ALTERNATIVE WEFT SHAPES FOR TODAY'S DRYER FABRICS

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DIFFERENT MONOFILAMENT SHAPES AND NEW CROSS SECTIONS ENABLE PAPER MACHINE CLOTHING SUPPLIERS TO DESIGN DRYER FABRICS WITH IMPROVED PROPERTIES AND PERFORMANCE.

During the last 20 years, dryer fabrics have evolved from bulky multifilament cloth to sleeker, all monofilament designs. **Figure 1** shows the market trends in the United States for dryer fabric styles.

During this evolution, the primary task of the dryer fabric remained the same—support the sheet and ensure good contact between the dryer surface and the sheet. Remembering these primary functions, clothing suppliers have attempted to optimize existing dryer fabric designs to meet the primary goals while maximizing fabric life, cleanliness and stability. In dryer fabric designs to date, the cross direction (CD) strands (weft) fulfill two important roles. The density of the weft in strands per inch of fabric length sets and controls the air permeability of the finished fabric. The concentration and diameter of the weft gives the dryer fabric its CD stability and caliper. In contrast to the weft in forming fabrics that are responsible for the fabric's fiber support and wear characteristics, the weft in most dryer fabric designs does not intimately contact either the sheet or the dryer surface. There has consequently been very little thought given in the past to the shape of the weft yarns used in dryer fabrics. Recent research shows that the weft, through its interaction with the machine direction (MD) strands (warp), can significantly influence such important fabric characteristics as contact area, stability, boundary layer air flow and cleanliness. By varying the shape or cross section of the weft, significant improvements to these fabric properties can result.

HOLLOW MONOFILAMENT

Until recently, many designs required the use of a plied monofilament weft in the weave to achieve low air permeabilities. **Figure 2** shows that plied monofilament material consists of small monofilament strands twisted together to produce a bundled effect. In a protected position, such as the center stuffer position of a common design in **Fig. 3**, the plied monofilament is very effective in achieving air permeabilities of 50–350 ft^3/min. Plied monofilament does have several significant disadvantages. Fabrics containing plied monofilament strands fill faster due to their propensity to attract and retain contaminants. This reduces the air permeability of the fabric. In some critical applications, it can lead to edge drop-off or wrinkling in the sheet. From a stability viewpoint, the plied monofilament stuffer does very little in the way of adding either CD stability to the fabric or seam strength in the weave back area. Finally, the small diameter of the individual monofilament strands making up the plied material offers little resistance to the degrading effects of the high heat and moisture of the dryer section. The plied material therefore is usually among the first strands in the dryer fabric to hydrolyze.

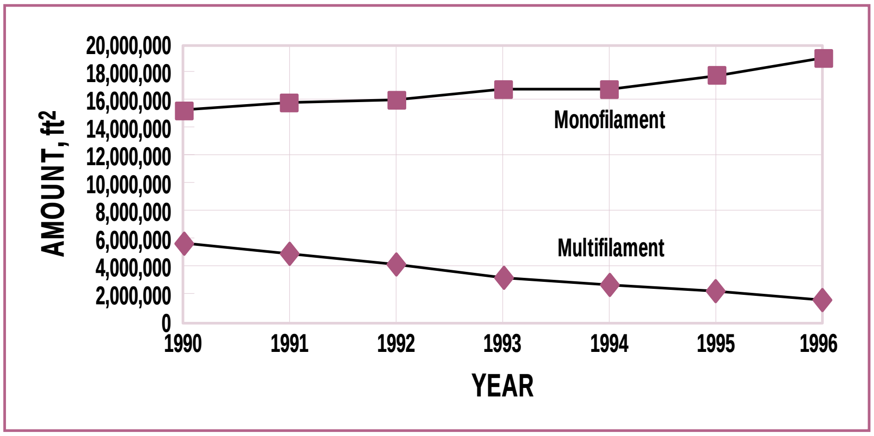
For the reasons noted, efforts are underway to replace the plied monofilament material in existing designs with a strand of unique, hollow cross section. There are several important advantages to using hollow weft as a replacement for plied:

Stability

Initially circular in cross section, the hollow strands deform during the weaving and heat setting processes to conform to the shape of their surroundings as **Figs. 4–6** show. This deformation is important because it locks the warp and the weft into position to increase the total stability of the weave structure.

Contamination resistance

The collapsing of the hollow monofilament in the stuffer position of the fabric pictured in Fig. 4 allows the weaving of fabrics at air permeabilities previously only achieved with plied material. Figures 3 and 4 show the same weave pattern. The only difference is that the fabric in Fig. 4 is woven with hollow material in the stuffer position. The substitution of the hollow strand results in



1. U.S. market trends in dryer fabric styles

a truly all-monofilament fabric thereby eliminating a primary target for contaminants. The smoother surface of the hollow strand presents fewer opportunities for the mechanical trapping of contaminants.

