Multi-Layer and Multi-Ply Concepts – Driving forces and advantages

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The discussion of multi-ply/multi-layer concepts is as old as the paper industry itself. Though the limitations of modern wet part concepts are quite different from those of the past, the basic principles are still valid. In order to minimize the total cost per net ton of paper, production and high fibre yield have been the main driving forces for the development of advanced forming concepts. This paper focuses on the reasons for multi-ply/multi-layer technology from the past until today and introduces a new multi-ply/multi-layer concept which offers additional advantages.

Paper quality and production

When installing a new paper machine, the layout has to be done in a way that the market quality demands can be fulfilled very soon after start-up *(Fig. 1)*. After optimization, a new paper machine normally exceeds the quality demands, enabling the papermakers to increase production in order to reduce the total cost per net ton. But this will also reduce the quality level.

In addition, the general furnish trend has to be considered and may change the cycle time until the market quality level is reached. At this point at the latest, the question will come up how to speed up the machine further and simultaneously maintain the quality level.

In case the machine production is limited due to the wet part, there are mainly two options: add one more ply or switch to the next forming generation.

Multi-ply cylinder mould formers

In cylinder machines, multi-ply forming was required because of the very limited production of one single former. The operating window of a recent cylinder mould former is shown in *Fig. 2*.

Production can be increased by adding additional plies, as long as the operating

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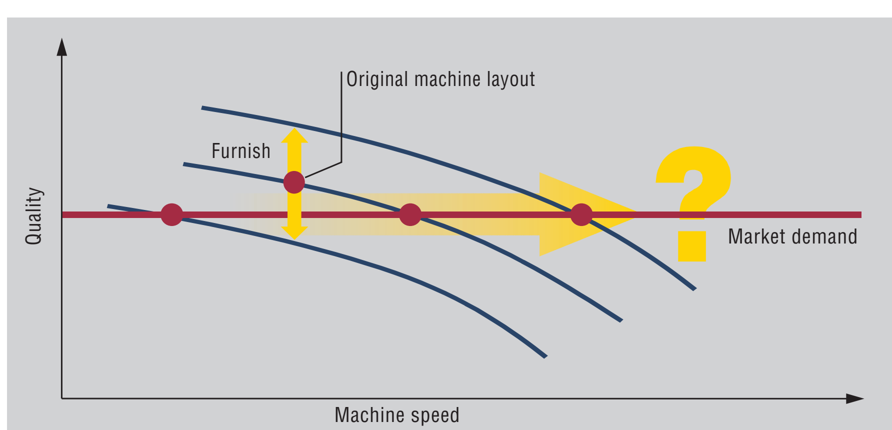

Fig. 1: Effects of machine "squeezing".

Fig. 2: Basis weight pick-up of a cylinder mould machine.

Fig. 3: Forming concepts – Design limits for board machines.

Fig. 4: Forming concepts – Design limits for packaging paper machines.

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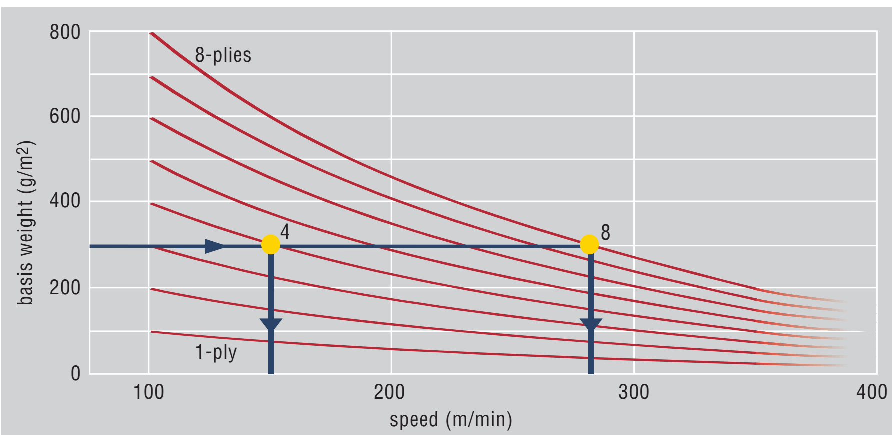

