# Matching the Change in Raw Material: Fiber & Fabric Development for the Board & Packaging Sector

**Taylor Carl. J.**


### ABSTRACT

The evolution of the paper machine from the humble Fourdrinier is clear to see. The production of board has progressed to an increasing number of lower weight plies on multi position formers, often with hybrid top units to further increase dewatering capacity and sheet quality. Packaging producers are progressing towards gap former technology at speeds only seen in the graphic sector around five years ago.

The evolution of the raw material is often overlooked. Virgin fiber is processed under controlled conditions by the pulp producers and so the conditions are relatively consistent. Recycled fibers have many more irregularities and as papermakers look for new ways of reducing costs, the source of furnish is often a target area resulting in a more degraded fiber arriving at the paper machine!

The development in stock preparation systems have allowed fibers to be recycled more times before they become impossible to handle. Fibers have become shorter and with an increased fines content. When combined with the higher speeds and dewatering forces on the paper machine, the forming fabric has the task of retaining smaller solids in the sheet yet ensuring sufficient water is removed.

Now more than ever, a concern of the papermakers is how to use today's furnish and still achieve machine efficiencies and sheet quality. Voith Paper has quantified the change in furnish quality and matched this to the sheet support mechanism of the forming fabric. Further, the drainage requirements for the range of paper machines in the board and packaging sector have been analyzed and the open area through the fabric structure developed.

This paper outlines Voith Paper's considerations on paper machine design and fiber characteristics ahead of developing the MultiForm HC and MultiForm HR forming fabrics.


## Introduction

### The Paper Machine

Gap former technology was in the market at the end of the 1990's though based more on the already proven machines in the graphics sector. The requirements for the production of packaging grades differ significantly from graphics and Voith developed the DuoFormer Base for higher demands of water handling.

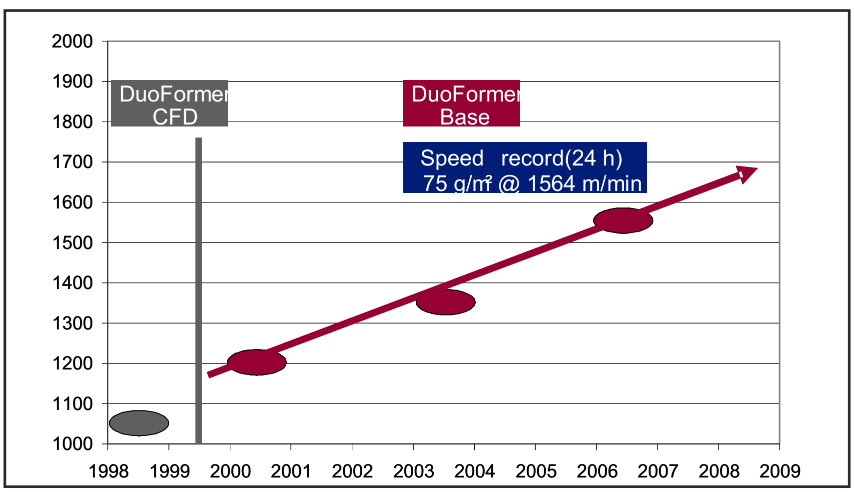



**Figure 1: The speed increase achieved with the DuoFormer Base on light weight packaging grades.**

*Voith Paper Fabric & Roll Systems Asia - Kunshan, China*

Top packaging producers like Visy VP8 and Zülpich PM5 achieved over 1000 m/min with a DuoFormer CFD and Figure 1 shows the improvements Voith have made with the DuoFormer Base over the last 7-8 years.

The development of the DuoFormer Base allowed, in the first years after market introduction, a significant jump in production speeds to 1200 m/min.

Further optimization allowed an increase to 1350 m/min over the next 3-4 years. Now, in 2009 world speed records could be achieved over 1600mpm.

That means, by keeping basically the same former concept, a speed increase of over 30% was possible, the largest potential gain in productivity of all paper grades.

In other words, our customers who started-up their machines with the first generation of DuoFormer Base can be sure, that they can keep the same former if they want to increase their machine speed by 30% or more. No additional significant investment is required. This potential is also expected on newer formers as pilot machine trials have shown 2000m/min is not out of the question for packaging grades but there may be limitations in terms of investment costs which mean a plateau speed in the region of 1600mpm.

