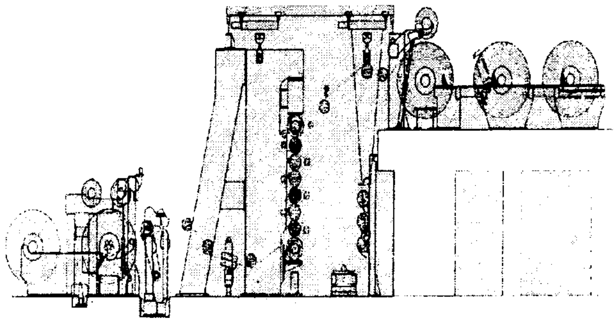


Fig. 43 OptiLoad off-line calender, design speed 1500 m/min

Cylinder Dryers

Cylinder drying can be used only after the coating layer

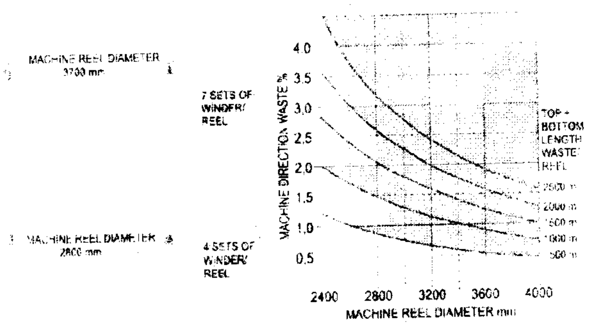


Fig. 44 Reel diameter influence. Large-diameter defect-free parent rolls maximize material efficiency

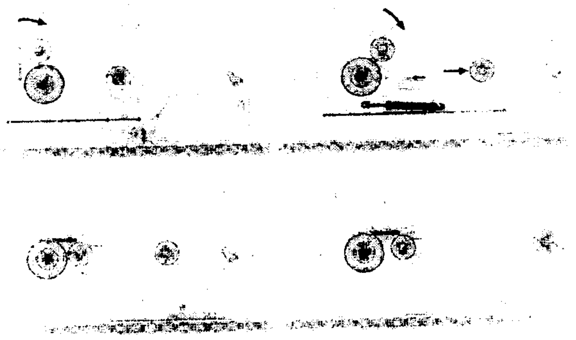


Fig. 46 OptiReel Plus reel change sequence

has immobilized and withstands mechanical contact. Therefore, the cylinder section is normally the last drying stage for the coating. In addition to its drying effect, the cylinder section pulls the paper web forward. The cylinder sections used in coating machines are relatively short, including typically 2 to 6 cylinders (7).

Effect of the Coating Drying on Paper Quality

Drying is one part of the quality formation process of LWC paper. During the past 20 years tens of studies have been completed on how drying affects quality, especially the quality of offset papers. The major conclusion is the fact that the drying rate at the so called "critical" drying stage is the main factor behind mottle, or the unevenness of the printed surface. Uneven binder migration has been assumed to be the reason for uneven surface properties and consequent uneven print, yet no conclusive proof of that has been found in surface binder content analysis. Attempts are nowadays made to apply the high-low -high theory introduced in the 1980s to drying. The problem with these studies has been the layout of pilot coaters, namely IR, free draw and air drying. When part of the coating has been consolidated in an IR dryer or free draw, the rest of the coating also has to be consolidated under the same conditions. This leads to a failed strategy where a low drying rate at the beginning of consolidation has to be simulated in the later part of the drying section (7). New drying strategy is based on the all-high theory. The evaporation rate vs. coating dryness is presented in Fig. 40. All recent new LWC lines are based on the new concept and have proven the theory in practice.