Hydrolysis resistance

The hydrolysis resistance of the thicker, hollow strand is far superior to that of the plied monofilament stuffer. It is nearly equal to a solid strand of the same diameter. **Figure 7** shows this relationship with the results from an accelerated hydrolysis test conducted on plied, solid, and hollow weft material at 35 psi and 138°C.

Hollow material is also an effective replacement for plied monofilament in weave positions other than the stuffer. Figure 5 and **Fig. 8** show the same weave pattern with the latter woven with plied material and the former woven with a combination of solid and hollow monofilaments. Note the way that the hollow strand conforms to the surrounding warp and weft. The surface characteristics and air permeability range of this design remain the same. The CD stability and contamination release properties improve significantly. The CD stiffness of this design improved by more than 77% through the substitution of hollow weft for plied.

New fabric designs

Innovative new weave patterns also use the benefits of hollow material. Figure 6 depicts a weave pattern using the hollow weft on the top surface of the fabric. This design has been quite effective against contamination because the nature of the weave itself confines any contaminants to the top surface of the fabric where conventional cleaning methods are most effective. The collapsing of the hollow strand in this design also allows very low air permeabilities without the use of plied material. The resultant fabric has a caliper ideal for unirun and single tier applications and provides a degree of stability normally associated with designs of a higher caliper. In addition, the seam strength of this design has increased partly due to the improved crimping between the warp and the weft. **Figure 9** shows the actual warp strands removed from a conventional design employing plied material and the new design using hollow weft. Both fabrics were woven to achieve a final air permeability of 100 ft^3/min. Note the increased number of cross-over points—hills and valleys—between the warp and the weft in the new design using hollow material, compared with the conventional design using plied material. The 37.5% increase in cross over points in the hollow design results in a 41% increase in seam strength over the conventional design.

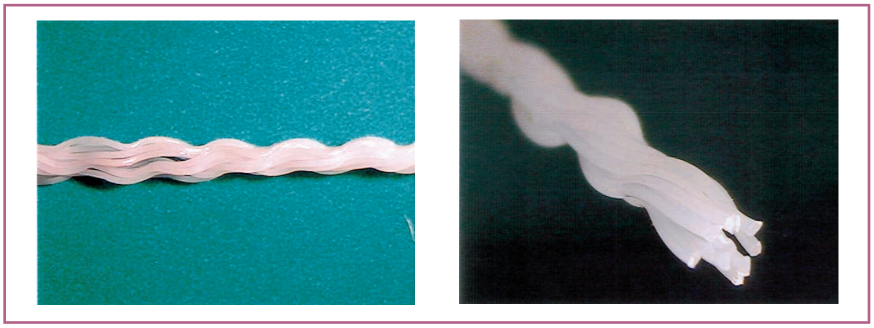
Figures 10 and 11 illustrate the use of this new design with hollow weft on a contamination prone position. The air permeability required for this unirun position is 125 ft^3/min. This would normally require a fabric woven with a plied monofilament stuffer. Using a design woven with hollow weft allowed elimination of all plied material. Although the fabric did pick up contaminants, the after-cleaning view shows how well the all-monofilament design released the contaminants during cleaning.

FLAT WEFT

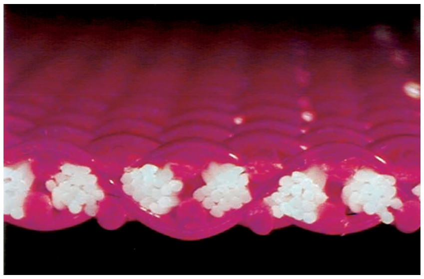
The use of flat monofilament material in dryer fabrics has been common since the late 1970s with the introduction of polyester dryer fabrics. Flat was selected as the shape for the warp strands in the belief that flat offers superior contact and wear potential, compared to round warp. The flat revolution did not extend to the weft. Round weft has been the standard even in the multifilament era. Recent research has shown that the shape of the weft plays an important role in determining the final properties of the fabric. **Figure 12** shows the warp profile of a fabric woven with round weft on the top surface of the fabric. **Figure 13** shows the identical weave pattern using a flat weft in place of the round weft.

