Fabric design: a logical approach

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Introduction

The cleanliness of any forming fabric operating on a paper machine is the combined result of the fabric design, the paper machine design, the machine operation, the cleaning system performance, and the type of stock being run.

A tissue machine is a particularly good example of this complex interaction since it represents the extremes of difficulty in most instances. The fabrics must drain freely using small strand diameters to achieve a fine mesh. They are, therefore, sensitive to drainage losses caused by contamination, and the small strands are prone to shower damage. The typical short length of the fabrics also means that there is an above average work load per square foot of cloth. The machines are often very compact in layout, making it difficult to add cleaning systems to the preferred locations, and the drainage itself occurs rapidly. The sheet is lightweight and easily upset by a dirty fabric, and the production speeds are among the highest of any grade. Finally, the stock often contains a high percentage of ink-laden recycled fiber and a mix of proprietary chemicals.

Fabric design

It is difficult to understand how different cleaning methods work without first comprehending the importance of fabric design.

Differences between one fabric design and another can have more impact on the ability to clean a fabric than any single cleaning method. This often leads to confusion because most changes in cleaning methods are introduced to the paper machine during a fabric change.

The fabric design parameters listed below all affect fabric cleanliness and should be taken into account when assessing the performance of a cleaning method or a fabric design change:

1. Fiber support index
2. Drainage index
3. Fabric permeability
4. Cloth thickness
5. "See-through" angle
6. Internal void volume.

Fiber support and drainage index

If the fabric is just considered a conveyor belt, receiving from the headbox and delivering to the presses, it then becomes clear that fiber support and sheet release are very important parameters. Fiber support keeps the fibers on top of the fabric and provides for easy release of the sheet to the presses.[1]

High drainage pressures work against this fiber support. They pull the fibers and fines into the mesh, leading to possible entanglement with the weave and making release more difficult.

Sheet and fiber release are, therefore, improved by fabrics with a high drainage index that minimizes the drainage forces pulling the sheet into the mesh.[2]

Permeability

The air permeability of a fabric is a measure of its flow resistance to both water and air through the fabric. It is, therefore, an excellent guide to how well a conventional sheet knock-off shower will perform. Also, because most cleaning applications rely to some extent on water passing through the fabric mesh to either reach the contaminant or to wash it away, a fabric with high permeability is also easier to clean.

Multilayer fabrics

The thickness, the "see-through" angle, and the inside void volume of the cloth have been introduced by multilayer fabrics as further complications to the understanding of cleaning methods.

Cloth thickness

The thickness of the fabric, and the fact that it is a multilayer design, is important when a water jet is expected to pass through the fabric at high paper machine speeds. After the water jet has passed through an opening in the fabric surface facing the jet, there may no longer be an opening in the fabric on the far side, although one was visible when the jet entered the mesh. This is because the fabric has a velocity at right angles to the water jet. At water pressures typical of cleaning showers, the velocity of the jet is high and is less affected by this problem. However, as shown in **Fig. 1**, the error at a typical trim squirt pressure of 100 psi and a 3000-ft/min fabric speed would be 42°, and the spray would bounce back off the bottom layer of the fabric, unless it was angled with the run, i.e., chasing the fabric.

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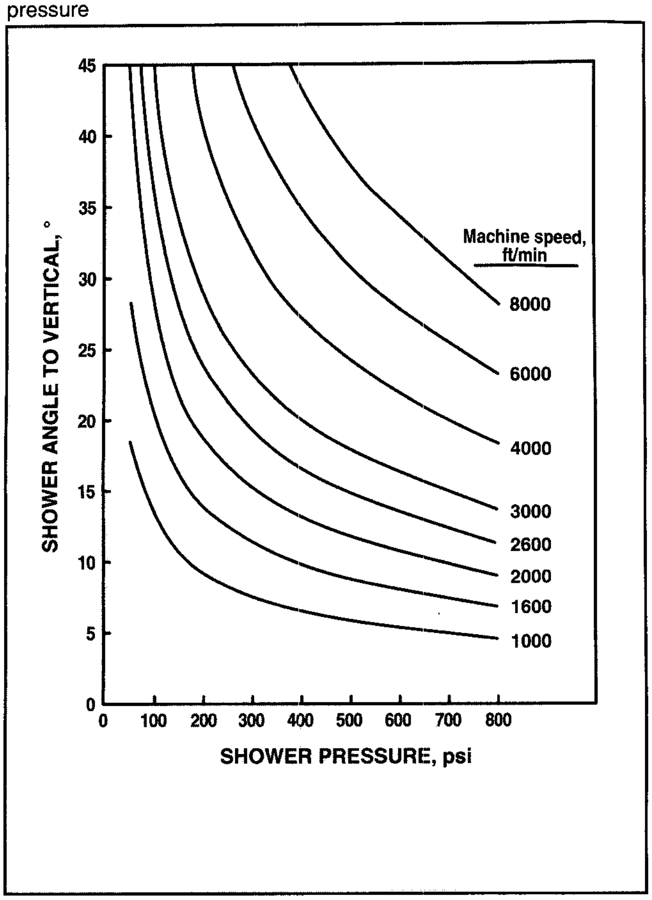
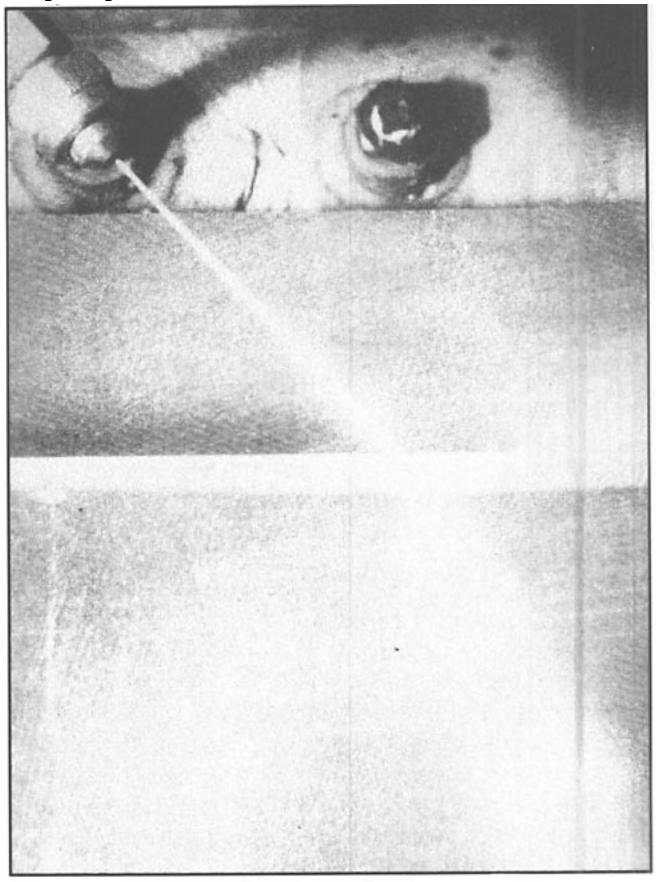
[1] Beran, R.L., Tappi J., 62(4): 39(1979).