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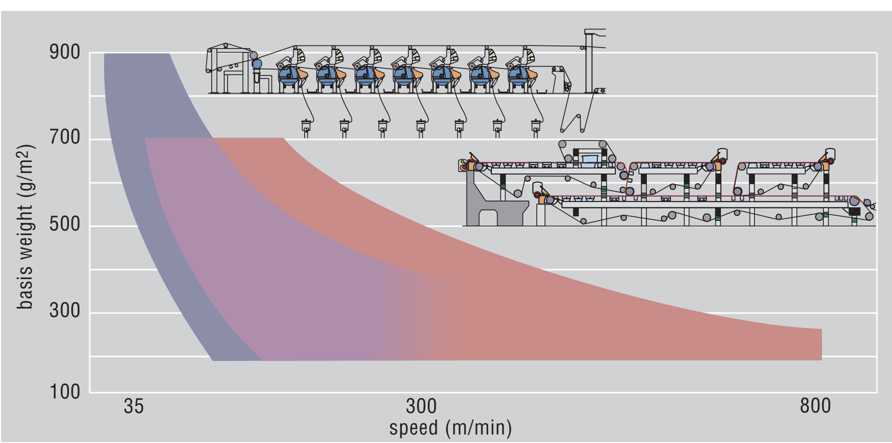

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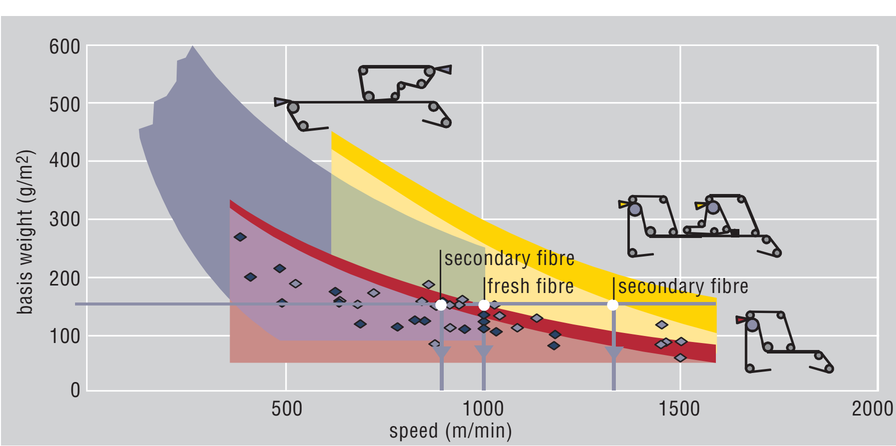

speed is not a limiting factor. To overcome the speed limitation, an upgrade to the next forming generation is required.

However, such concepts still reach reasonable production levels for board grades.

Forming concepts – design limits for board grades

Multi-ply fourdriniers combine the advantages of single fourdriniers with those of multi-ply cylinder mould formers. As shown in *Fig. 3*, the operating window of multi-ply fourdriniers is much wider compared to the cylinder mould formers.

The driving forces for multi-ply fourdriniers for the production of board have been speed, which means production, and sheet quality such as smooth formation and bending stiffness.

Forming concepts – design limits for packaging grades

The trend towards lower basis weights and, at the same time, high production levels made gap formers the state-of-the-art concept for packaging grades for new machines and rebuilds. Similarly to the cylinder mould formers discussed before, it is again the speed limit – in this case of the fourdriniers – which is the main driving force for the next forming generation.

Voith Paper introduced the gap former technology as early as in 1992. In the meantime, 14 gap formers for board and

Fig. 5: Effect of multi-ply gapforming on strength.

Fig. 6: Single-ply sheet 200 g/m² (top). Double-ply sheet 200 g/m² (bottom).

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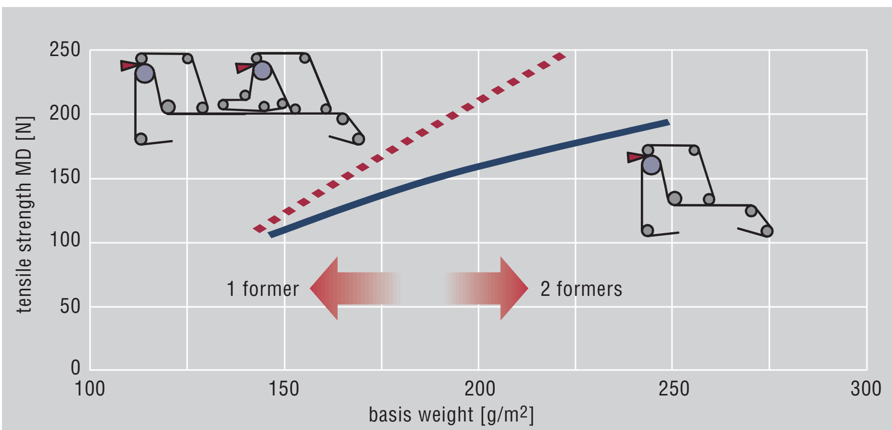