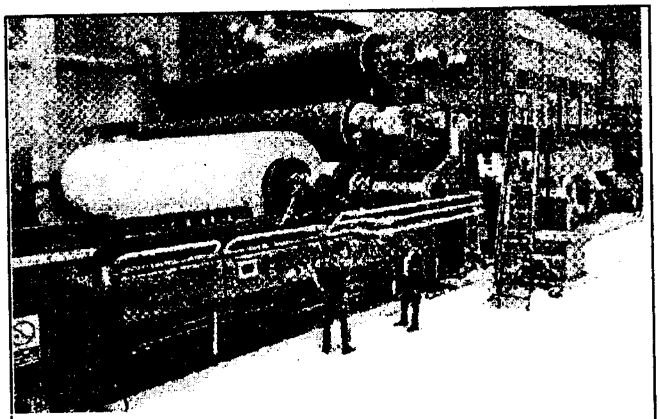


Fig. 45 Burgo Verzuolo PM9 OptiReel Plus

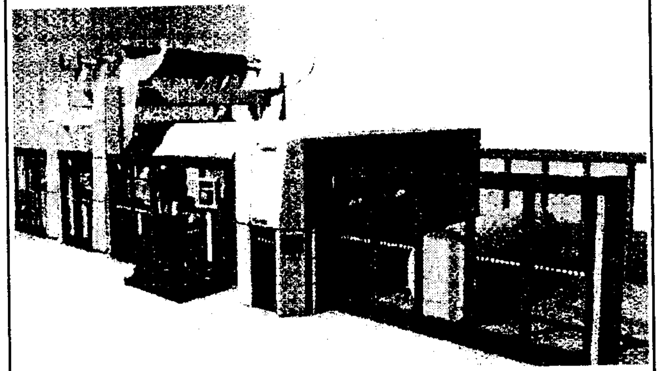


Fig. 47 WinBelt sinder

Final Calendering with an Optiload Multinip Calender

To ensure a high -quality printed image and high print gloss, the paper gloss also has to be developed to a sufficiently high level. Therefore, the final calendering of high-quality LWC grades is performed using multinip calenders, either in an on-line process or as a separate off-line process. As recently as a few years ago no calendering concept existed that could produce these grades on-line, as final calendering was performed with supercalenders using cotton or wool/cotton filled rolls that were easily marked by paper defects (holes, wrinkles etc.) With supercalenders, the maximum production speeds were 900 m/min. On-line calendering (Fig. 41) with

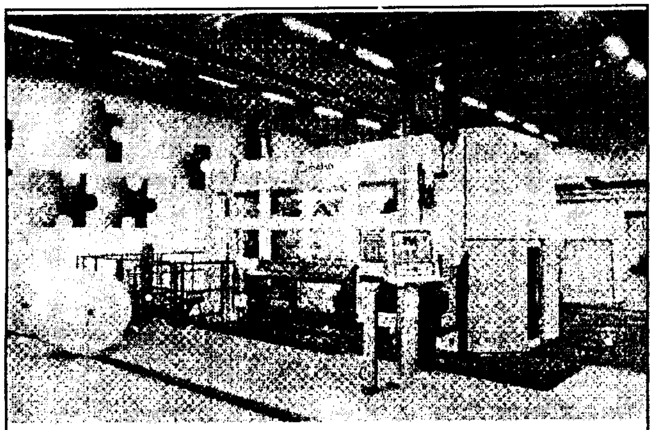


Fig. 48 WinBelt Prowinder

multinip calenders has been the most popular solution both in new paper machines and in paper machine rebuilds in recent years (Fig. 28). The good runnability of the OptiSizer coaters, together with the good moisture profiles achieved with this coating method, makes on-line calendering ideal in the production of LWC off-set grades. To be able to achieve the desired gloss level in an online process, 4-8 hot and heavily loaded nips are needed, depending on the speed of the paper machine.

In a multinip calender, nips are formed between a polymer-covered soft roll and a hot thermoroll. Metso developed the Optiload multinip calender especially for wide, fast application to overcome the technical limitations of traditional multinip calenders. In traditional calenders a major part of the loading is created by the weight of the rolls. Additional loading is created by hydraulic cylinders. The loading level increases from nip to nip as the paper travels down the calenders stack. This traditional method is particularly problematic on wide calenders where the loading level of the first nips is low and the potential of the paper and the calendering process cannot be fully utilized.

