TIP 0404-61
ISSUED – 2002
REVISED – 2006
REVISED – 2011
REVISED – 2017
REVISED – 2022

Paper Machine Shower Recommendations

Scope

This TIP outlines basic considerations for the application of showers on paper machines, and specific recommendations for showers to clean and condition forming and press fabrics and other components. Dryer fabric cleaning is discussed in TIP 0404-38 “Dryer fabric cleaning.”

The recommendations are presented as starting points to install and evaluate showers on paper machines. It is recognized that all machines are unique, and common sense is needed for specific applications.

Safety precautions

As with all system design and evaluation, standard safety procedures must be followed. When near a paper machine, special care must be taken to avoid unsafe contact with moving fabrics and machine elements, and potentially hazardous chemicals. Modern trends of hotter shower water use can result in very hot surfaces, requiring special care to avoid burns. Shower mist can coat catwalks, hand rails, and the floor creating very slippery surfaces. Three point contact should be maintained when climbing stairs or ladders, especially near shower systems.

Definition of showers

Showers are by definition systems that apply fluids. On a paper machine, there are basically two types of showers: fan showers and needle or jet showers. Fan showers are used to apply a liquid, usually water, evenly across the whole cross machine width of a fabric. Sometimes fan showers are used for the application of chemicals. Needle jets are used to directly apply energy via a high velocity stream of liquid, almost always water, to the surface of a fabric. Even though these showers are both designed to apply liquid, they are very different in design and application.

Fan showers

Fan showers are designed to apply liquid evenly across the width of a fabric or roll. The liquid is usually water but can also be water with chemicals to effect contaminants or some other aspect of operation. That water can be used for cleaning or lubrication.

Fan showers do not clean by direct application of energy with the water stream. Rather, water is applied in sometimes relatively large volumes and flushes, or floods, contaminants away. For persistent contaminants, a chemical product can be added, too. Additional information can be found in TIP 0404-65 “Chemical Cleaning and Conditioning”. A lubrication shower is used to apply a surface film of water between a moving element and stationary element such as a doctor blade or vacuum box. For flooding, chemical, or lube showers, the most important factor to judge efficiency of operation is profile of water volume applied. Ideally, there is exactly the same volume per width applied for every unit width showered.

Showers are conventionally designed with nozzles. The most economical means of even water application is a row of discrete nozzles. For a fan shower, each orifice is produced such that the water is dispersed, or "fanned" out, evenly in the CD. *The quality of CD water distribution is predominantly determined by evenness and efficiency of CD dispersal through each nozzle.* Nozzles must be spaced such that for the standoff of the shower from the target, flow is even and consistent across machine and meets the volume requirements of the application. Alignment of fan showers should be checked often to ensure uniform CD fluid distribution.

Needle jets

While both fan and needle showers are designed to spray water, the mechanisms of their functions are very different. Fan showers deliver water for its own sake. Needle showers use water as a vehicle to apply power to the fabric to dislodge contaminants, usually at or near the surface. The mechanism of high pressure needle jet function is power application. Power is energy over time. The energy of a stream of water can be determined from the simple relationship

$$\boldsymbol{E = \frac{1}{2} m v^2}$$

where E is energy, m is mass, and $\mathbf{v}$ is particle velocity.

Local cleaning is determined by instantaneous energy. Energy over time is power P, which can be calculated by substituting mass flow for mass

$$\boldsymbol{P = \frac{1}{2} \dot{m} v^2}$$

For a given orifice of fixed diameter, the operational parameter that determines both mass flow and velocity is pressure. (This assumes other factors such as viscosity and temperature are constant, a fair assumption for this system.)

Figure 1 illustrates the four zones of a needle jet. When the stream leaves the nozzle, the stream is clear and flow is laminar. As edge effects begin to become significant, turbulance is introduced into the stream, and the velocity profile becomes more uneven. The stream begins to contract in the second zone. In the third zone, air begins to mix with water and flow becomes two phase, but still remains reasonably concentrated. Eventually, in the last zone the flow begins to disperse and the jet becomes ineffective. Experiments have shown that the most effective point of cleaning is around zone two and early in zone three, after the jet has contracted but before it is dispersed, and while the flow is two phase. It is very interesting that laminar high pressure showering is relatively inefficient, as shown in Fig. 1. Particle collisions as droplets of water striking the fabric apparently play a large role in cleaning effectiveness.

