A new approach to fabric cleaning for nonwoven machines

Joseph A. Bolton

ABSTRACT: Forming fabrics or wires must be kept clean and dewatered. A number of different systems have been designed to keep the fabric clean of contaminants. One new system consists of a single jet slow speed traversing shower, a high-pressure hot water source, and an air knife.

KEYWORDS: Air knives, cleaning, continuous process, fabric, forming fabrics, high pressure, hydraulic equipment, jets, machine clothing, machinery, nonwovens, nozzles, paper machines, paper making equipment, pressure, separation, showers, temperature, water, water removal.

Almost all nonwoven products (health care, gowns, wipes, filter media, interlinings, wall covering, etc.) are made with the aid of a forming or conveying fabric. All must be kept clean, free of fibers and contaminants, while maintaining a low and uniform moisture content to prevent wet streaks in the process web formed.

These webs can be formed using a fourdrinier, roll former, inclined wire, Rando weber, or other equipment. The processes may be air or wet laid, with the fibers bonded together by resins, thermal, mechanical, melt blown, spunbonded, needled, or hydraulic entanglement. The typical fibers used are a combination of cellulose, natural (cotton), or synthetic fibers which are long and strong.

The challenge is to come up with a cleaning and conditioning system which can be used to keep the forming fabrics or wires continuously cleaned and dewatered.

Types of cleaning systems

Stationary fan spray shower

The first forming fabric cleaning system used a stationary shower with fan spray nozzles at pressures between 700 and 1400 kPa (100–200 psi), as shown in **Fig. 1.** This shower was only used when the machine was down or during a break. If hot water was available, it was used to help remove any fibers or resins within the fabric.

To aid in cleaning the belt or fabric, machine operators would sometimes use wire brushes by hand or a rotating brush to remove the difficult fibers. This system worked adequately, but it required frequent shutdowns and could not be used during normal production.

High-pressure oscillating needle jet shower

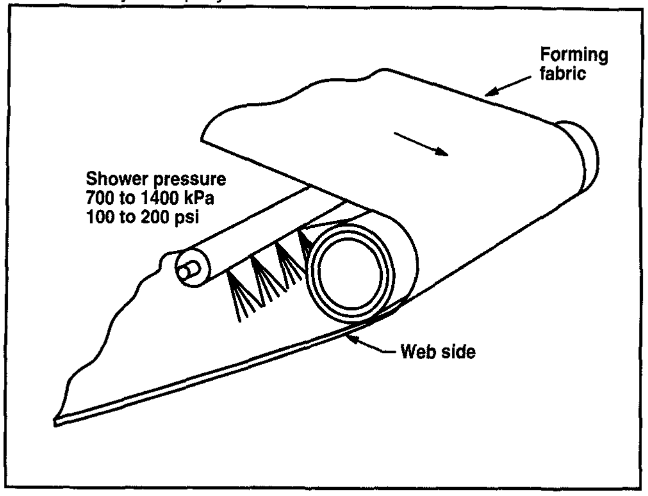
Some mills replaced their stationary fan shower with a high-pressure (H.P.) oscillating needle jet or alternating needle jet and 15° fan spray shower, as shown in **Fig. 2.** These showers ran at higher pressures, approximately 1000–3000 kPa (150–450 psi), and were much more effective than the low-pressure stationary showers for fabric cleaning.

Addition of air knife

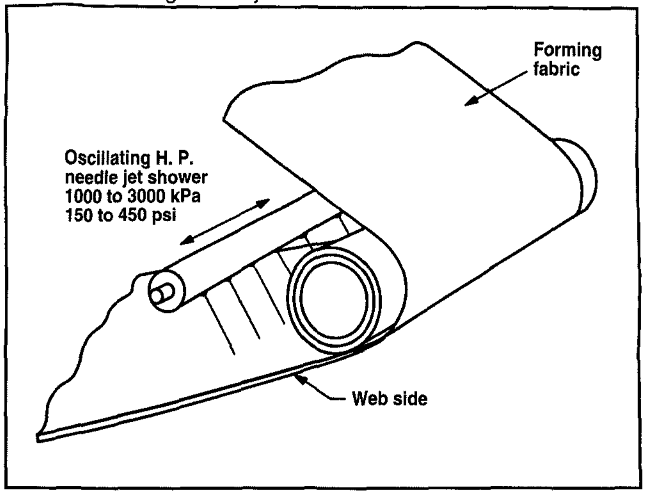
Even though the H.P. oscillating shower was more effective in fabric cleaning, it still could not be used on a continuous basis because of the wet streaks formed in the fabric and nonwoven web. To remove the wet streaks, additional dewatering equipment was added to remove both water and fibers from the fabric, as shown in **Fig. 3.** A low vacuum suction pipe and full width narrow slot air knife (0.5–0.75 mm or 0.02–0.03 in.) was added to the shower system to remove excess water from the fabric. Low vacuum (75–250 mm) of

Bolton is director of new technology with AES Engineered Systems, a Thermo Fibertek Company, 133 Quaker Rd., P.O. Box 7010, Queensbury, NY 12804.

