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# Advanced Paper Machine Concepts for the Production of Packaging Papers

D. Kruska and P. Mirsberger
Voith Sulzer

## 1. Introduction

An analysis of the market for packaging grades shows the following conspicuous trends:

- The required basis weights are continuously decreasing whilst the demands made on paper quality are increasing.
- Machine speeds and the use of secondary fibers are growing.
- To remain competitive, paper producers are making every effort to minimize production costs.

In order to fulfill the growing demands machine concepts for the production of packaging papers have undergone several innovations in recent years.

Multilayer headboxes in combination with Roll-Blade-Gapformers in the forming section, two shoe presses in the press section, single tier dryer groups in the first part of the dryer section, ropeless tail feeding and size presses with NIPCO rolls are typical innovative components.

The first paper machine which was rebuilt by Voith Sulzer using some of the components listed above already started up in Oct. '92. In the meantime Voith Sulzer has sold several rebuilds and 6 complete new paper machines equipped with multilayer headbox, DuoFormer CFD Gapformer and Tandem NipcoFlex presses.

The key components of this efficient machine concept for the production of packaging papers will be discussed.

## 2. Sheet forming

The successful use of gapformer technology in the production of printing papers logically leads to the use of this sheet forming concept also for the production of packaging papers with higher basis weights.

The combination of Gapformer and multi-layer technology enables the web to be built-up of layers with low basis weights. At the same time different raw materials can be used in the individual layers. In this way, sheet characteristics can be structured to suit the end use of the product .

The production of packaging grades using two different furnishes out one headbox has several advantages. An important one is that the investment costs as well as the operating costs of a two-layer forming section are considerably lower compared to a two ply sheet forming concept.

Since packaging papers such as Linerboard are often printed on the top surface the top side has to be of higher quality. This requirement can be taken into account in waste paper stock preparation by fractionating into long-fibre and short-fibre components for greater economy **(Fig. 1)**.

Another objective of two-layer sheet forming is to keep down the basis weight of the more "expensive" top layer while at the same time using low cost raw materials in the bottom.

### 2.1 Two-layer Step Diffusor headbox

Uniform fibre distribution in the micro scale range (formation), good layer purity and coverage are important quality characteristics for a layered sheet. The main requirement is separation of the two pulp streams.

The Step Diffusor headbox therefore comprises two independent headboxes combined in a single unit. Each layer has its own stock feed system with separate fan pump, distributor, diffusor block and nozzle chamber. The hydraulic concept - proven in practice more than 500 times - has been taken over with minor changes **(Fig. 2)**. The Step Diffusor block of each layer generates uniform disturbance-free flow across the machine width.

In order to ensure good layer purity special requirements concerning headbox design need to be observed. Turbulent mixing of the neighbouring suspension jets esp. at higher machine speeds has to be avoided as far as possible. The two lay-