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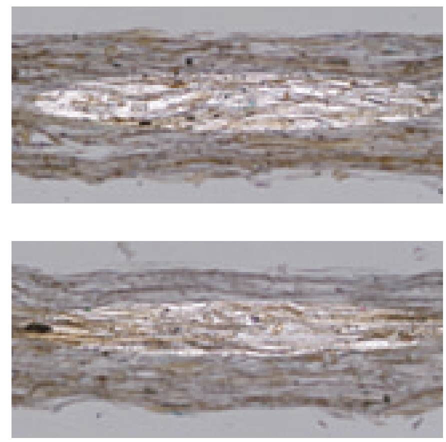

packaging grades are in operation, including the very first double gap former machine worldwide. One further top ply gap former is being delivered right now.

These gap former types have been specially developed for multi-ply board and packaging papers. The high two-side drainage capacity of the DuoFormer™ Base and DuoFormer™ Top results in very good sheets, even at highest production levels.

Fig. 4 compares the operating windows of multi-ply fourdriniers (blue area) with a single-ply gap former and a double-ply gap former. It can be seen that single-ply gap formers (red graph) are very competitive in the medium speed range. A sheet with 150 g/m^2 can be produced at a speed of eg. 950 m/min with one gapformer only. Nevertheless, for very high production, a second ply is required.

The yellow graph shows the operating range for a two-ply gapforming concept. Such a concept allows to produce a high grammage sheet even at high speeds.

Fig. 4 further shows operating points (dark blue) of Voith paper machines already installed as well as layout points of recent projects (light blue).

Apart from production, there are other reasons which make a multi-ply gapforming concept attractive.

Strength is one of the decisive factors for the production of linerboard. There is a significant improvement in strength when producing two plies instead of one ply. Though the strength might be different when using different forming concepts, the multi-ply technology always gives a clear advantage.

Fig. 5 shows the breaking length of a 100% OCC sheet for different basis weights, using one or two gap formers. It can be seen that the two-ply concept results in a clearly better strength at higher basis weights. Sheet forming is enhanced with better formation and lower z-orientation of the fibres, which will both help to optimally utilize the fibre potential, thus saving fibre cost.

The crosscuts as shown in *Fig. 6* demonstrate the higher density in the centre of a multi-ply gapformer sheet.

A multi-ply gapformer concept *(Fig. 7)* ensures best formation and strength at highest production levels.

Multi-ply/multi-layer technology

In the following, a new concept using three secondary fibre fractions will be introduced. If the multi-ply sheet is additionally stratified in the headbox, further advantages for even better machine performance can be achieved.

In such a concept, the stock is fractionated as follows:
- long fibre
- long/short fibre
- short fibre.

The long fibre fraction is fed to the DuoFormer™ Base, which produces the top ply. The long/short fibre fraction and the short fibre fraction are supplied to a

Fig. 7: Multi-ply/multi-layer gapforming concept.

