Aspects of hydraulic entanglement technology

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The hydraulic entanglement process produces a strong, soft, lint-free fabric without the use of chemical binders.

The hydraulic entanglement process uses jets of water to enhance the level of bonding in wet- or dry-laid nonwoven webs. The process is capable of transforming conventional low-strength webs into soft, drapable, lint-free fabrics with increased tensile strength and higher absorbency. The ability to obtain these improved qualities and the manufacturing flexibility of water-jet entanglement systems have heightened the level of interest in this technology as a viable method of producing nonwoven fabrics. Hydroentangled, spunlaced, and jetlaced fabrics are all produced using hydraulic entanglement technology.

History of hydraulic entanglement

The origin of the hydraulic entanglement technique dates back to the late 1960s, when DuPont revealed some experimental samples that had been prepared in its research center. However, DuPont did not begin full-scale production until 1974, when it opened its first hydraulic entanglement production line in Old Hickory, Tenn.

Hydraulic entanglement was a technological breakthrough in the manufacture of nonwoven fabrics. The marketplace, however, was not yet ready for this new nonwoven product and did not respond immediately to this new technology. The materials produced from this early entanglement system found a niche in the medical nonwovens market.

Surgikas, a Johnson & Johnson medical disposables company, was a primary user of the DuPont product. Another J&J division, Chicopee, became interested in hydraulic entanglement and introduced their version of the fiber entangler in 1981. This entanglement system was installed in Benson, N.C.

In 1985, Kendall brought their hydraulic process on line in Bethune, S.C. This system had been in development since the 1970s. Overseas, the J. W. Suominen Co., a large manufacturer of nonwoven products in Nakkila, Finland, brought their spunlaced system on line in 1985.

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The Unicharm process from Japan is yet another version of hydraulic entanglement. This process, introduced in the 1980s, uses lower-pressure water jets to semi-entangle or partially modify wet-laid nonwovens.

Today's two major suppliers of complete industrial or commercial hydraulic entanglement systems are Honeycomb Systems of Biddeford, Me., and Perfojet of Grenoble, France. Honeycomb Systems supplies hydraulic entanglement rolls, including tension rolls, transfer rolls, extraction rolls, porosity rolls, and forming rolls. Many of these component rolls were used in the early hydraulic entanglement processes.

The Perfojet machine (**Fig. 1**), introduced in the early 1980s, creates a pattern or perforation in a hydraulically entangled fabric by injecting a single curtain of water through a patterned screen. This curtain can be varied in pressure, thickness, and angle to produce a variety of aesthetic effects. The Jet Lace machine, introduced in 1986, is a water-jet entanglement system that can be used in conjunction with the Perfojet machine.

The hydraulic entanglement process

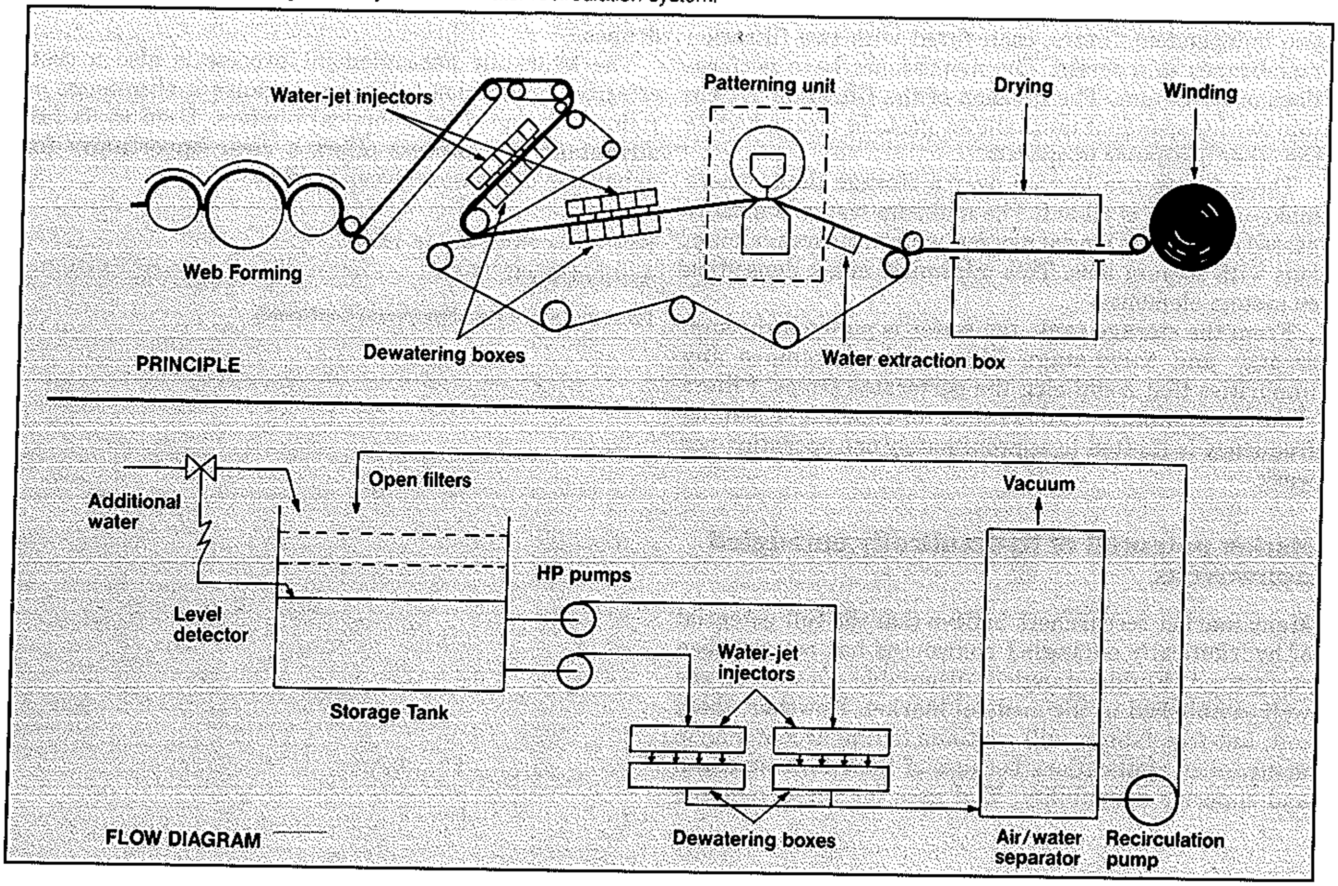
A typical hydraulic entanglement production line consists of the following components:

- Web-forming machine or headbox
- Water-jet injectors or manifolds
- Dewatering section or vacuum boxes
- Filtration/water-recovery system
- Patterning or perforating unit (optional)
- Dryer
- Winder.

Hydraulic entanglement of fibers is achieved by directing fine jets of water at a web that is supported by a conveyor belt. After penetrating the web, the water is removed by a dewatering section or vacuum boxes located beneath the conveying element. This water is transported to an air-water separator and on to a filtration unit.

Entanglement can be achieved on one or both sides of the web. Pressures used to achieve this entanglement vary from 5 bar to 120 bar. Likewise, the number of jet

1. Perfojet's hydraulic entanglement system with water recirculation system.



manifolds varies, depending on the amount of entanglement required. A hydraulic patterning or perforating machine can be located immediately after the entanglement units.

Conveyor belts

The conveyor belt is an important part of the hydraulic entanglement process. The conveyor must be sufficiently fine to reduce fiber losses and maximize the reflection of the water jets against the substrate. Greater reflection provides better entanglement and higher tensile strength. The conveyor must also be smooth, resist clogging by the wet fibers, and easily evacuate the water emitted from the jet manifolds.

Fine-mesh stainless-steel or bronze is generally used for dry-laid fabrics. In the case of wet-laid nonwovens, entanglement of the first side is achieved on the forming wire of the nonwoven machine. In this case, a plastic conveyor in two or three layers is preferably used.

Jet manifolds

The jet manifolds produce high-kinetic-energy water jets over a wide range of pressures (5-120 bar). The number, size, and energy level of the water needles produced by the injectors are determined by the type of fiber in the web and by the desired end-product properties. Wet-laid nonwovens made of short fibers generally require closely spaced jets of small diameter. For this type of nonwoven, the water pressure is generally lower than for conventional dry-laid webs.

Each injector includes:

- Water inlet pipe
- Upper chamber, where water is distributed uniformly across the injector's entire width
- Lower chamber
- Perforated strip, generally with two rows of holes
- Upper hydraulic jacks, which are attached to brackets supporting the perforated strip. The jacks facilitate quick removal of the perforated strips.

The jet manifolds can be cleaned by remote control with a minimal amount of downtime.

Suction boxes

Individual suction boxes are installed below each injector. The width of the suction slot is adjustable to minimize energy loss. Vacuum boxes are individually adjustable to match the water-pressure of the injectors.

During the manufacture of wet-laid webs, fibers tend to accumulate inside the suction slots. It is nearly impossible to eliminate this problem completely in a continuous operation, so the boxes are designed for easy cleaning. The suction boxes are installed on a frame that can be lowered swiftly. The suction slots are then cleaned using pneumatic bellows attached to the lowered frame. Downtime is minimal.

Water recirculation system

Water from the suction boxes is transported to air-water separators and then passed through a first-stage filtration process. This first stage of filtration includes two independent filters, each fitted with two filtration membranes in a series. The membranes have perforations of 60–80 μm. The division of the filtration system into two independent units allows one to be cleaned while the other continues to operate.

These filters are located over a storage tank, where make-up water is added. The make-up water is usually passed through an ion exchanger, which replaces calcium ions with sodium ions. This minimizes chalk deposition on system elements.

From the storage tank, the water is pumped through second- and third-stage filters, which remove any impurities that could clog the perforated strips. Filters require a minimum of downtime for cleaning. Cleaning frequency is limited to approximately one operation per week.

Market potential of hydraulically entangled nonwovens

Many market researchers believe that the full potential of hydraulically entangled nonwovens has not yet been recognized. Fluid-entangled, disposable nonwovens are well established in the medical market. However, these soft, lint-free fabrics will continue to find acceptance in many other applications because of their high strength and superior drapability. End uses for these versatile products include apparel fabrics, interlining fabrics for clothing, and decorative fabrics such as wallpapers and drapes.

The hydraulic entanglement process is also a cost-effective production technique because it eliminates or reduces the need for chemical binders. Used to its full advantage, the process offers a clear opportunity for expansion of the nonwovens market.

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