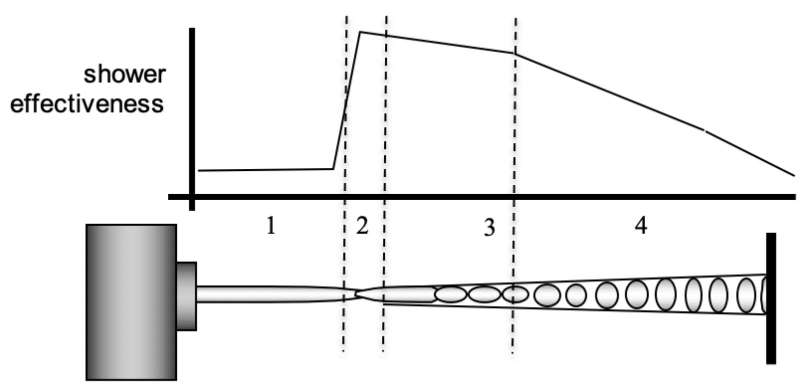

Fig. 1: Needle jet effectiveness vs. distance from the fabric. Preferred location is peak of curve

For application, the above translates to an optimum placement of a high pressure shower from 6 to 10 inches (150 to 250 mm) from the outside surface of the fabric. Note that nozzle quality has a large effect on the jet character. A poor or worn nozzle will have a very short laminar zone and the flow will disperse immediately. It's easy to tell the condition of a nozzle by looking at the stream. If the flow disperses immediately, the nozzle should be replaced. Some nozzles by either character or quality never have laminar flow zones. A good example of these is a self-purging nozzle. Because the orifice is made up of two pieces of metal it is imperfect, and the flow almost always begins to break up the moment the water leaves the nozzle.

The "effectiveness" plot in Figure 1 is is shown qualitatively, but it has been empirically developed and is based on real data developed at pressures up to about 3,000 psi (20,700 kPa) (see reference 3). At extremely high pressures (approaching 10,000 psi), that effectiveness relationship can become distorted. Depending on the nature and especially permeability of the target fabric, the extremely high velocity of the stream can tend to puddle water over the target and thus dampen the effectivenss of the power transfer. Sometimes this can be mitigated by placing the nozzle closer to the target fabric. Again, this effect has been observed only for extremely high pressures. The relationship shown in Figure 1 is well proven for conventional pressures which for full-width showers, are usually no higher than about 600 psi (4,140 kPa).

Application of power with a high pressure water stream is an effective way to clean a fabric surface. The "down side" of high pressure showers is that the mechanism that cleans is the same as that which destroys. If a needle jet is directed at a fabric for long enough duration and at high enough pressure, it will destroy the fabric. Therefore, needle showers should *not be run at a pressure higher than absolutely necessary to clean the fabric.*

While it is optimum to oscillate fan showers, *it is absolutely imperative that needle jet showers be oscillated.* The stroke length of an oscillating high pressure needle shower should always be an integer multiple of the nozzle spacing. A stroke length of twice nozzle spacing gives double coverage and is useful should a nozzle plug, because "dry" streaks are prevented. Commonly two and up to four times nozzle spacing is conventionally used for stroke length; the more the better. The speed of oscillation is important for complete coverage and cleaning. Oscillation can be synchronized with machine speed for perfect coverage. Optimally, oscillation rate is one nozzle width per fabric revolution. A .040 inch (1 mm) diameter orifice is the most common needle jet size. For machines without synchronized oscillation, it is better to run such that coverage is calculated for the slowest machine speed and reduntantly cover at higher speeds, rather than incompletely clean the fabric. This guideline is generally followed either with continuous motion oscillation or stepper motion. Oscillator reversal time at the end of the oscillator stroke will yield over-saturated fabrics. Longer reversal time will translate to poor sheet moisture profile. Oscillator reversal time therefore needs to be as close to zero as possible.