[2] Johnson, D.B., Pulp Paper Can., 85(6): T167(1984).

1. Correction to shower angle according to machine speed and water pressure



2. Water jet leaving the underside of a double-layer fabric at the "see-through" angle



"See-through" angle

Double-layer fabrics generally have no direct passages visible when viewed perpendicular to the cloth. This is because of the high density of machine-direction strands, combined with the stacking of two cross-machine strands on top of each other. These same fabrics can, however, look quite open when viewed at an angle of 60° to the cross-machine strand axis. Any water jet that *must pass through* the cloth to function will, therefore, work much more efficiently at this 60° angle in the cross-machine direction.

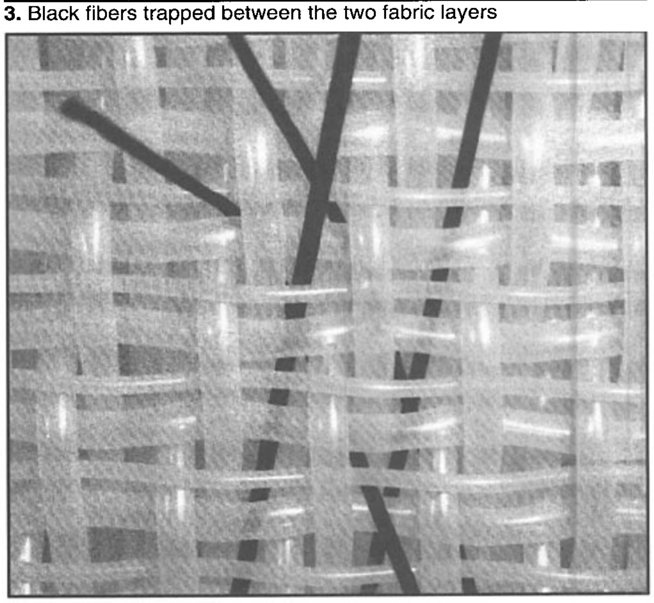
This is illustrated in Fig. 2 by the photo of a needle jet passing through a double-layer fabric. The nozzle is angled at about 45° to the cloth, but the spray leaves the cloth at the "see-through" angle of about 60°.

Internal void volume

The weave complexities of multilayer fabrics generate internal chambers that are open to both fabric surfaces. These openings are frequently smaller than the major dimensions of the internal chamber, and the openings to one surface can be smaller than those to the other surface. The effect on cleaning is that it is almost impossible to push fiber from the sheet side through the fabric and remove it from the machine side of the fabric. Many long fibers will hang up inside the mesh voids and refuse to move toward either surface.

This is shown in **Fig. 3** by simulated black fibers lying in the internal chamber between the sheet-side and machine-side surfaces.

3. Black fibers trapped between the two fabric layers



Another effect of fabric void volume is on the operation of flooding-nip-type showers, which must first fill the voids with water and then have enough excess volume to knock the sheet or fiber off. With different designs, the volume required can vary greatly, and an undersized shower may no longer function when a new, thicker cloth design is installed on the machine.

Paper machine operation

An extension of the foregoing fabric design discussion is the sheet consolidation process, which should be designed and managed to achieve the highest possible first-pass retention.

Poor retention is usually equated to recirculated solids, which some mills with adequate saveall capacity are not concerned about.

However, this nonretained portion can become trapped in the fabric, on the foil blades, or inside suction boxes and couch holes. This makes for a "dirty" machine and leads to cleaning problems.

A well-managed sheet consolidation process is efficient in that minimum energy is expended to form the sheet. The forming pressure should be gently escalated as the mat thickens, and the consistency of the white water should decrease from the headbox to the reel. Any sudden increase in drainage pressure to a value higher than required will result in an undue loss of material from the sheet and the potential for a cleaning problem. □

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