Voith Paper is now launching the next generation of packaging machine with the DuoFormer Base II to meet the market requirement for low basis weights. Building on the success of the existing former, this new version "II" incorporates improved water handling around the forming roll and internal flow channels to reduce aeration of water at high speeds.

The distribution of drainage through the forming zone is shown in figure 2 with emphasis on what this means for the forming fabric. Packaging papers are typically produced at consistencies of 1 1,3% corresponding to head box flows of about 14 - 15.000 l/m.min. The consistency at the separation point between the fabrics and forming roll has already reached ~6% resulting in ~90% of the head box flow being removed over this short area. The dewatering split between the top and bottom fabrics is almost equal around the forming roll.

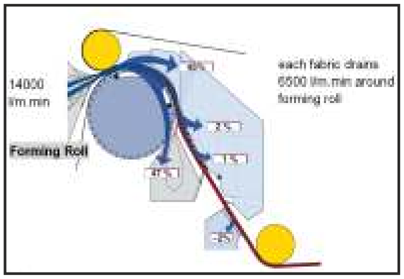



**Figure 2: DuoFormer Base drainage conditions.**

The forming fabrics must be designed to drain over 6,500 l/m.min each. The main dewatering process is finished within 100ms, if you assume a machine speed of 1500 m/min and a length of 1,5 m around the forming roll.

In board manufacturing, the multilayer machine gives the opportunity to use low cost materials in the ply sandwich. However, todays furnish quality used in the filler ply puts greater demands on the outer plies to maintain the stability of the board. Retention of the fines becomes important on the filler ply to maintain internal ply bonding, the rate of dewatering on all formers is important for formation and visual properties.

## The Raw Material

The ratio of recycled fibers used in the production of packaging grades around the world is shown in figure 3.

In Western Europe the ratio of recycled fiber is 80% and 20 % virgin; the trend is similar in Asia. In North America the ratio of recycled fibers is 55% to 45 % virgin. Therefore, for all machine and fabric developments, an understanding of recycled fiber characteristics is paramount.

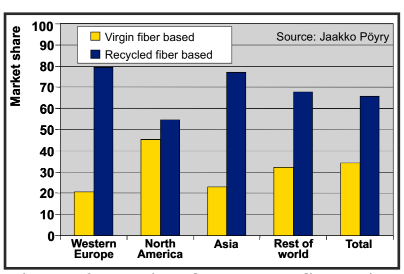



**Figure 3: Ratio of recycled fibers in packaging grades.**

In Europe the recovered paper qualities used for packaging papers consist of super market & mixed waste. The dominating material in the USA is old corrugated containers (OCC). The most important supplier of recovered fibers for Asia is USA and Western Europe as shown in figure 4.

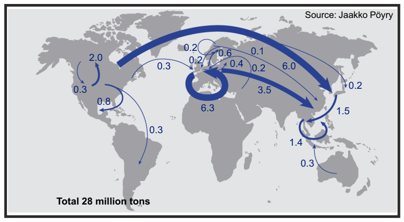



**Figure 4: The dominant flows of recovered fibers around the world.**

There are three dominant flows of recovered fibers, from the USA to Asia, within Europe and from Europe to Asia. The morphological properties of the recovered fibers from the different regions are quantified and compared to those of virgin fiber in Table 1.

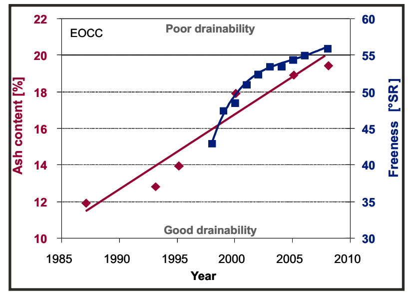



**Figure 5: Development of ash and dewatering resistance (SR°) of EOCC used for packaging grades**

increased ash and fines and so must sell these onto his customer by retaining in the sheet. Retaining fines has a positive effect on formation and ply bonding, retaining ash a negative effect on ply bonding.

By fractionating the fiber in the stock preparation system we are able to control both the formation and sheet strength properties.

