

Sabit Adanur, Ph.D. | AJU Faculty

# Paper Machine Clothing

Second Edition



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# Paper Machine Clothing

Second Edition

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## Other Designs

Other forming fabric designs are also possible. In one design variation, there are three layers of weft yarn and one layer of warp yarn as shown in Figure 2.12. This design is not often used, as SSB triple-layers provide similar profile benefits with fewer water carrying issues.

### 2.2.2 Forming Fabric Design Variables

The fiber support and drainage characteristics of most fabric designs can be varied by changing yarn diameter, mesh count, weave, and yarn predominance.

The yarns used in warp and weft directions in forming fabrics have different properties. The rule of thumb in a forming fabric is that CD yarn is for wear and MD yarn is for load bearing on the paper machine. Therefore, higher modulus yarns are used in MD to reduce stretching on the paper machine.

Proper selection of yarn diameter and mesh makes it possible to create a variety of hole sizes and open areas to meet the machine conditions.

Many different factors are taken into account and are essentially built into the fabric when it is designed to satisfy the end use requirements. The following design and manufacturing parameters are calculated and adjusted to achieve the desired properties (See Section 2.2.4 and Section 2.3):

1. Material type
2. Mesh (warp and weft count)
3. Warp and weft size and types
4. Weave pattern
5. Plane difference
6. Percent top surface open area or percent drainage area (% DA)
7. Air permeability (air perm), (AP)
8. Void volume
9. Fiber support index (FSI)
10. Drainage index (DI)
11. Number of holes per unit area

### 2.2.3 Manufacturing of Forming Fabrics

The design and manufacture of a forming fabric for a paper machine is complex. In general, these fabrics are machine- and grade-specific. Quite often, a forming fabric is designed for

a particular position on a particular paper machine type.

Papermakers demand long-lasting forming fabrics which produce high quality paper products. Forming fabrics are manufactured to meet various demanding requirements which include stability, wear resistance, proper drainage capacity, uniform fiber distribution, no wire marking, and proper retention. Figure 2.13 shows the flow chart for manufacturing forming fabrics.

## Forming Fabric Materials

The first synthetic forming fabric was introduced in 1969. Until the 1950s, forming fabrics were made of phosphor bronze or stainless steel. Since they were constructed from metal, they were called "wires." There were very few design variations in those days, and the average wire life was one to two weeks. The stability of the wire was good, but it was prone to damage due to creases and metal fatigue.

By the mid-1970s, 75% of all paper machine clothing was made from monofilament or multifilament yarns. Multi-layer forming fabrics were introduced in the mid-1970s. In 1976, triple-layer fabrics were introduced. Today, almost all forming fabrics are made with high molecular weight and high modulus monofilament polyester. For wear resistance, alternating nylon yarns can be used in the bottom layer of multi-layer fabrics (Figure 2.14).

However, nylon is not dimensionally stable under wet conditions, which limits its use in forming fabrics. Still, with an increase in alkaline papermaking, more nylon yarns are being used along with polyester. Polyester has good stress-strain properties and is resistant to acid. It is subject to hydrolysis under alkaline conditions. Nylon has more memory than polyester and takes longer to recover.

Nylon and polyester have the following comparative properties:

- For flexural modulus, nylon is softer than polyester.
- For compression resistance (and impact resistance), nylon is superior. Polyester tends to fracture under pressure. That is why nylon is used in press fabrics.