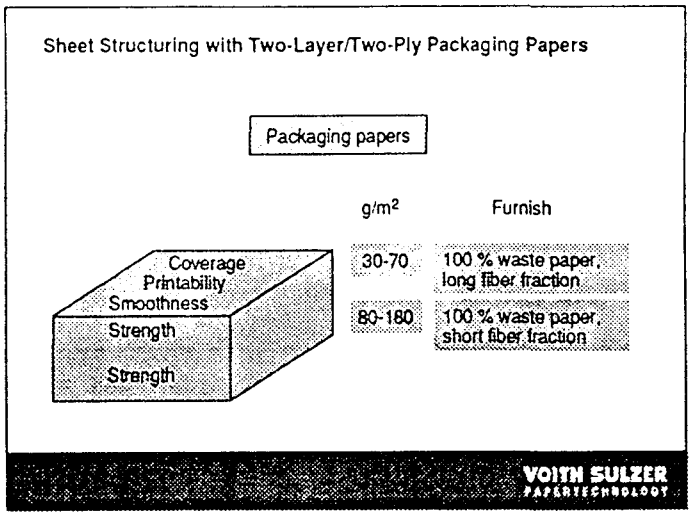


Fig. 1

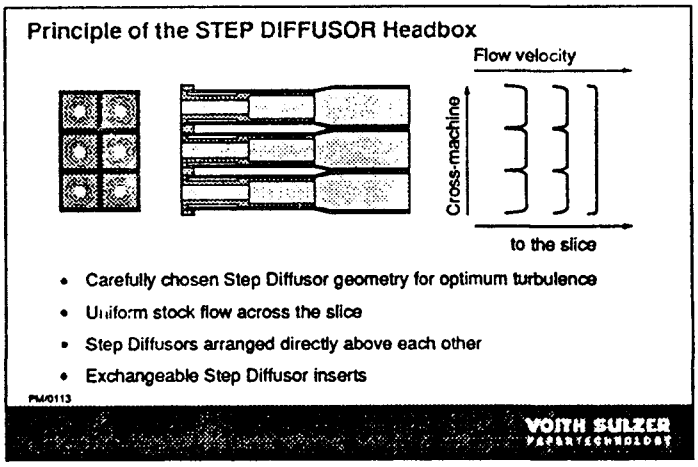


Fig. 2

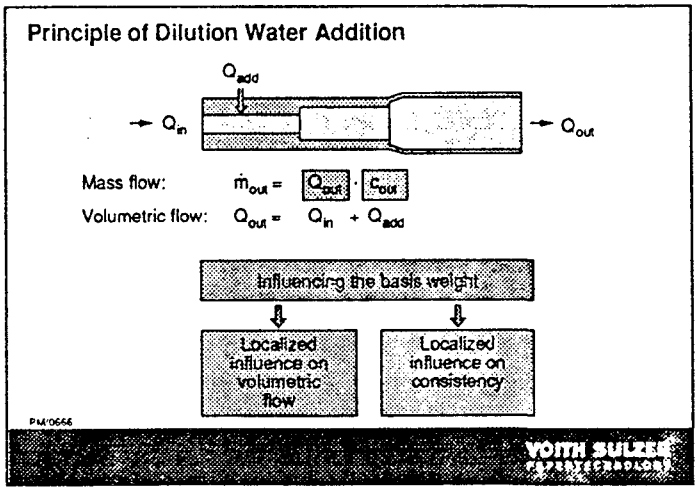


Fig. 3

ers are therefore kept apart as long as possible and then fed quickly to the sheet formation zone in a short free jet. The free jet exiting from the headbox is only approximately 200 mm long.

By dividing the nozzle in two sections, different consistencies for both layers can be used in order to optimize the formation as well as the layer purity. In addition the nozzle geometry is specially designed to ensure high stability of the jet when leaving the headbox.

*The most important requirements for controlled, limited mixing of the pulp jets in* the headbox and forming zone are a short and stable jet and pulsation free dewatering on a forming roll.

## 2.2 JETCO dilution water profiling system

If the CD basis weight profile is corrected by adjusting the slice lip locally, cross-flows are generated and the fiber orientation profile and layer purity are negatively influenced. The Module Jet or JETCO dilution water profiling systems have been developed to ensure a uniform slice gap across the machine width.

The governing principle to be followed for a sectional change in basis weight without affecting the fibre orientation is to keep the total flow to the slice in each section constant. Only the ratio between main flow and dilution water flow, i.e. the consistency of the suspension leaving the headbox, is adjusted **(Fig. 3)**. Numerous metering valves driven by an electric motor are arranged adjacently across the machine for controlling the dilution water flow. The dilution water is fed directly to the step diffusor block where the generated turbulence is used for mixing.

Due to the small spacing of the JETCO dilution water supply lines (66 mm), the response width in the paper for basis weight adjustments is less than 100 mm. This means that even basis weigth deviations with a small wave length can be contolled. Several JETCO installations are already running sucessfully on different grades.

With the two-layer headbox the basis weight cross profile is controlled by adding dilution water locally to the bottom layer of the headbox. The base layer contributes the larger portion of the total basis weight and higher consistencies are used. The headbox still has a slice lip but is not equipped with spindels. A parallel slice gap is ensured by manuell adjusting of the slice lip profile.