Comparing the two weaves, one notes immediately that the long MD float that is in contact with the sheet appears much flatter in Fig. 13 than in Fig. 12. Upon closer inspection, the flat weft pictured in Fig. 13 obviously nestles lower in the weave structure, compared with the round counterpart. This nestling of the weft on the top surface of the fabric offers several important advantages to the papermaker:

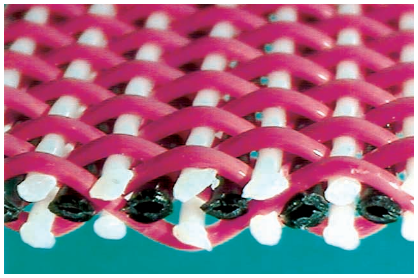
• Increased contact area: The nestling of the flat weft allows the warp knuckle to be flatter on the paper side of the fabric, thereby increasing the contact area between the sheet and the fabric. Testing on the two designs in Figs. 12 and 13 shows that the addition of flat weft on the top surface has increased the sheet to fabric contact area by 10%.



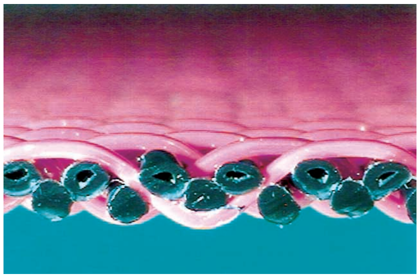
2. *Two views of plied monofilament stuffer*



3. *Center stuffer position*

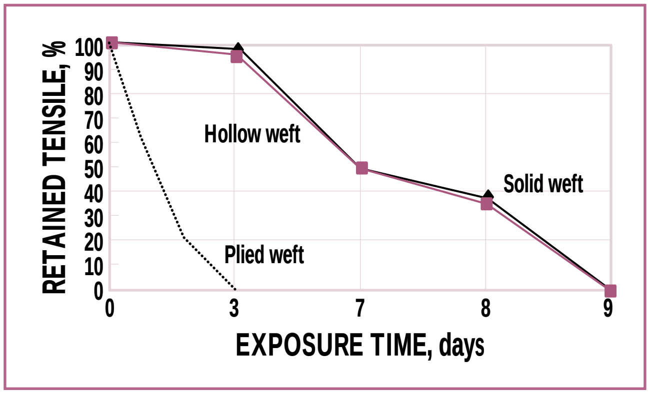


4. *Fabric woven with hollow material on the stuffer position*



5. *Pattern using the hollow weft on the top surface of the fabric*

6. *Pattern woven with a combination of solid and hollow monofilaments*



7. *Hydrolysis resistance*

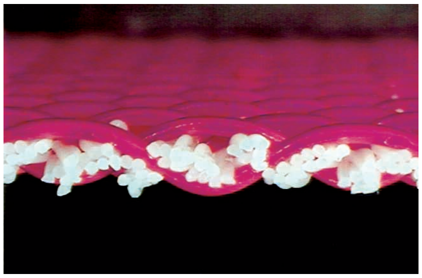
• Increased wear potential: This increased contact area helps stabilize the sheet and provides additional strand area for wear. The abrasion rate on the sheet side of this design therefore will be lower than the abrasion rate of the design pictured in Fig. 12. This is particularly important on machines where high sheet side wear is limiting fabric life, such as later sections on single tier machines or machines running abrasive paper grades. On-machine test results support this theory. One recent installation of this design resulted in doubling the average life on the position.

• Reduced boundary layer air flow: **Figure 14** shows that the compact nature of the flat weft weave greatly influences the surface topography of the fabric. With the weft sitting lower in the weave and the warp lying flatter, the smoothness of the surface increases. The amount of boundary layer air the fabric carries decreases. On-machine measurements indicate that the sheet side boundary layer air flow decreased up to 50% using a flat weft design over a conventional round weft fabric design. This reduction in boundary layer air flow resulted in the elimination of a sheet flutter problem in the transfer between a single tier and conventional section during a recent customer trial. The combination of reduced boundary layer air and increased sheet to fabric contact also eliminated an edge flipping problem on this machine. The result was fewer sheet breaks and improved machine efficiency.

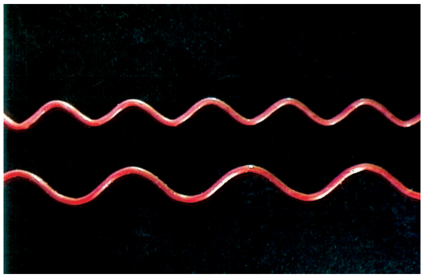
• Improved distortion resistance: The nestling effect increases the contact between the warp and both the top and bottom weft. Note how the warp contacts all the weft in Fig. 13. This warp to weft contact and the contact between the top and bottom weft increases the distortion resistance of the overall structure. This is a critical parameter on today's wide, high-speed machines.

• Maximum dimensional stability: The low profile of the flat weft further enhances the dimensional stability of the fabric. Because of the compactness of this weave, it is possible to maximize the diameter of the bottom weft for enhanced CD stiffness while maintaining an overall fabric caliper suitable for installations on high speed single tier and unirun positions.