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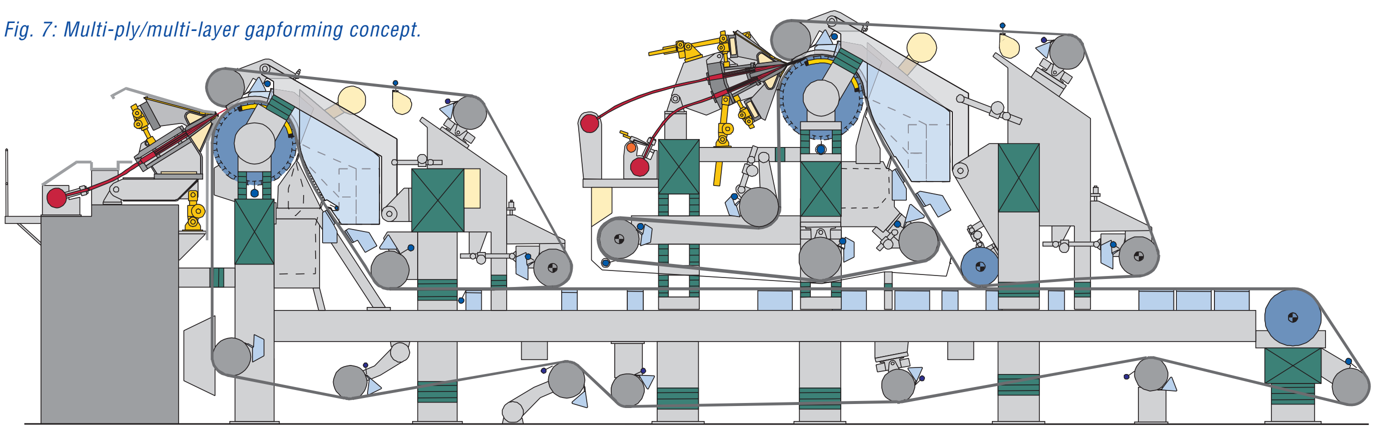

multi-layer headbox in a DuoFormer™ Top, thus allowing additional sheet stratification.

Fig. 8 shows the location of the fractions during the drainage process. The long/short fibre fraction is drained through the outer wire. The short fibre fraction containing most of the fines is drained through the inner wire. Gentle drainage by the forming roll helps to keep the fines of the short fibre fraction in the sheet, which is desired for several reasons but especially for good plybond. The long/short fibre fraction on the outer wire helps to reduce washout effects.

The sheet leaving the forming section has been stratified as follows *(Fig. 9)*:

- long-fibre top ply on the base wire
- short fibre fraction with high fines content inside the sheet
- long/short fibre fraction as back ply on top side.

Effects on the press work

Figure 10 shows a schematic sketch of a press nip. As generally known, a long fibre sheet is more open and easier to drain compared to a short fibre sheet.

Since the long fibre fraction and the long/short fibre fraction are located on the outer sides of the sheet, the water can drain with less resistance. This helps to avoid sheet crushing in the press section, which is especially important for high production. Better drainage also increases wet densification, which is positive for the strength development.

Effects in the dryer section

In the dryer section, there are also advantages related to the multi-ply/multi-layer technology *(Fig. 11)*.

With such a concept, the long fibre fraction is facing the dryer cans. Due to better bonding of the longer fibres in the sheet, the dust development in the dryer section will be reduced. Less dust will result in enhanced runnability and improved converting properties.

The second advantage is that the long/short fibre fraction is facing the dryer fabric. This fraction is very clean with a low content of stickies. Therefore, the contamination of the fabrics will be reduced, which is again a plus for runnability but also for cleanliness and maintenance.

The higher surface porosity of a stratified sheet allows the steam to escape easier, which is the third advantage. Due to the fact that the sheet gets more open towards both surfaces, also the danger of blistering and delamination is reduced.

Effects in the size press/SpeedSizer™

High strength figures demand full starch penetration. At high speeds, the dwell time in the nip gets shorter and it is more difficult to achieve full starch penetration of the sheet.

In the press section, the stratified sheet structure makes drainage easier. Vice versa, the open surface of the stratified sheet allows better starch penetration *(Fig. 12)*.

Especially for high basis weights and high production, this effect is of advantage.

Fig. 8: Two-layer gapforming.
Reduction of washout effect
– higher retention.

Fig. 9: Sheet structure after couching.
Perfect location of fines
– higher ply bond.

Fig. 10: Effects of a stratified sheet on the press work.
More open sheet surface
– better drainage
– high wet densification.

Fig. 11: Effects of a stratified sheet in the pre-dryer section.
The long fibre fraction faces the dryer can surface
– reduced dusting;
The clean short/long fibre fraction faces the dryer fabric – improved runnability due to low stickies content.

Fig. 12: Effects of a stratified sheet in the size press/SpeedSizer™.
Higher porosity on outer sides
– better starch penetration (CMT, SCT)
– better ply bond in the centre.