Retaining both ash and fines have a positive effect on printability. This has been important for the face plies of board for many years. Now, it is also important for the packaging producer.

| Origin of fibers / Fiber morphological parameters | | Recovered fibers for packaging papers | | | Virgin fibers |
|---|---|---|---|---|---|
| | | Western Europe | North America | Asia | – |
| Ø Length weighted fiber length | [mm] | 1.1 - 1.3 | 1.5 - 1.8 | 1.2 - 1.5 | 2.1 - 2.3 |
| Dewatering resistance | SR | 40 - 50 | 30 - 40 | 35 - 45 | 20 - 25 |
| Ash content | [%] | 15 - 20 | 5 - 10 | 12.5 - 15 | > 3 |
| Potential of formation | Ambertec units | High | Low | High | Low |
| Potential of sheet strength | – | Low | High | Low | High |
| Fines content | [%] | ~ 30 - 40 | ~ 20 - 30 | ~ 25 - 35 | > 10 |
| Content of Stickies | – | High | Acceptable | High | Very low |

**Table 1: Morphological properties of fibers around the world.**

The recovered fibers from USA are of a higher quality level compared to those from Europe, have a longer average fiber length and a lower dewatering resistance. There is a worsening trend in recent years in terms of the dewatering resistance of European recovered paper stock and the ash content is increasing. This trend is shown in figure 5.

There is a clear relationship between the fiber length and formation potential for the sheet, the shorter fiber providing the possibility for better formation. There is a significant increase in the fines content within recycled fibers today. The papermaker is buying the

The development of "micro fluting" has allowed a box to be produced with increased strength but with a surface which can be printed more easily, important for the low-cost supermarkets that use the outer boxes as the shelf structure within the store. The producers want their product to sell out on the shelf and so demand high quality printing properties of the box.

## Development Of Multiform HC

### Development Targets

The MultiForm HC project began in 2007 after reviewing the industry trends in furnishes, economic production and increased machine speeds. The plan was to develop a weft bound SSB (Sheet Support Binder) forming fabric which met the following criteria:

1. Customer savings
2. Improved sheet quality
3. Increased productivity

To define performance targets, it was important to break down the measurable fabric properties and understand how they relate to the demands of the papermaker. The MultiForm HC requires:

*Customer savings:* will be achieved through an increased yield. *Increased support points* and a more *CD orientated pore shape* on the paper side of the fabric will allow improved fiber bridging, retaining more solids in the sheet. *Increased mechanical retention* often results in the ability to *reduce expensive chemicals* in the process which turns into significant costs savings. This is not only good for the customers pocket but also *important for the environment*.

*Improved sheet quality*: can also be obtained by increased retention of fines & fillers which can translate into *formation and printability improvements*. *Ply bonding* can be improved with fines retention. However, the drainage rate though the fabric can affect the *SCT (Short Span Compression Test)* results. The fabric needs to be designed with a *large open area* on the machine side to ensure water can easily pass but with the ability to be able to control the dewatering if formation is particularly important.

*Increased productivity:* will be achieved with *increased machine speeds* and *reduced downtime*. The HC needed a low caliper to reduce risk of water being carried at high speeds. Minimizing water carry within the fabric structure whilst at the same time increasing the retention of fines reduces the risk of misting and contamination of the machine frame, reducing sheet breaks and increases overall machine efficiency. *Increasing fabric life* is an obvious saving for the customer. *Longer machine side weft (CD) yarn floats* increase the material content and *abrasion resistance*. *Reduced frequency of fabric changes* not only positively affects the clothing budget but results in a significant reduction in downtime through the year. *This increase in production* is often overlooked by purchasing departments when simply calculating the costs of only the fabric itself.

Voith has supplied a warp bound SSB fabric to the board & packaging sector, particularly through the Asia Pacific region for the last five years. Its success was based on a high open area and "straight through" drainage path in the Z direction. The main applications have been where a high demand for dewatering, difficult furnishes or high grammages existed. However, limitations were found in terms of its ability to retain the increasing numbers of fines in the sheet. This was used as benchmark for the MultiForm HC.

The concept of the MultiForm HC was already in place. Voith had already been very successful with the PrintForm HQ and HR in the graphics sector. These designs pioneered the idea of the open warp (MD) yarn structure which allowed increased numbers of weft (CD) yarns. The increase in weft yarns not only benefits the sheet support mechanism but also the abrasion resistance on the machine side. Using this concept enabled the development of a coarse fabric design, complementing the finer MultiForm HR ensuring a solution for all the demands of the board and packaging sector. At the same time, fitting seamlessly into the existing MultiForm H family of SSBs.