The main advantages of the JETCO dilution water profiling system for multi-layer

headboxes and packaging papers are:

- excellent CD basis weight profiles due to the small spacing of the actuators and the small response width;
- more uniform strenght properties across the width due to the uniform fibre orientation;
- good coverage of the top layer since the profiling will be done in the bottom layer without affecting the top layer.

A further advantage of the dilution water profiling system is that due to the lack of spindels the multi-layer headbox can be positioned more close to the gap. The free jet length can be considerably shortened which improves the layer purity.

### 2.3 Duoformer CFD - Roll-Blade Gapformer

When producing packaging papers such as corrugating medium and testliner, the sheet formation concept must ensure high strength characteristics both in the machine and cross-machine directions. The DuoFormer D with two-layer Step Diffusor headbox meets these requirements.

The DuoFormer CFD **(Fig. 4)** is a typical roll-blade gapformer and combines the merits of roll formers and blade formers.

A large diameter high drainage suction forming roll with an appropriate wrapping angle initiates drainage and formation of the two outer layers. Drainage is then continued up to and beyond the immobilization point by the subsequently arranged D-section. A number of suction boxes and the suction couch roll further increase the consistency. The two wires separate over a suction box.

The radius of the suction forming roll ensures a large angle between the top wire and the flung-off white water. Thus the white water is separated from the wire in a uniform manner and immediately after its penetration through the wire. This further contributes to a uniform CD basis weight profile.

The two wires converge on the forming roll, wrapping it at an angle of up to 100 degree. Due to the high drainage pressure between the two converging wires, the suction forming roll also provides a high drainage rate. It discharges approximately 60% of the white water within a drainage length that is only 40% of that of a blade former. This reduces the overall dimensions of the unit.