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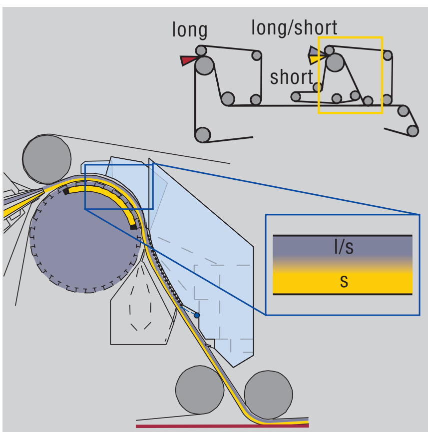

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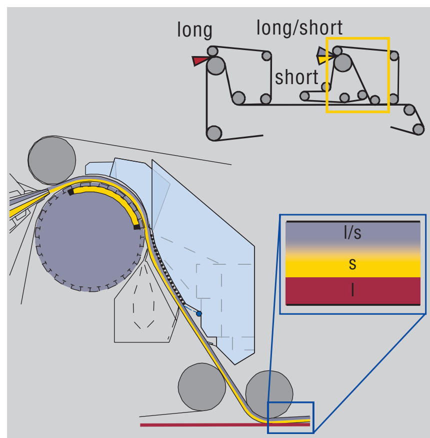

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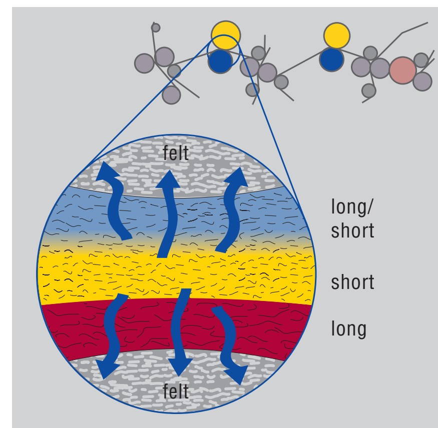

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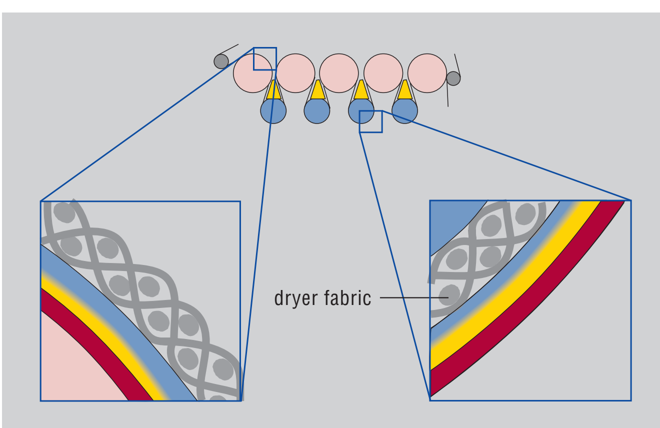

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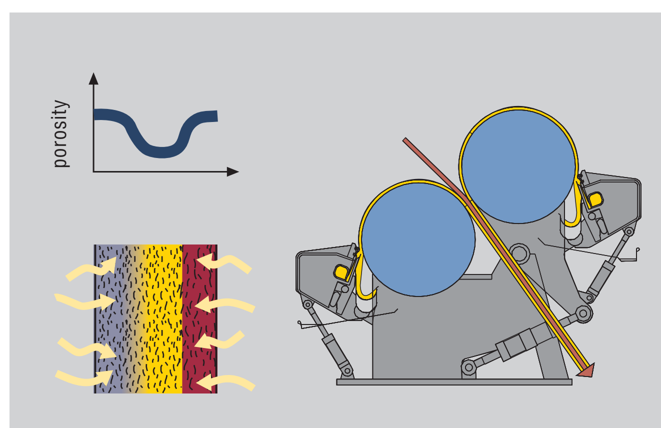

Effects on converting

The long fibre fraction on the surface maintains a certain roughness required to achieve the desired sliding angle. Further, the hot glueing properties will improve. The glue can better penetrate into the surface and develop a mechanical interlock with the sheet.

Summary

The main driving forces for the multi-ply/multi-layer technology have been speed and production, but also quality. This also applies to the latest board and packaging gapforming concepts.

Though the additional advantages of a stratified sheet are difficult to quantify, this technology will improve the machine performance and runnability as well as the sheet properties required for further converting and final usage. As a consequence, the natural resources are utilized more efficiently, which helps to protect our environment, but also the total costs per net ton of paper can be reduced, thus increasing profits.

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