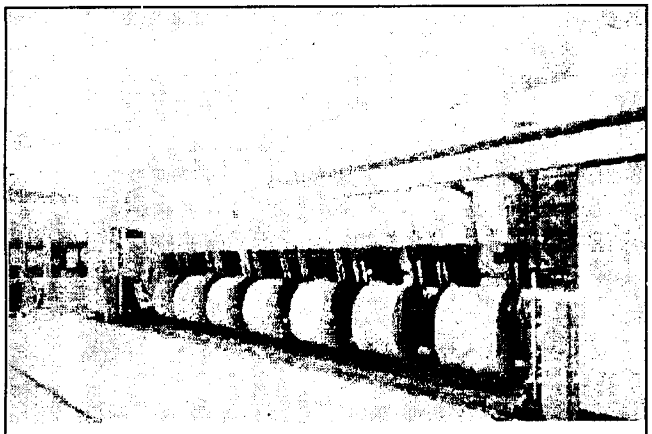


Fig. 49 WinRoll winder

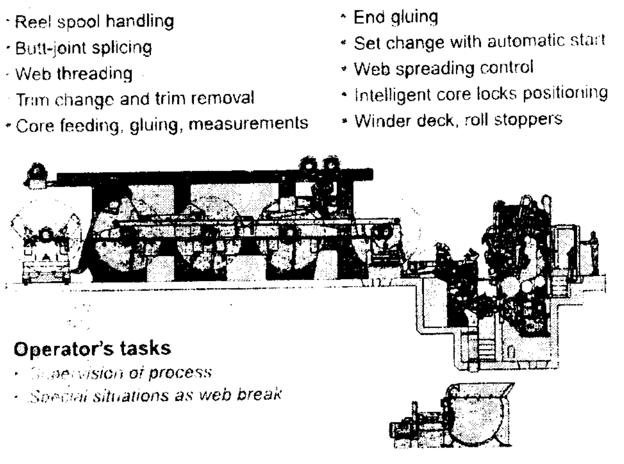
The Optiload calender has a totally different loading method (Fig. 42). The weight of the intermediate rolls is totally relieved by hydraulics and the additional loading is created by the bottom hydraulic cylinders. With this method the loading level can be the same in all nips. This method gives the calender a very wide loading window, from a low loading level to a high loading level in all nips. The capacity gain in the top area of the calender stack is the secret behind the high production speeds achieved by optiload calenders (Fig. 41). As the loading level of the top nips is at a higher level than on traditional multinip calenders, the desired paper quality can be achieved without extreme loading of the bottom nips. This ensures a longer life for the polymercovered rolls. The first installation of an Optiload on-line calender in a fast, wide OptiConcept LWC paper machine is the UPM-Kymmene Augsburg PM3 (Fig. 41). There the 8-roll OptiLoad has produced LWC paper at speeds of over 1800 m/min. The on-line process is, however, more challenging to operate and the off-line proces is therefore also sometimes applied to new wide and fast production lines (Fig. 43). If rotogravure LWC is produced, the smoothness target necessitates blade coating and leads to off-line, calendering. Two off-line Optiload calenders have enough capacity even for a 2000 m/min paper machine. As the web temperature is much lower in an off-line process, 6-8 hot nips are needed for final calendering. Splicing unwind and wind-up sections ensures good efficiency of the calenders as there is no need for threading the calender at every parent reel change. As the paper web travels during the splicing sequence, the thermo roll temperatures are also kept at the right level, which leads to more stable paper quality.

Reeling

The standards for a paper machine reel are:

- to maximize line efficiency by minimizing reeling waste and breaks
- to produce large-diameter parent rolls with excellent unwinding characteristics
- to preserve web quality

Right from the prototype delivery, OptiReel technology has pushed maximum parent roll diameters to new heights. What used to be 2.5 m is now 3.7 m and more, without reeling defects. This means more sets in a parent roll, fewer turn-ups, and better time and material efficiency at the reel and winder (Fig. 44). Based on 10 years of second generation reeling experience and 67 running references, the OptiReel concept was further developed into the OptiReel Plus. Currently 24 units are running (Fig. 45), and several more are on the order books bringing the total number of OptiReels to over 100. Twenty-two of these are used in LWC production as PM and coater reels



- Reel spool handling
- Butt-joint splicing
- Web threading
- Trim change and trim removal
- Core feeding, gluing, measurements
- End gluing
- Set change with automatic start
- Web spreading control
- Intelligent core locks positioning
- Winder deck, roll stoppers

Operator's tasks

- Supervision of process
- Special situations as web break

Fig. 50 Continuous Winding concept

and rereelers. These include all the latest Metso Paper LWC line references and many old reel replacements. The reeling process has taken a huge leap forward with the introduction of on-line calendering technology. The base requirement has been even better parent roll structure and hence better reeling parameter control due to smoother and glossier paper and higher running speeds. At high speeds more air moves along with the web and machine elements, ending up in the parent roll. This can cause parent roll structure and quality problems due to lower paper-to-paper friction (smooth,glossy, low porosity LWC paper). Air is controlled with proper reel drum coating and grooving. Parent roll oscillation, a well known reeling tool from supercalender windups, has been integrated into the OptiReel Plus, As paper density nears 1200 kg/m^3, even the smallest CD profile variations cause roll hardness differences, especially when winding tens of thousands of paper layers on top of each other. These can be evened out with parent roll CD oscillation. The OptiReel Plus is designed for reliable reel change (Fig. 46). For lightweight grades a high speed full -width knife is used to cut and steer the web to the empty reel spool . The new reel spool is already down on the reeling rails and the web is cut after the primary nip to ensure high turn up efficiency.

	WinRoll	WinBelt
Nip load control	Multi-purpose Bleted rider rolls	Belt Suport
Winding Force	Surface Traction	Surface Traction
Continuous Winding	Standard	Availabe
Design Speed	3000+m/min.	3000 m/min.
Set change	30 Sec.	50 Sec.
Max roll #	1800	1800
Max roll width	4000 + mm	4000 + mm
Min roll width	400 mm (edge rolls)	142 mm
Different core O in the same set	yes	no
Surface traction control.	individual for each rolls	for each set
Roll release	two sides	one side

Fig. 51 Winding concept comparison, LWC grades

Winding

The present and the future requirements for the winding process can be divided into three main categories:

Capacity

A winder has to have enough capacity to match increasing paper machine speeds. In rebuild cases, when the paper machine speed is around 1200-1500 m/min, one winder must handle the whole production.