1. Stationary fan spray shower



2. H.P. oscillating needle jet shower



water (3–10 in. H_2O) was induced at the suction pipe by a high-efficiency single-stage centrifugal exhauster (not shown). This suction pipe removed not only some excess water but also the fiber and other contaminants blasted from the fabric by the oscillating H.P. shower.

High velocity (250 m/s) and hot (80–100°C or 175–210°F) air from the air knife does an excellent job of removing excess water and contaminants from the moving fabric. Hot air is supplied to the air knife by a high-efficiency multistage centrifugal blower (not shown). The air from a centrifugal blower is heated by both compression and air friction.

The velocity of the air leaving an air slot can be calculated by the general equation[1]:

$$V = K\sqrt{\Delta} \qquad (1)$$

where

V = velocity

K = constant

$\sqrt{\Delta}$ = pressure drop.

A high efficiency centrifugal blower is an ideal compressor for feeding the air knife. Not only is it the most efficient for the pressures desired (35–50 kPa or 5–7 psi), but the air remains hot, unlike the case with the mill's compressor, where the air is cooled for removing water and improved efficiency. Also, the air does not cool as much because of lower expansion with the centrifugal blower.

The advantage of this system, as shown in Fig. 3, is cleaning and dewatering on a regular or continuous basis.

Slow-speed, programmable single-nozzle shower

A recent further improvement on the fabric cleaning and dewatering system for nonwoven applications is shown in **Fig. 4.**[2] The improved cleaning system was the replacement of the H.P. oscillating multiple needle jet nozzle shower. The new system is a slow-speed, programmable, traversing single-nozzle high-pressure cleaning shower. It has the advantages of continuous cleaning and full coverage due to its programmable speed adjustment in relationship to machine speed. With a single nozzle (one to three jets), the amount of shower water required is greatly reduced for pumping, heating, and removing contaminants from the fabric. Using the minimum amount of shower water for fabric cleaning reduces streaking. Orifice sizes for the typical needle jets vary between 0.5 and 1.0 mm in diameter.

As with the system in Fig. 3, an air knife is still used to remove excess water and contaminants from the moving fabric. But, unlike the system in Fig. 3, the low-vacuum suction pipe is now located just below the air knife on the web side to carry away the water, mist, and contaminants removed.

We have found through experience that the single most important variable for effective fabric cleaning with minimum streaking is the use of high-pressure hot water (75–80°C or 175–210°F) in the traversing shower nozzle. Hot water not only does a better job of cleaning, but because of its lower viscosity at higher temperatures, it is easier to blow and evaporate the water from the moving fabric.

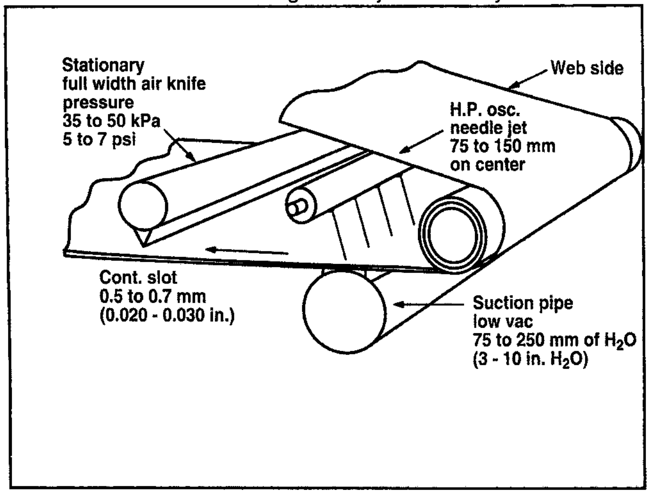
High-pressure heat exchanger and pumping system

To eliminate the problem for mills of finding or supplying hot water at sufficient pressure and temperature, we have designed and supplied a high-pressure heat exchanger and pumping system, as shown in **Fig. 5.** Fresh water is supplied to a low volume (4.0–9.0L/min or 1.0–2.5 gal/min), high-pressure, positive displacement