During the weaving process, the warp settings such as materials, yarn diameters and counts are fixed, therefore it is important to determine the ideal warp layout. Figure 6 shows the overlap of warp (MD) structure compared to that of the benchmark design. On the paper side, the use of smaller diameter yarns and a wider spacing allowed an increase in open area. This provided the opportunity to significantly increase the number of weft (CD) yarns and thus maintain high dewatering but more importantly for the paper side, support of the solids in the furnish solution. On the machine side, the yarns were also set in a more open structure which enabled the use of larger diameters. This provides a stronger pull on the weft yarns creating a crimp shape and more abrasion resistance. The larger warp yarns also provide a higher resistance to elongation, important to resist the force from higher water flows and fabric tensions of the gap former machines.

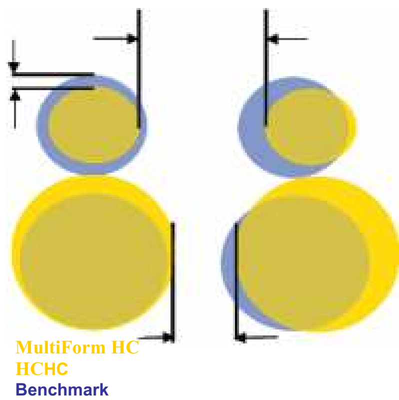


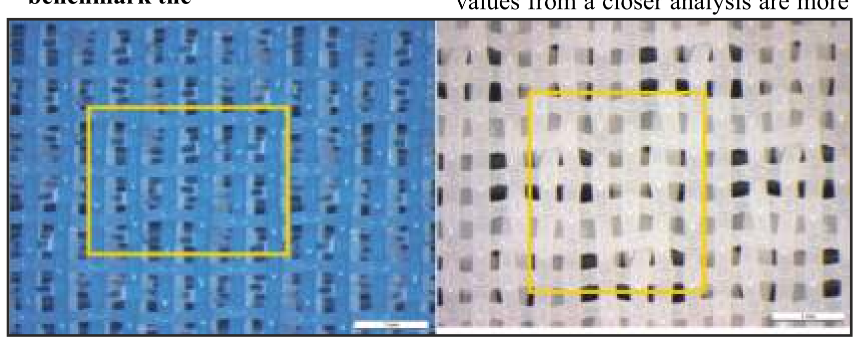
**Figure 6: Overlay of the warp to benchmark the**

**First Product Comparison**

The key parameter is the sheet support mechanism on the paper side and its ability to provide bridging of the shorter fibers and fines. Figure 7 shows the paper side weave of the HC compared with the benchmark warp bound structure. The change to a more CD orientated pore shape is clear.

The yellow box covers an area of 6x6 warp and weft yarns averaging the individual pore dimensions in each structure. Both HC (a) and the Benchmark (b) have permeability close to 450cfm.

The visual properties are important in terms of whether the targets are heading in the right direction. However, the values from a closer analysis are more



**A (MultiForm HC)** **B (Benchmark)**

**Figure 7a-b: The paper side pore shape and sheet support mechanism**

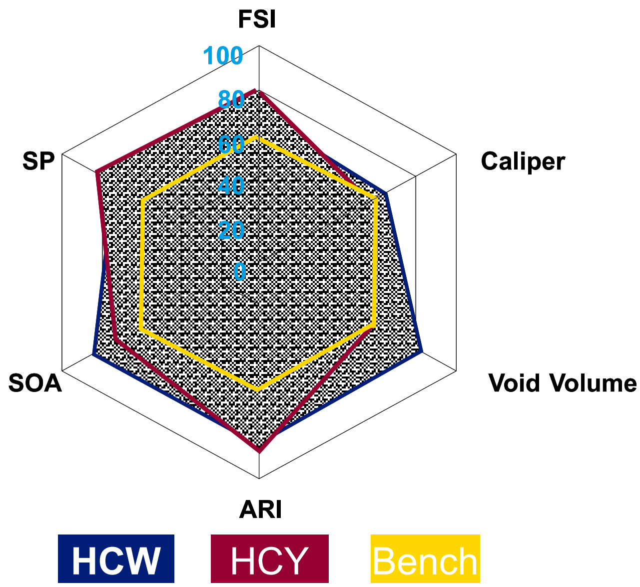



**Figure 8: Product comparison of the technical parameters.**

important. The spider's web in figure 8 shows the extent of change from the benchmark design.