One-Man Operation

One operator should be able to handle the entire winding process under normal circumstances. Higher level of automation; manual work should be minimized eliminated to create a continuous winding process

Integrated Noise Reduction

Noise level reduction is becoming more and more important with winding speeds increasing past 2500 m/min.

Winder Types

Three solutions for winding LWC can be provided These solutions are the Win Belt winder (Fig. 47), WinBelt Pro (Fig. 48) and the WinRoll winder (Fig. 49). Both Winbelt and WinRoll winders are high-capacity winders. Win Roll is the highest capacity winder available in the market. Both WinBelt and WinRoll can be equipped with continuous winding concept (Fig. 50).

WinBelt gives more flexibility in roll widths. On the other hand, WinRoll gives the ability to use different core sizes in the same set. A detailed WinBelt and WinRoll comparison is given in (Fig. 51).

Winbeit ProTakes Capacity to New Heights

WinBelt Pro is the latest addition to Metso Paper's renowned winder family. It is based on the proven WinBelt winding method, but contains new features that significantly speed up winding and its related sequences. They, in turn, boost the winding capacity to a new level.

The new WinBelt Pro winder features:

- Up to 15% more capacity
- A completely new set change -now in 12 seconds
- New active tools to avoid vibration and bouncing

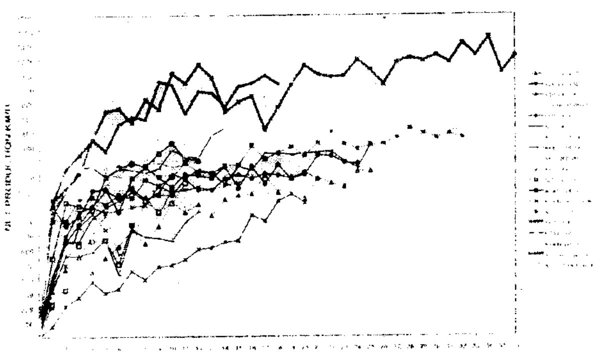


Fig. 52 Three latest startups of Metso Paper LWC lines compared to others

during high-speed winding:

- Adjustable rear drum and belt bed nip distance is used to avoid resonances
- Proactive feedback vibration damping system
- Intelligent core chucks

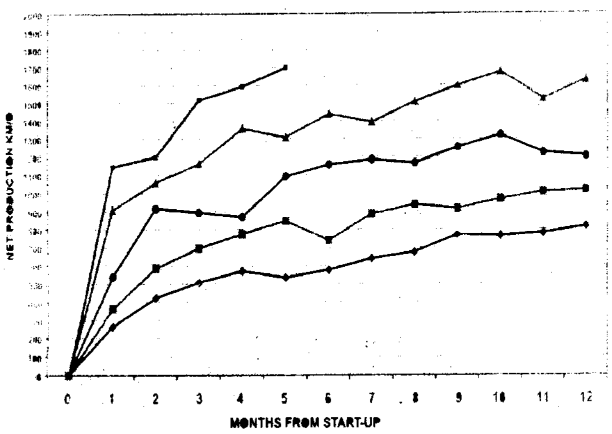


Fig. 53 Startup development of LWC lines from the early 1980's

One of the keys to Winbelt Pro's outstanding winding performance is its unique winding angle that allows a long nip of up to 55 cm. As the roll diameter increases, most of the roll weight is transferred to the belt bed. The nip load distribution of the rear drum and belt bed is actively controlled through the correct winding angle and belt tension (as function of roll density and diameter). The extremely flexible large surface area of the belt nip minimizes winding pressure. Every subprocess and raw material along the fibre and paper making line has an effect on final LWC quality and mill efficiency. The final quality of the paper in fibre to LWC paper process can be optimized through pilot trials. With a good process development plan and a single -source supply, the mill can enter the LWC market soon after startup at a high production rate. Three cases of the latest LWC projects give a good example of this type of cooperation and Metso Papers extended range of products and services. These customers produced high-quality LWC paper very soon after start-up with a world record startup curve (Fig. 52).

CONCLUSION

Every subprocess and raw material along the fibre and paper making line has an effect on final LWC quality and mill efficiency. The final quality of the paper in fibre to LWC paper process can be optimized through pilot trials. With a good process development plan and a single-source supply, the mill can enter the LWC market soon after startup at a high production rate. Three cases of the latest LWC projects give a good example of this type of cooperation and Metso Paper's extended range of products and services. These customers produced high-quality LWC paper very soon after startup with a world record startup curve.

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