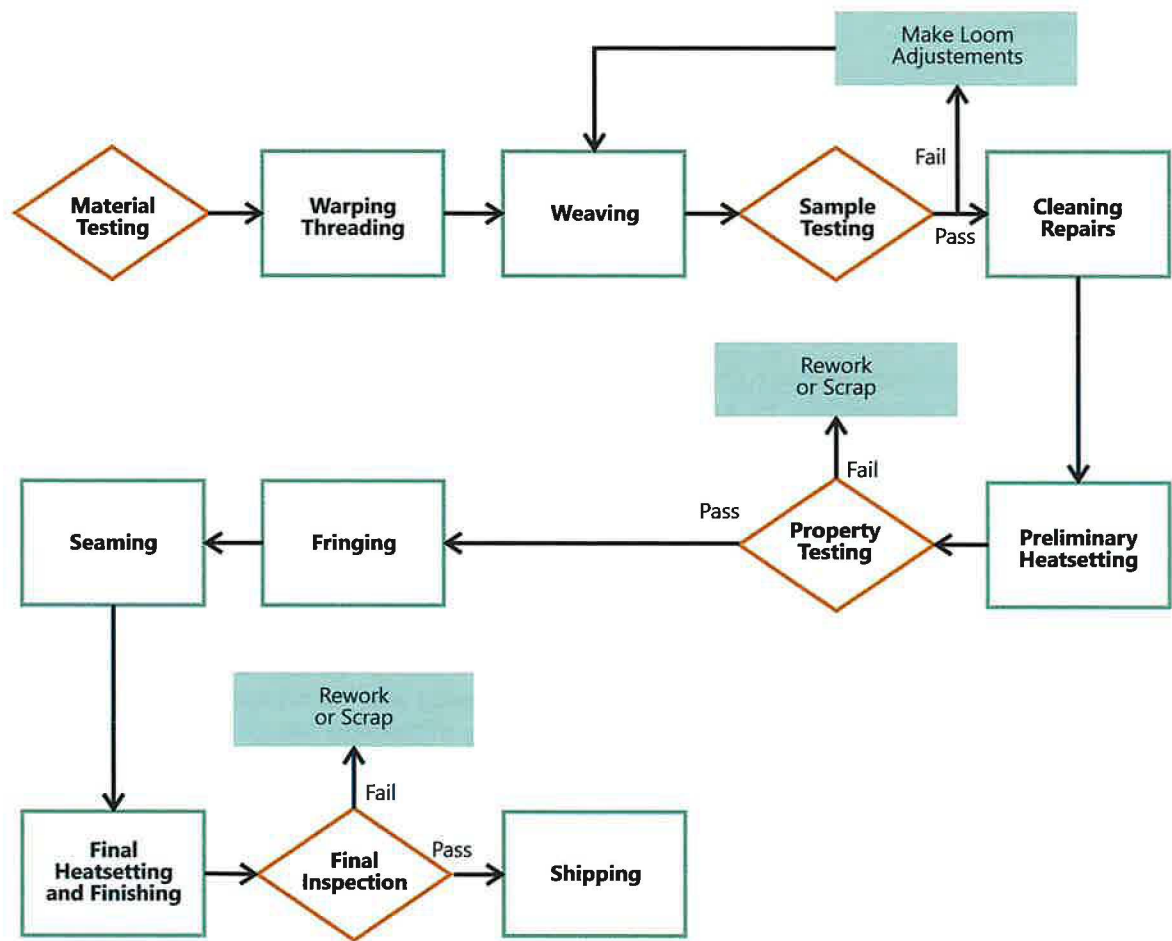


FIGURE 2.13. Forming fabric manufacturing flowchart.

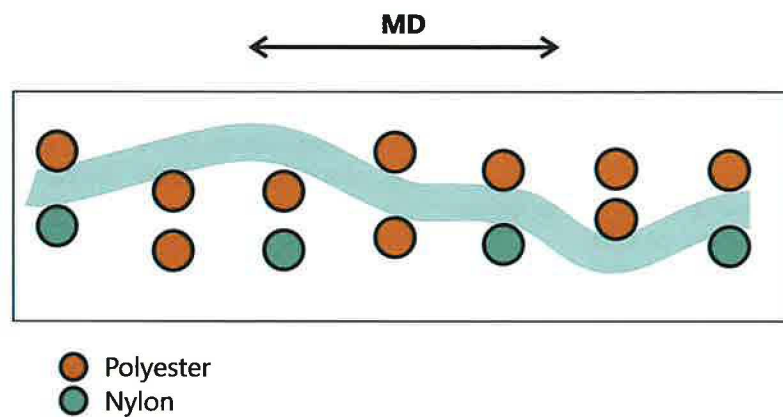


FIGURE 2.14. Use of alternating nylon cross direction yarns on the machine side of a double-layer design.