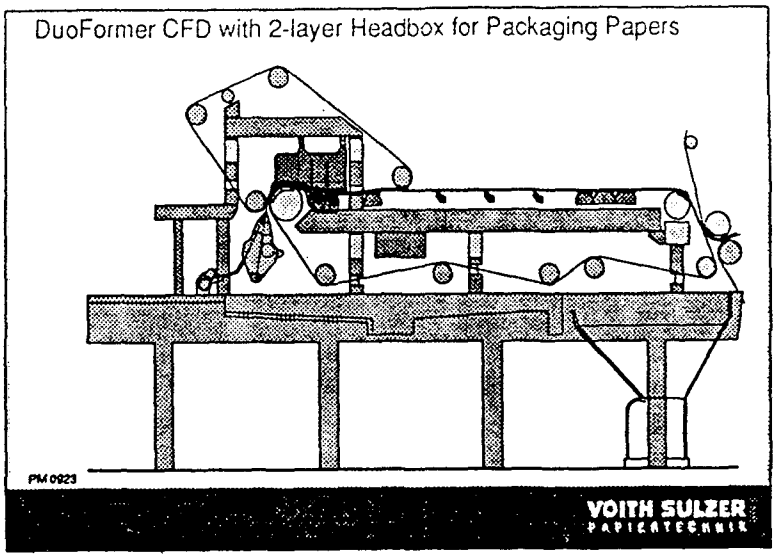


Fig. 4

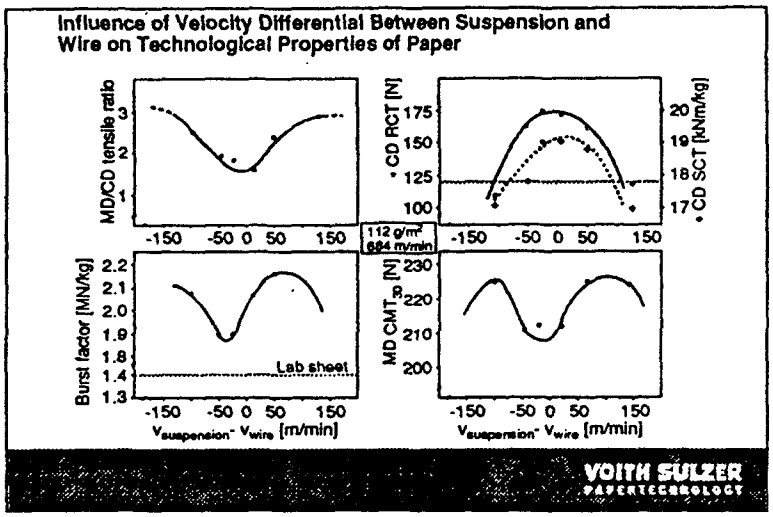


Fig. 5

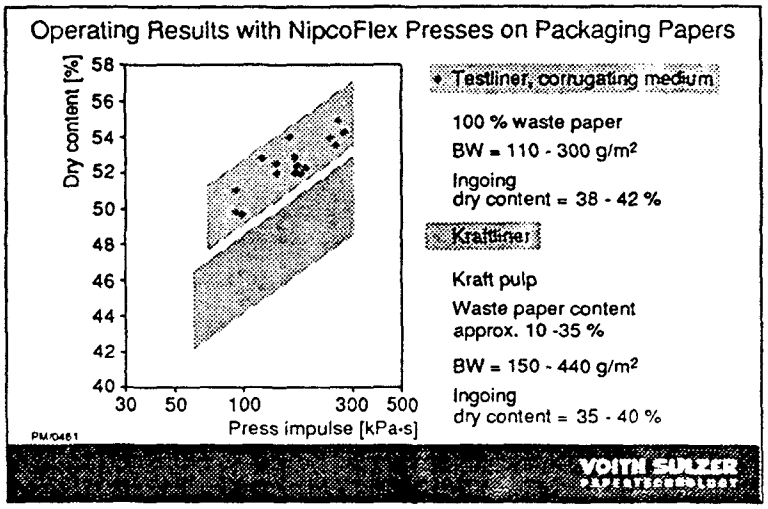


Fig. 6

The forming roll favours fiber retention because no pressure variations are generated here. Shooting the stock jet between the breast roll and forming roll is simple, formation is not harmed and fiber orientation can be influenced over a wide range.

The D-Section consists of a top unit and a bottom unit, each of them with a large number of ceramic blades. The top and bottom blades are staggered so that the two wires form a converging channel with a slight zig-zag pattern. The white water squeezed through the top wire is discharged via vertical channels and weirs into vacuum augmented chambers. The white water squeezed through the bottom wire goes directly into a pan. The white water is split approx. 50:50 % between top and bottom wire.

The blades create pressure pulses and shear forces in the stock suspension. Their intensity depends on the wire tensions and on the pressure in the air hoses. Thus the pressure in the hoses is a mean to control formation. Due to the large number of blades, the pressure amplitudes can be kept low to obtain an adequate effect on formation. Therefore the wash-out is moderate and influences the retention to a minor degree only. Wet retention is enhanced by the fact that the two outer layers formed by the suction forming roll act as filter mats. With a suitable shoe length, furnishes which are difficult to dewater or higher basis weights can be run.

The D-section provides a perfect support on the wires both in machine and cross directions. This keeps them from forming wrinkles and from running apart. This fact minimizes sheet defects. In connection with the supporting effect of the forming roll it also eliminates the need for the installation of spreader rolls.

The forming shoe ensures very good formation. Despite increased consistencies up to 1.5% being run, formation quality can be improved significantly leading to improvements in paper properties. The increased headbox consistencies further reduce the total specific flow to the headbox and improve the retention.

## 2.4 Rush/Drag curves

For packaging papers a high strength in cross direction is a must today. With increasing operating speeds good adjustment of MD/CD ratio must still be possible. With the roll/blade Duoformer CFD the MD/CD tensile ratio will continue to be easy to adjust compared with fourdriniers and other gapformers and a low MD/CD ratio can be achieved.

Most strength values depend on fibre orientation. The DuoFormer D enables the papermaker to adjust fibre orientation and hence the MD/CD tensile ratio by altering the velocity differential between suspension and wire (rush/drag curves), and it allows a very wide range of MD/CD tensile ratios.

**Fig. 5** shows the rush/drag curves for some of the most important strength characteristics of packaging papers measured at the reel of a commercial machine.