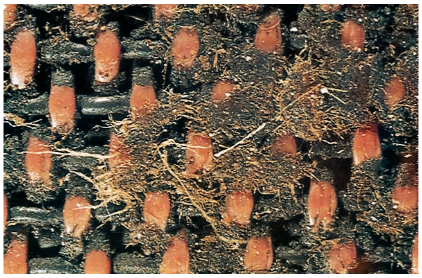
Installations to date of fabrics employing flat weft technology on several high speed applications in Europe and North America have been very successful in maximizing



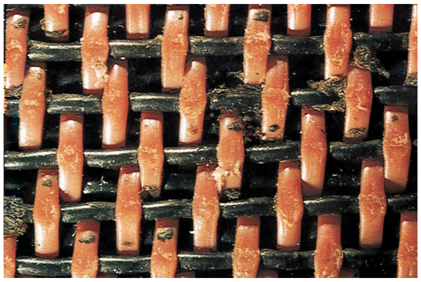
8. Pattern woven with plied material



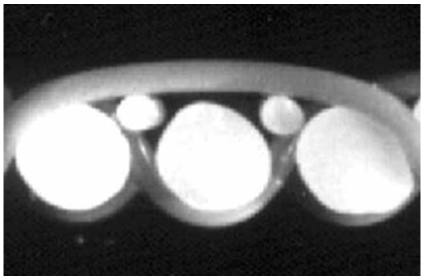
9. Actual warp strands removed from a conventional design employing plied material (bottom) and the new design using hollow weft (top)



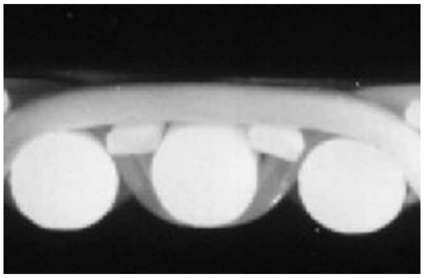
10. New design with hollow weft on a contamination prone position before cleaning



11. New design with hollow weft on a contamination prone position after cleaning



12. Warp profile of a fabric woven with round weft on the top surface of the fabric

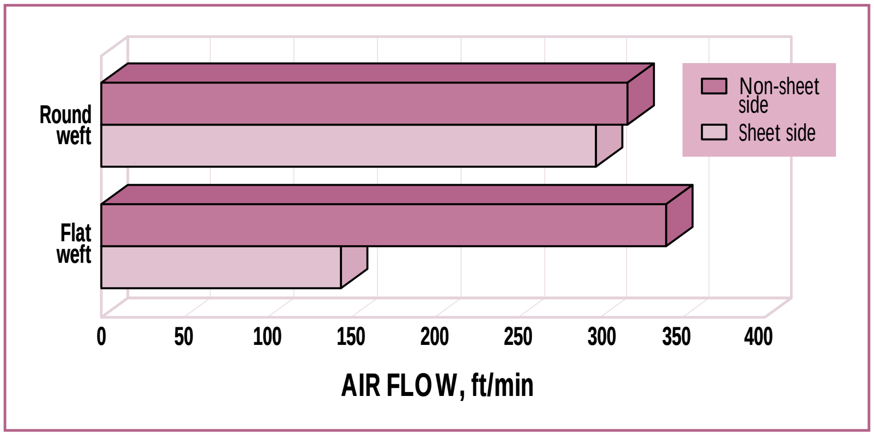


13. Warp profile of a fabric woven with flat weft on the top surface of the fabric

sheet stability and eliminating fabric and seam marking at speeds up to 5400 ft/min., a world record for newsprint, and widths up to 380 in.

CONCLUSION

While the use of conventional weft shapes in fabric designs was sufficient to meet most needs of today's machines, demands on dryer fabrics will grow in the future. With design speeds on new machines approaching the 6000 ft/min point and trim widths increasing toward 400 in., there will be an increased focus on the problems associated with wide, high-speed operation, namely fabric and sheet stability. The advantages of using such alternative weft types as hollow and flat to meet these challenges as summerized in **Table 1** are clear. The difficulties associated with manufacturing these materials and employing them in the production of fabrics have also been overcome. The challenge today is to investigate fully the possibilities offered by these new materials and apply the technology most beneficially to the papermaker. **TJ**



14. Boundary layer air flow for flat weft vs. round weft

Property	Plied	Hollow	Flat
Stability	—	+	+
Cleanliness	—	+	+
Hydrolysis resistance	—	+	+

Table I. Comparison of properties for plied, hollow, and flat wefts

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