These properties are inherent in the polymers.

- Heat transfer is different for nylon and polyester.
- The abrasion resistance of nylon is higher than polyester.
- Polyester has higher density than nylon.

The typical structure of a polyester monofilament is depicted in Figure 2.15.

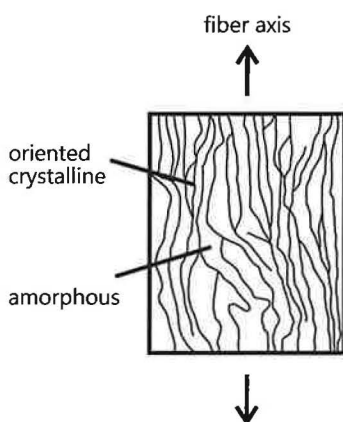


FIGURE 2.15. The internal structure of polyester.

Polyester molecules can be observed in three types of arrangement within the strand:

|              |                                                       |
|--------------|-------------------------------------------------------|
| Crystalline: | Dense, regular arrays                                 |
| Oriented:    | Parallel molecular chains aligned with the fiber axis |
| Amorphous:   | Random entanglements of molecules                     |

This diversity of structure allows the physical properties of polyester to be varied by controlling the degree of crystallinity and orientation during the extrusion process. This is done to control the very different properties required for the warp (MD) and weft (CD) strands used in the fabric (Table 2.4).

Another important property of polyester, which has implications for forming fabrics, is its molecular weight. Fabrics produced from High Molecular Weight (HMW) polyester strands in both MD and CD have the following advantages:

- Higher elastic modulus
- Increased wear resistance
- Increased resistance to shower damage

There have been advancements in material development which have resulted in engineered

polymers that reduce the compromises between dimensional stability and wear resistance. These materials are used in combination to give the best performance on the paper machine (Figure 2.16).

TABLE 2.4 Summary of the Different Property Requirements for the Warp and Weft.

| Comparison of warp and weft properties |      |      |
|----------------------------------------|------|------|
|                                        | Warp | Weft |
| Modulus                                | high | low  |
| Shrinkage                              | high | low  |
| Crimping                               | low  | high |

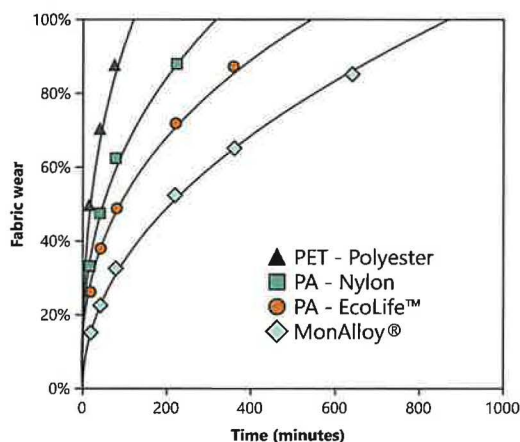


FIGURE 2.16. The wear resistance of forming fabric materials.

## Manufacturing of Yarns for Forming Fabrics

Yarns for forming fabrics are produced by the melt spinning (extrusion) method. Polymer chips are fed to the extruder (Figure 2.17) and are melted under heat and with shear forces generated between the screw and the barrel. At the end of the extruder, the molten material is forced through tiny holes in the spinnerette (often referred to as capillaries). The hole diameters are selected for the yarn diameter to be produced (Figure 2.18). The extruded filaments come out in molten form from the spinnerette. They are stretched and quenched (with water or air) and solidified. Air quench is used for very fine denier yarns like multifilament. At this stage, the monofilaments are amorphous with almost no crystallinity.