The MD/CD tensile ratio curve is relatively wide and the flanks of the curve are not as steep as with a fourdrinier. The result will be a uniform MD/CD profile across the machine with only small deviations of main fiber orientation from machine direction. In spite of the free draws in the dryer section as well as before and after the size press, products manufactured on the rebuilt machine show minimum MD/CD tensile ratios of 1.6, measured at the reel.

A particular advantage of the DuoFormer D over the traditional fourdrinier is ease of adjustment. With corrugating medium, a high MD/CD tensile ratio is desirable, with testliner on the other hand the lowest possible tensile ratio, in other words a square sheet, is required. The main technological characteristics can be adjusted via the velocity differential between jet and wire. This gives the papermaker a very wide range of adjustment for optimizing sheet strength characteristics. MD/CD tensile ratios at the reel of 1.6 to 3.3 can be set over a velocity differential range of -120 to +120 m/min between suspension and wire with roughly the same good formation. On a fourdrinier this range is limited normally to -20 to +20 m/min. Burst, RCT and CMT values can be adjusted with equal ease.

## 3. Pressing - Tandem NipcoFlex press

Shoe presses are state of the art for the production of packaging papers requiring high dry content and high strength. (**Fig 6**) summerizes the dry contents attained with NipcoFlex presses on various machines and with different furnishes as a function of press impulse. The attainable dry content of the waste paper based products is between 50 and 54%, while in the case of Kraftliner dry contents of 45 to 50% were obtained.

The main technological properties of testliner and corrugating medium are tensile, burst, plybond, RCT and CMT. The extent to which the main strength properties can be influenced by a shoe press is shown in **Fig.7.** on Testliner made from 100% waste paper. As expected density increases with increasing dry content, while strength increases on average by 1 to 2% for each 1% increase in density.

