PATTERNING OF NONWOVENS

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ABSTRACT

In an effort to make nonwovens appear to be like woven textiles, work has been carried out for over 50 years to put patterns into nonwovens to make them appear as woven or even knit materials. The work has usually involved water to move the fibers of the nonwoven into a pattern that was similar to that of the textile. Similar techniques have been applied to wet form and dry form materials. Recent efforts have not only looked at the pattern, but more importantly the function of the nonwovens. It is not enough to have something that looks woven, but to have something that performs like a woven as well. The main techniques of patterning nonwovens will be discussed and the recent findings that allow for improved performance will be covered as well.

BACKGROUND

It has always been a goal of nonwoven producers to have their products perform and look like woven textiles. In many applications nonwovens are truly “engineered fabrics” and one only has to look at a baby diaper or incontinent product to understand the breadth of technology that is incorporated in these end uses. Diapers are one example of a textile replacement where the function of even the earliest products was of such interest to the users that the fact that they didn’t look like textiles was of little interest. On the other hand, the annals of nonwoven history are filled with examples of nonwovens that were tried in apparel and home furnishings where even functional products haven’t displaced traditional textiles. The paper dresses and disposable swimwear did little to enhance the image of nonwovens as serious textile products and probably contributed to negative impressions that are even today being overcome.

Early attempts at creating patterns were very successful at providing patterns in nonwoven materials (1). These were initially dry formed webs that were subjected to water streams that caused the fibers to rearrange. In some cases the products had a “woven” appearance (Fig.1). The bonding of these products was usually by latex saturation or by printing of the latex to provide strength and some softness. Most of us remember when we first saw the “snowflake” nonwoven (Fig. 2) and the first wiping cloths that were printed with a diagonal pattern on a dry formed web with apertures that looked something like a woven cloth. The use of an external binder did not help to overcome some of the usual strength/softness problems that occur with nonwovens.

While the work on dry form nonwovens was being carried out, the wet form developers were working on their own patterning techniques. The use of heavy forming fabrics or
“knuckled” wires allowed specialty papers to be made with a “woven” look as the paper formed around the heavy pattern of the forming wire. Complex patterns were developed for single and multiplayer nonwovens and specialty papers. Again, water was used to develop the patterns during the forming of the sheet. Patterned or “textilized” tea bags have been used for some 40 years and contain patterns and designs from simple woven patterns to complicated logos.

The development of hydroentangled bonding was a great step forward in the development of strong and soft nonwovens. The fact that water is used for bonding led to a series of new fabrics that indeed started to have textile qualities. Wipes were developed that had texture for capture of material during cleaning operations. Other materials had the look and feel of woven materials and even were introduced into home furnishing applications. Even the ever-elusive apparel applications were being talked about for nonwovens.

Finally, recent activity is focusing on developing function in addition to the pattern of nonwovens. Improved wiping action, abrasion resistance and strength are some of the attributes that are desired on these new materials.

In addition to water arrangement of fibers, it is possible to form nonwovens on surfaces. A few spunbonded products are by spinning molten filaments onto a form.

The following sections will discuss the main processes used to day to form patterned nonwovens. Most are patented processes, but like other nonwoven technologies, patents do expire and present opportunities for new research.

LOW PRESSURE WATER PATTERNING

The work to pattern nonwovens began in the mid 1950’s, starting with fiber based nonwovens and then continuing with wet form processes. The pioneering work of Kalwaites used water sprays and a patterned cylinder to displace fibers in a web to produce patterns(1). In the process, a web of carded fibers was carried to a patterned drum by a woven screen and the fibers were held against the pattern Fig. 1. In one arrangement, the fibers were displaced by water impinging from inside of the patterned cylinder. In this instance, the fibers were moved away from the openings and formed the pattern of the cylinder. In another variation, water sprayed from outside of the carrying fabric and the fibers were forced into the openings of the patterned cylinder giving the opposite effect. After the patterning, the web was dried and usually bonded before being reeled up for final conversion. The process was very successful in the production of limited use towels and wipes.
In the area of wet form nonwovens and papers there are two systems for patterning webs using “low pressure” water. The first one is the “water knife” process for making patterned wet form nonwovens\(^2\). In this process a wet form web is prepared from a mixture of wood pulp and other fibers. As the web is formed, it is subjected to a patterning process that consists of a water knife that sits inside of a patterned screen (Fig. 2). A uniform sheet of water is formed in one chamber of the knife and is sent through a patterned screen. A vacuum chamber in the knife adjacent to the water supply removes excess water inside of the cylinder. The water that passes through the screen causes some of the fibers in the wet form sheet to be moved as the water passes through the sheet produce a pattern of the cylinder in the sheet. If the sheet is a two-phase construction, it is possible to move the fibers in the top phase leaving the bottom fibers intact. Products made with this process include heatseal tea bag papers where logos and patterns are formed in the top layer.