The weft (CD) yarn ratio between the paper and machine side provides the ability to control the build-up of the sheet through the forming process. The MultiForm HCW is a 3:2 weft ratio (paper : machine side) and provides a potential for controlled dewatering, higher stability & life time. The MultiForm HCY has a 2:1 ratio and offered increased sheet support and a faster initial drainage rate.

The fabrics used in figure 8 have a permeability of ~400cfm. The figure shows that MultiForm HC has improved all key parameters from the benchmark. One of the main targets from the development was for the sheet support mechanism to allow the fabric to retain the shorter fiber and to increased fines in the sheet. The benchmark fabric has a 3:2 weft ratio and so the direct comparison would be the HCW. The increase in support points is 14% (FSI +10%) but, the HCY provides a further increase by 21% (FSI 20%). The open area (SOA) is an indicator on the drainage potential of the fabric. In both the MultiForm HCY and HCW we achieve an increase of 14 &24% in SOA indicating that more weft yarns can be added without reducing drainage but further increasing the support. The machine side structure is obviously important to achieve an economic fabric life. The ARI (Abrasion Resistance Index) provides an indicator for the abrasion resistance by taking into account the yarn count, yarn diameter and float length in the weave repeat. The longer machine side float has allowed an increase in ARI by 2 and 26% with the HCY & HCW. The increase in ARI with the HCW is particularly satisfying given the use of 0.40mm machine side yarns compared to 0.45mm in the benchmark. The ability to use smaller weft yarns and still increase life is a major step forward and provides a reduced void volume in the structure by 22%, which is important for reducing the water carry and misting.

Further benchmarking was carried out by comparing in more detail the support mechanism of the MultiForm HC with other designs supplied to the board & packaging sector. The paper side weave and how the support structure relates to fiber lengths found around the globe is shown in figure 9. A typical 2.5 layer fabric is compared to our benchmark warp bound SSB and the MultiForm HCW & HRW.

All fabrics in figure 9 have a permeability of ~450cfm. The pictures cover an area of ~5mm in the MD. The weft counts /cm are 21, 20, 27 & 28 and support points /cm$^2$ are 150, 458, 572 & 883 respectively for the four fabrics A-D.