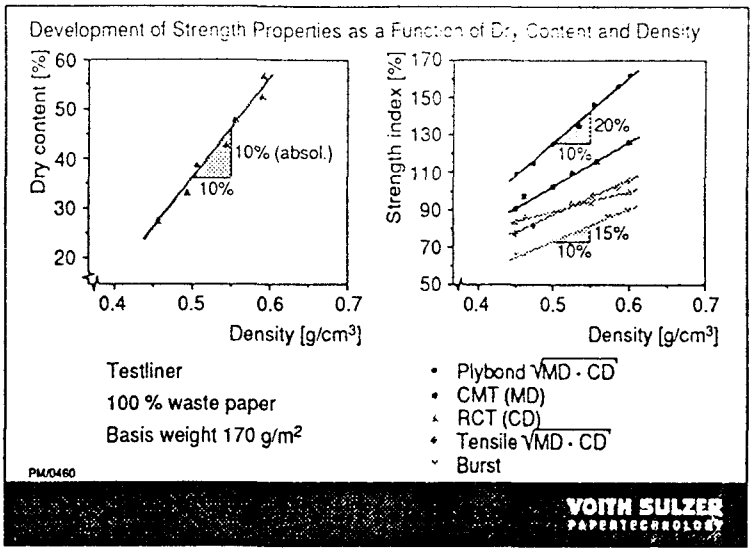


Fig. 7

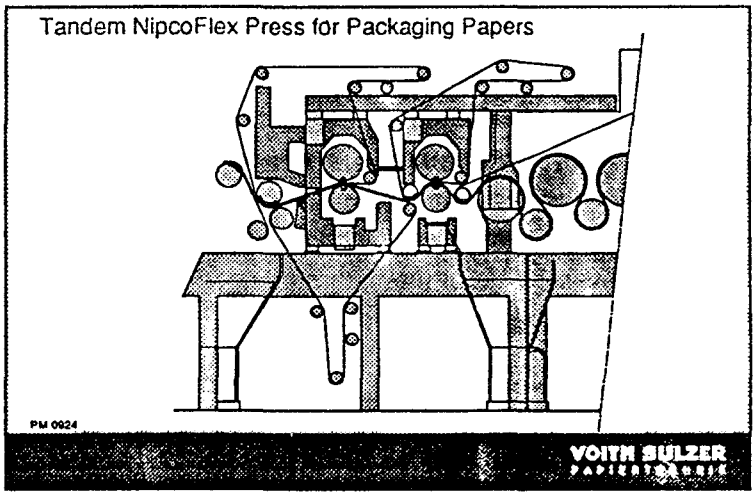


Fig. 8

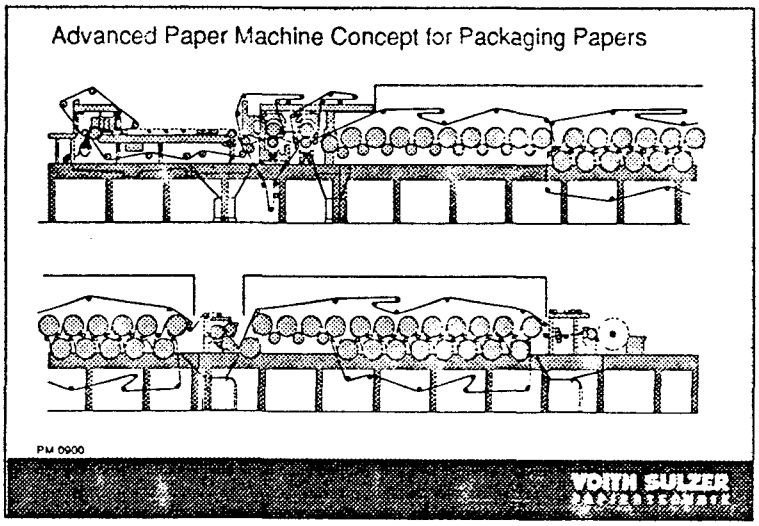


Fig. 9

The improvement in strength will also compensate for decreasing quality of waste paper furnish.

The joint venture between Voith and Sulzer in paper technology has brought a symbiosis of the best products from both sides. Based on more than 200 years of accumulated operating experience with closed shoe presses, the greater patent freedom now applying has been exploited to unite the advantages of both concepts in a single product: the **NipcoFlex press.**

This symbiosis is not limited to the roll and shoe alone, but also includes the backup roll - in other words, the entire press system . Since the market launching of this concept, more than ten NipcoFlex presses have already been sold.

The new NipcoFlex roll combines the shoe design of the Flexonip press with the pressing system of the Intensa press. Pressed against the roll by individual elements, the shoe is made up of a top and a bottom part which are thermally insulated from each other. As a result, thermal deformations are largely avoided. The shoe is asymmetrical to the pressing direction, displaced towards the ingoing nip. The flexible roll sleeve is likewise asymmetrical to the pressing direction, thus allowing a more favourable sleeve intake geometry. Lubrication between the press shoe and roll sleeve is purely hydrodynamic. To this purpose a lubricating oil distribution pipe spreads cool oil uniformly over the sleeve immediately after the press nip, thus ensuring freedom from wear. An added benefit of this single-source system is the above-average life of the yarn reinforced QualiFlex press sleeves, a patented product of Voith Sulzer Paper Technology.

As backup to the NipcoFlex roll, the Nipco-P roll combines the advantages of the classical Nipco roll with the stable bearing positioning of the profile roll. In fact the designation Nipco-P stands for 'position-stable'. The roll bearings are spaced directly opposite the main roll bearings, and therefore unaffected by the inevitable beam deflection. This brings some important advantages with regard to press operation. According to the wellproven Nipco principle, the roll shell run on internal hydrostatic support elements.

**Fig. 8** shows the NipcoFlex press concept for packaging papers with two inverted shoe presses in tandem and closed web run. This concept is already running successfully in several installations. Both NipcoFlex rolls are installed in top position, the first press is double-felted and the second single-felted with the felt on top side.