Figure 1

Figure 2
A variation of this process has been developed where the water knife is replaced with a nozzle strip that allows fine water jets to penetrate the patterned screen and impinge on the wet sheet causing the fibers to move. In both of these cases, the fibers move away from the apertures in the screen leaving the pattern of the screen cylinder in the wet sheet. In both cases the wet form webs are then dried, treated to give strength and then converted to their final form.

HIGH PRESSURE PATTERNING

The advent of hydroentanglement introduced new methods of forming patterns in nonwovens. Work in the 1960’s recognized that using high pressure water jets against a patterned surface would allow for movement of fibers to follow the pattern of the surface as well as to allow for entanglement of the fibers to produce a strong and yet soft material. The work of Evans is described in a patent where fibers are entangled on a perforated plate or on a woven screen\(^3\). The plate or screen is supported on a second porous fabric to help retain the fibers. In this process, the fibers are not just displaced, but are forced through the pattern toward the screen. The fibers are additionally entangled to give much more strength than was seen in the earlier work where the fibers were just displaced and then subjected to additional bonding.

In the high pressure process, the patterned member is often a woven belt and the fibers are forced to take the pattern of the belt, similar to the action in a wet form patterning with a knuckled wire. The appearance is then similar to a woven fabric with the improved strength and softness of a hydroentangled nonwoven material.

In the early 1990’s patents appeared that extended the concept of patterning of nonwovens with hydroentanglement. The work of Drelich, et.al. introduced a specific shaped surface of pyramids as the support for entangling a carded fiber web\(^4\). The introduction of the pyramids as well as the location of the perforations on the surface introduced new properties to the nonwoven that were starting to come more into line with some woven structures (Fig. 3). The pyramids and the location of the apertures in the forming plate introduce a twist in to the fibers that resembles that of a textile woven from spun yarn. Not only was the clarity of the fabric as good as woven gauze material, but the density of the fabric was similar.

![Figure 3](image-url)
The importance of the use of shaped surfaces can be seen in the continued flow of patents and applications. One of the more interesting is a recent application for a wiping fabric that has improved abrasion properties over more conventional hydroentangled materials (5). The surface is extremely complex and is produced through complex electrodeposition techniques (Fig. 4). In addition to the shaped entanglement surface, thermally active bonding fibers are used.

![Figure 4](image)

**Figure 4**

Work in patterning continues to expand and other ideas are being introduced. In production of hydroentangled fabrics, it is possible to first form and bond the nonwoven and then in a later step, pattern the product. Noelle describes a machine that will pattern a nonwoven that uses a cylindrical screen with a sheath covering the screen (Fig. 5). Benefits of this process are that patterns are produced on bonded materials and indeed woven textiles can be “patterned” using this method.

![Figure 5](image)

**Figure 5**
Conclusion

The patterning of nonwovens continues to be a focus of much research in the industry. The ability to make nonwovens appear more like woven textiles as well as to increase the performance of those materials. While many of these products and processes are patented and therefore protected, technology is available that has been disclosed and is the subject of expired patents and is therefore available to anyone. The discovery that not only is it possible to improve the appearance, but the performance has brought great value to nonwoven producers and their customers.

References
1.) Frank Kalwaites; *Method and Apparatus For Producing Nonwoven Product*; US 2,862,251 (1958).
6.) Frederick Noelle; *Machine For Producing A Patterned Textile Product Thus Obtained*; US 6,865,784 B2 (2005).