The 2.5layer fabric would provide

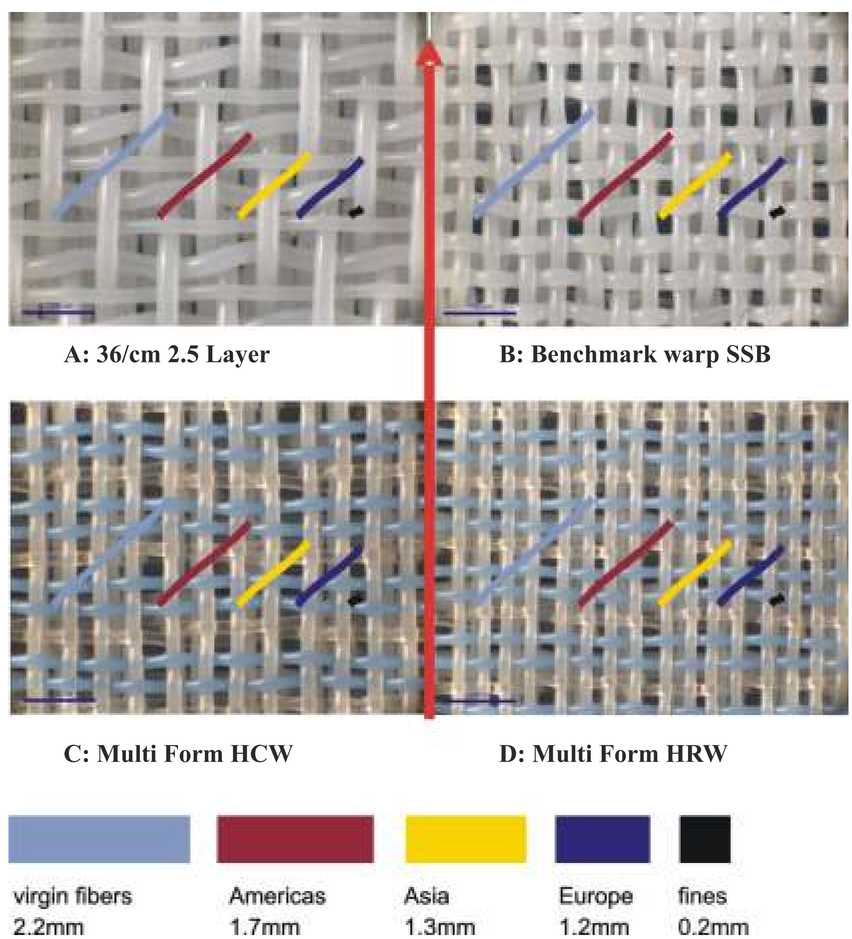



**Figure 9a-d: Paper side weave and fiber length comparisons of typical fabrics used in the board & packaging sector.**

reasonably good support for virgin and recycled fibers used in the USA. However, for Asian and European fibers the HCW and HRW would clearly provide increased support, the fibers bridge a structure of 3x3 yarns with the HCW compared to only 2x2 in the benchmark. The main difference between the HC and HR is the higher warp density.
The support structure of the fabric will hold the fibers in the initial drainage zone quickly forming a mat on the fabric. A higher number of support points will stabilize the fiber mat sooner and the fines will not be allowed to flow through the structure.

To understand the dewatering relationship between different designs, a comparison of the mass distribution through the structures was compared

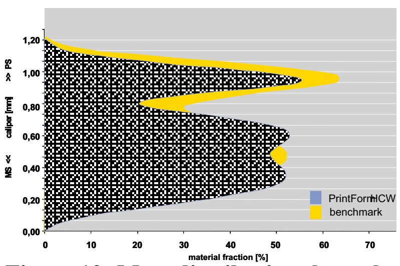



**Figure 10: Mass distribution through the MultiForm HCW and compared to the Benchmark.**

and shown in figure 10.
The profile of the MultiForm HCW shows clearly the effect of the finer diameter yarns on the paper side resulting in a thinner caliper fabric. There is a transfer of material mass from the paper side to the machine side providing the potential for increased stability and life time. The increased stability is to important give the higher dewatering forces at high speeds and it was important that we did not create a

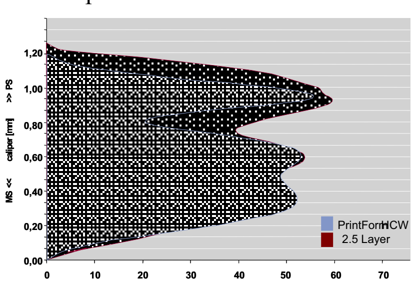



**Figure 11: Mass distribution through the MultiForm HCW and compared to a 2.5L commonly supplied to the packaging sector.**

bottleneck restricting drainage.
In figure 11, the material distribution in the 2.5layer is clearly unbalanced with almost half placed in the paper side half of the structure. The paper side pictures seen in figure 9 shows this increased material is not providing support for the fibers. The MultiForm HCW will again provide an improved balance between support for the fibers, stability and life potential.

**The Ultimate test - The Customer trials**

Voith Paper has successfully supplied the MultiForm HR to a wide range of board & packaging applications. Its success is centered around the top and under layers of multiply board machine where high sheet support has provided exceptional surface properties. In the packaging sector, it has proven itself to retain solids at the highest speeds. The coarser MultiForm HC was developed to complement the HR for positions where increased dewatering was required.

A DuoFormer Base started up in June 2008. The machine has a design speed of 1800mpm and a width of 7.28m. CM at grammages below 70gsm for the micro fluting market is produced. The high machine speeds result in water and solids being projected away from the forming roll between the fabric sandwich. The MultiForm HR was supplied to retain the solids in the sheet yet ensuring high water removal. The dewatering forces towards the top fabric were countered by the more open MultiForm HC on the bottom position. This combination has allowed a balanced dewatering with 38% being removed through the forming roll (bottom fabric) and 53% into the skimmer (top fabric), a 92.3% water removal after the forming roll. Our competitors achieved a 91% water removal around the forming roll but the split between top and bottom fabrics was 31/60% resulting in an imbalance in dewatering. The benefit of starting up a Voith machine with Voith clothing was clear with a world record start-up speed of 1,210mpm producing 100gsm.