This Tandem NipcoFlex press concept provides the following significant advanta-

ges with regard to improved quality and greater efficiency:

- High runnability and low wet web stretch in MD due to the closed web run right into the dryer section. Web drop-off from the second top felt is prevented by the arrangement of the suction felt guide roll.
- Easy web handling: The web is picked up from the wire over its entire width by the pick-up roll, and during tail feeding and at web breaks the full web width runs over the plain bottom roll of the second press. Here it is doctored off into the press broke pulper.
- Both shoe presses are designed for a line load of 1500 N/mm. High dry content after the press section even at increased machine speeds are possible keeping the specific drying costs low.
- Improved paper quality: The long dwell time provides uniform cross machine moisture profile, uniform compression in z-direction and improved strength characteristics across the width.
- A minimum number of spare rolls is required.

## 4. Drying - Combi Duo Run

Main requirements on the drying section of fast running machines are high runnability and high specific evaporation capacity as well as uniform paper properties across the width.

The Voith Sulzer DuoRun dryer section with its overhead drying cylinders and the DuoStabilizers on top of the drilled guiding rolls meets all these requirements. The Combi DuoRun is a combination of single tier dryer groups in the first part and double tier dryer groups in the second part of the dryer section. (**Fig.9**).

Immediately after leaving the last press nip, the web is sucked on to the fabric of the first dryer group by a suction guide roll and fixed. It is then supported on the fabric ensuring stable running and reducing the risk of a break to a minimum. In case of a break the waste material falls easily on a conveyer belt. This principle is used not only in the first part of the predryer section but also after the size press where the wet web strength is low. High availability will be ensured.

Since the web is fixed to the fabric the longitudinal extension and lateral shrinkage are low. The final sheet characteristics esp. the CD strength properties will be more uniform across the width.

On the operator side a transfer zone is incorporated in the DuoStabilizers and the drilled rolls for ropeless tail feeding. During the transfer procedure vacuum is applied to the transfer zone only. This ropeless tail transfer system is reliable and trouble free. Tail removal from the cylinder and attachment to the fabric is assisted by air blow nozzles.

## 5. Sizing - NIPCO size press

Sizing of the sheet in the size press is a prerequisite for sufficient paper strength if mixed waste paper is used for the production of packaging papers. Sizing improves the strength characteristics of the sheet considerably.

The improvement depends on the amount of starch taken up by the paper and on its penetration into the sheet. The higher the machine speed the more difficult it is to get a sufficient penetration of the starch. With increasing machine speed higher roll diameters are required to prevent starch jumping. In order to overcome the high hydraulic pressures in the resulting wide nip, the line load of the size press has also to be increased.

On the other hand an uniform line force distribution across the width is required. The use of softer roll covers is limited by the high speed and high line load.

In order to solve the conflicting requirements a NIPCO roll can be used for the size press of fast running machines. Due to the adaption of the NIPCO roll shell to the deflection of the mating roll a uniform line force distribution across the width is achieved over a wide line force range. The penetration of the starch and the final strength properties will also be very uniform in cross direction.

As an alternative to the conventional pond type size press a Speed Sizer with metering size application can be used at higher machine speeds. The starch concentration can be increased up to 12% reducing the length of the after dryer section.

With optimized starch a similar penetration and the same increase in strength can be achieved. On the other hand a higher cleanliness of the furnish is required to ensure a high runnability.

## 6. Reel

The reel at the end of the machine is completely automatic controlled. A reel hardness controller is incorporated for uniform and reproducable tambour quality and for minimized paper losses during tambour changes.

## 7. Summary

Up to now 5 Voith Sulzer paper machines with multi-layer headbox and Gapformer are sucessfully running on papckaging papers. Linerboard, testliner and corrugating medium is produced in the basis weigth range from 105 to 275 g/m$^2$ at machine speeds up to 900 m/min.

The next one, starting up in Oct. '96 in Germany, will be the world's fastest paper machine for packaging papers. The 5.6 m wide machine is designed for a maximum operating speed of 1200 m/min. Approx. 220.000 tons of corrugating medium and testliner based on 100 % waste paper in the basis weight range from 90 to 160 g/m$^2$ will be produced each year. An expansion stage planned for the future is intended to increase annual output to 280.000 tons.

This machine will not only be the fastest one for packaging papers, it also comprises all described innovative key components which are available today in order to fulfill growing demands of the future with regard to quality and productivity.

The concept of this advanced machine is shown in **Fig.9**.