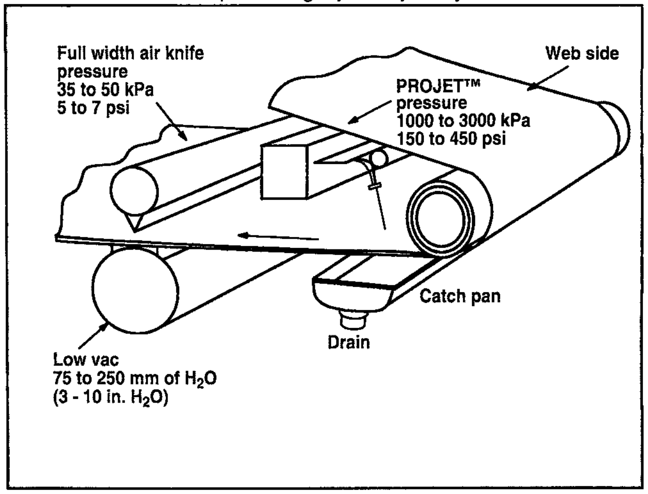
[1] Nixon, H.E., Hoffman's Handy Engineering Data Book, *Hoffman Air Filtration* Systems, East Syracuse, NY.

[2] Scarano, R.V., U.S. pat. 4, 701,242 (Oct. 20, 1987).

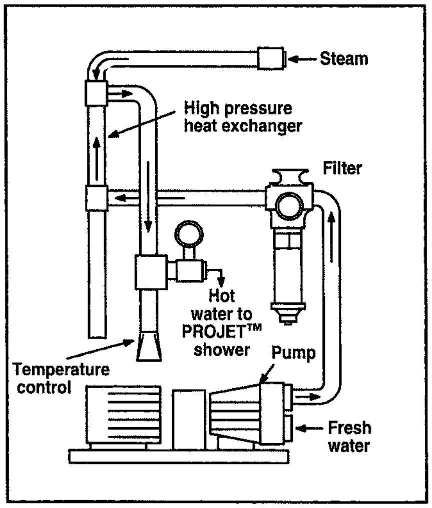
3. Air knife and H.P. oscillating needle jet shower system



4. Air knife and slow speed single jet Projet™ system



5. High-pressure heat exchanger and pumping system



pump. Discharge from the pump goes through a filter and H.P. heat exchanger. The filter protects both the exchanger and needle jet nozzle.

The miniature stainless steel shell and tube heat exchanger is designed for operating pressures up to 8200 kPa (1200 psi). Having the exchanger on the pump discharge versus the low-pressure inlet is a big plus for the operation of the H.P. pump. High inlet water temperatures to a pump can lead to problems with pump cavitation, erosion, corrosion, and low available suction head due to the high vapor pressure of the hot water. At 80°C (175°F), the vapor pressure of water is around 50 kPa (7 psia).

Water temperature leaving the heat exchanger is controlled by regulating the steam flow to the exchanger. Hot water at the desired pump discharge pressure then flows to the traversing shower nozzle. The jet spray from the nozzle forces or loosens the fibers and contaminants from the fabric, and most are caught in the catch pan.

The excess water and contaminants still left in the fabric are blown and vacuumed away by the air knife and low-vacuum suction pipe.

Conclusions

A successful fabric or belt cleaning system for nonwoven applications needs to be designed for continuous operation versus batch or intermittent cleaning. For continuous operation, a complete system is needed. The key components of the system are:

1. A slow-speed, traversing shower nozzle programmed to give complete cleaning coverage of the forming fabric or belt
2. Use of H.P. hot water in the traversing nozzle. Water pressure up to 3000 kPa (450 psi) at temperatures around 80°C (175°F) should be available for good cleaning and dewatering.
3. Use of a full width air knife system to blow high-velocity hot air continuously through the fabric or belt to help clean, dewater, and minimize wet streaking problems
4. A suction pipe and low-vacuum centrifugal exhauster for removing excess water and contaminants.

Eliminate any of these key system components, and the fabric cleaning and dewatering system will not be effective. Poor cleaning, streaking, or other unwanted effects may result.

The author wishes to thank Murray M. Cutts and Robert G. Fabian of Albany International for encouragement to write this paper.

Received for review Dec. 15, 1992.

Accepted November 6, 1993.

Presented at the TAPPI 1993 Nonwovens Conference.