In order to impart crystallinity into the yarns, they are passed through a series of godets at progressively increasing speeds and, usually, through two ovens followed by a relaxing stage

is not the same on both sides of the fabric, this is called an asymmetrical weave pattern, which has one smooth and one rough surface. The neutral line in an asymmetrical weave pattern lies more towards one side of the fabric.

## Mesh

Similar to forming fabrics, the number of warp and filling yarns per unit length has a direct influence on many properties of dryer fabrics including:

- Contact area
- Fabric and seam tensile strength
- Air permeability
- Air carrying capacity
- Stability

Warp density can exceed 100% in some designs. In certain designs, the warp yarn count is decreased on purpose to reach high air permeabilities and/or to obtain good fabric ventilation.

## Number of MD and CD Layers

Usually a woven dryer fabric has one to four MD (warp) layers. In special cases, there may be more layers. More than one warp layer is used to obtain a special dryer fabric surface and/or to improve the stability of the fabric. Figure 4.10 shows one and four MD layer fabrics. The disadvantage of a traditional woven fabric with several warp layers is the thickness. However, this disadvantage is minimized in recent multi-layer fabric constructions [10].

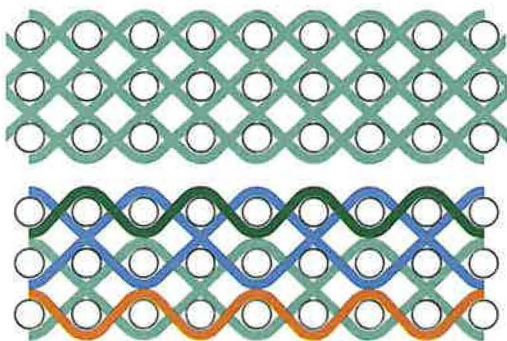


FIGURE 4.10. One (top) and four MD layer fabrics.

Woven dryer fabrics generally have one to three CD (weft or filling) yarn layers. Fabrics with only one CD layer are generally thinner than

fabrics with two or more CD layers. For fabrics with only one weft layer, it is difficult to obtain a warp loop seam which is easy to close without sheet marking and which meets the dynamic requirements of the paper machine. This problem can be solved with a design having one weft layer combined with two warp layers [10].

## 2. Spiral Fabrics

Spiral fabrics are not woven but are made with monofilament yarns (typically polyester) that are fabricated in spiral form. The spirals are linked together by monofilament cross yarns or pintles (Figure 4.11).

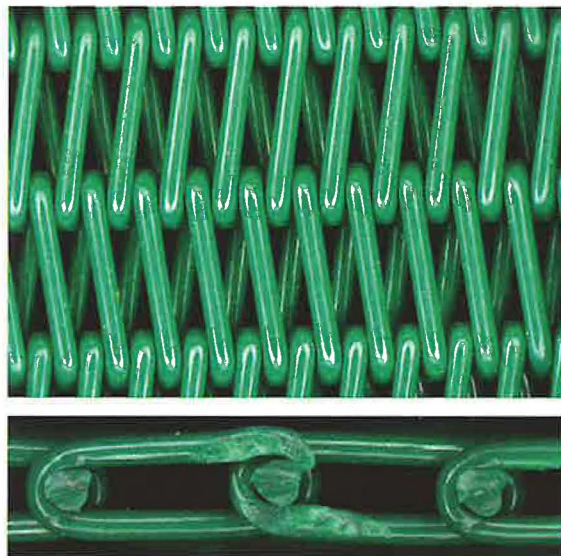


FIGURE 4.11. Spiral fabric. Coil: round PET, pintle: round PET.

The main advantages of spiral fabrics are good dimensional stability and good fabric ventilation. The seam joint has the same construction as the rest of the fabric. Still, from a technical application point of view, woven dryer fabrics are preferred over spiral fabrics. Disadvantages of spiral fabrics are a relatively high fabric thickness and a limited contact area. High air carrying capacity also limits the use of spiral fabrics. The high air permeability of spiral fabrics (800-1000 cfm) can be reduced by filling the spirals with different materials (Figure 4.12).



FIGURE 4.12. Schematic of filled spiral fabric.