Another machine with a DuoFormer Base for the bottom ply and TopFormer F producing CM and TL at a width of 7m wide with a design speed of 1300mpm. The customer wanted to improve internal ply bonding within the base ply and also reduce water spray from the Base top forming fabric. Our consideration was to supply a MultiForm HCW to the DuoFormer Base top position. Compared to the customer's previous fabrics, the void volume was reduced by 24%, the support points were increased by 17% and the FSI by 14%. The machine side yarn of 0.40 was larger than our competitors by 25%. The first trial was installed in March 2008 and ran for 51 days, the best life since January 2005 (the 2nd fabric on after start-up!). This was followed by four consecutive fabrics being installed in MultiForm HC with an average life of 49 days. Figure 12 shows the condition of the machine side on a fabric after 47 days, the remaining life time was more than 50%! To put this into perspective, the average life time from the previous 12 months over the 8 fabrics excluding damages was 39days. We have provided the customer with the ability to significantly reduce their costs by expanding the fabric life time and reducing downtime, ultimately with

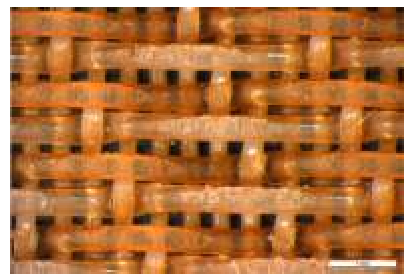


**Figure 12: The condition of the MultiForm HC after running a new record life on a DuoFormer Base top.**

more production.
The success of the MultiForm HC is not only on high speed gap former machines. Pascorp Paper in Malaysia produces 105-150gsm CM on a Fourdrinier at speeds upto 400mpm.

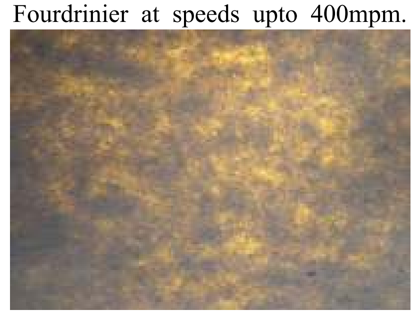


**Figure 13a: Formation at 120gsm before HCW**

**Figure 13b: Formation at 120gsm when running the HCW**

The concern of the customer was how to improve dewatering without negatively affecting retention and other sheet qualities. MultiForm HCW was supplied and resulted in a formation improvement on 120 and 150gsm (shown in figure 13.).

The RCT values remained consistent from before the trial but the SCT values improved slightly particularly at the 120 and 150gsm grades. The main benefit for the customer came with the improved retention. For the 120gsm grades, the flow rate of retention aids was reduced from 550 to 330l/hr, a significant saving!

**Conclusion**

The papermakers concerns on how to transmit the increase in fines and ash to higher yields and sheet quality needed to be addressed. The higher machine speeds required a fabric to handle increased water flows.

Virgin fibers and those used in the USA could bridge the paper side structure of the 2.5layer designs and more open SSB structures. The MultiForm HC and HR now allows a combination of fabrics to be applied to gapformer and multiply machines within the board and packaging sector which can optimize dewatering flows for improved productivity and sheet quality.

The higher sheet support is already providing savings to the papermaker in terms of increased yields but also reduced chemical usage helps the environment. By moving the yarn mass from the paper side to the machine side the MultiForm HC and HR are able to help the customer target longer fabric lives and fewer machine shuts for clothing changes.

The ability to retain more fines in the structure is an ongoing project within Voith and further developments will emerge in this area in near future as we forge ahead with projects aimed at cost savings for the customer and green initiatives.

**Acknowledgments**

1. Johan Mattijssen - Product Manager Forming-Europe: For the use of DuoFormer Base material from the Voith Ulm Conference 2007

2. Harald Selder - Voith Fiber Systems: Trends in fibers used in the packaging sector.