Sometimes to reduce fabric damage especially for more delicate fabrics, needle jets are placed very close to the fabric. This greatly reduces the effectiveness of power application. It eliminates fabric damage, but it also reduces cleaning while maintaining the expense of pressurizing the water. It is far more efficient to leave the shower at its optimum stand-off and reduce pressure to acceptable levels.

Inside high pressure showers for forming fabrics are also often placed very close to the fabric. These showers are usually used to "flush" contaminants from the interstices of the fabric more than apply energy for surface contaminant removal. Single phase water flow penetrates better than droplets, so short flow spans are desirable.

Forming section shower applications

To achieve steady state operation, cleaning of forming fabrics should be done on a continuous basis, started when the fabric is new, using full-width oscillating showers. Pressures for needle showers should be high enough to clean and low enough to avoid fabric damage. All showers should be designed and placed using the considerations described above. Following are some specific "generic" recommendations, referring to the locations in Figs. 2 and 3. Each shower is described, and Table 1 gives operational specifics.

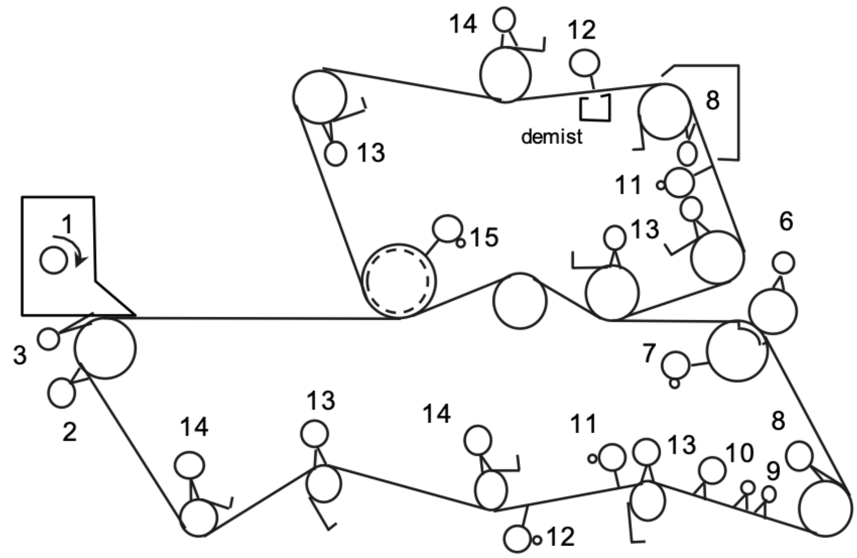

Figure 2: Typical Twin-wire Setup

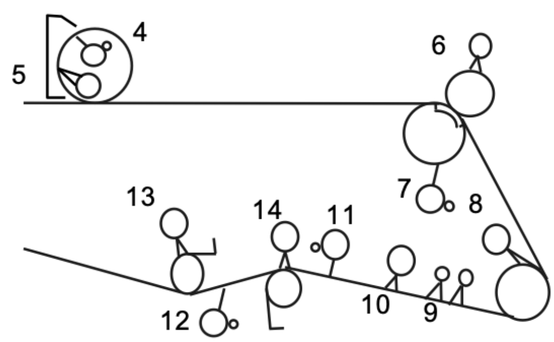

Figure 3: Typical Fourdrinier and Dandy Roll Set-up

Headbox – Shower 1

A swing shower is used for atmospheric or open headboxes, not hydraulic headboxes. Its nozzle pipe rotates over a 180° arc. A pressurized or closed headbox uses a shower rotating a full 360° and is furnished with seals at each end. This shower thoroughly cleans the inner headbox using low pressure fan nozzles, preventing fiber build-up and knocking down foam on the pond. Sometimes small rotary tank wash units can be used for this application for reduced water consumption.

Breast roll – Shower 2

Located on the outside of the forming fabric and directed toward the center of the breast roll, this shower fills the void volume of the fabric to retard drainage immediately following the headbox slice. Using white water prevents thermal and pH shock.

Headbox apron – Shower 3