Forming fabrics for spunlace applications

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A nonwovens manufacturing process uses forming wire designs to create patterns in the finished product.

When the spunlace or hydroentangling nonwovens process became operational in the early 1970s, new forming wire technology had to be developed. All of the existing technology was based on papermaking using metal wires. The initial forming wires were thus all-metal wires. Papermaking gradually switched to plastic wires, but that proved to be much more difficult for nonwovens fabrics. Because plastic strands react differently during processing from metal wire strands, a direct material substitution cannot be made without changing some of the final fabric characteristics. That in itself was not a major problem in papermaking. Spunlace, on the other hand, is a nonwovens process step where the forming wire design can be an integral part of the process. Even relatively minor forming wire design changes can result in a "different" nonwovens product. The result has been that metal wires still are used quite extensively in spunlace manufacture.

When both plastic and metal strands are used in a forming wire, some unique knuckle patterns can be attained which could be of interest to a nonwovens producer.

Table I compares some of the characteristics of metal and plastic wires.

Spunlace equipment

There are two basic methods using forming wires to make spunlace products. One is to use the forming wire as a moving belt. In this case, the forming wire is installed on the equipment just like any other forming wire and must also serve the basic needs to be stable, flat, and durable. In addition, there are some unique requirements for spunlace which will be detailed later.

Another spunlace manufacturing method is to use the forming wire as a drum cover. In this case, actual installation of the drum cover is extremely critical. Unless it is a metal wire which is brazed on the drum, the length dimensions of the drum cover must be very precise. In some cases, a plastic wire could be used, and it may be shrunk onto the drum using heat.

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I. Comparison of metal and plastic wires

Plastic wire	*Metal wire*
Good flex resistance	Poor flex resistance
Lightweight	Heavyweight
Easy to install	Difficult to install
Corrosion resistant	Corrosion prone
Difficult seams	Nonmarking seams
Shower damage prone	Shower damage resistant
Difficult to control knuckle height	Easier to control knuckle height

End product characteristics

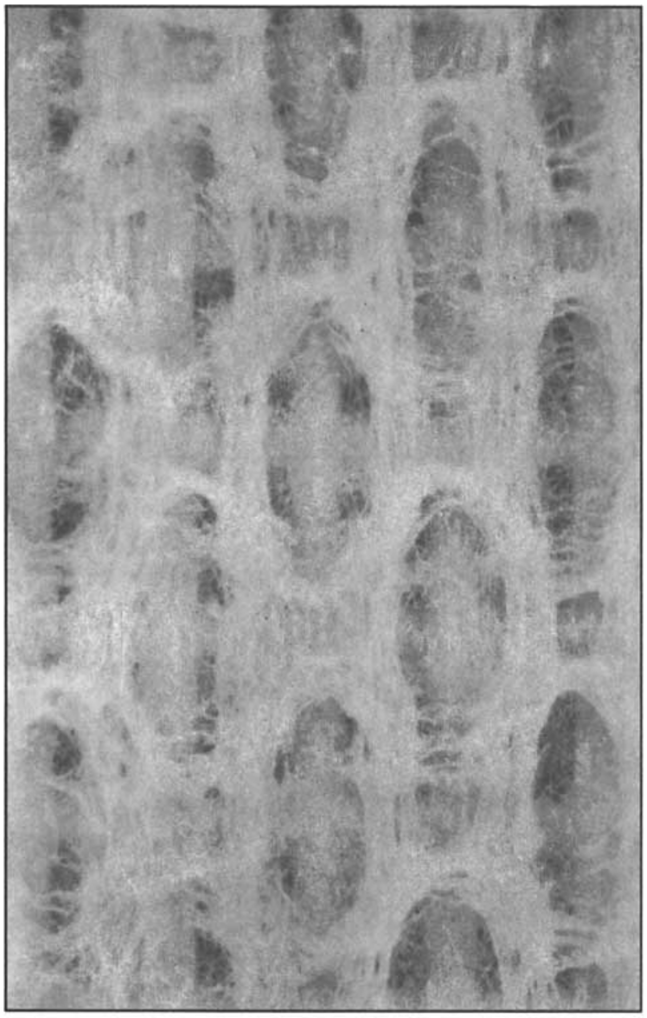
The nonwovens producer can utilize spunlace for two entirely different purposes. One method is to make a nonapertured product, which essentially is a way of bonding fibers together. The other method is to make an apertured or patterned end product. The requirements of the forming wires in these two end uses are vastly different.

Nonapertured spunlace

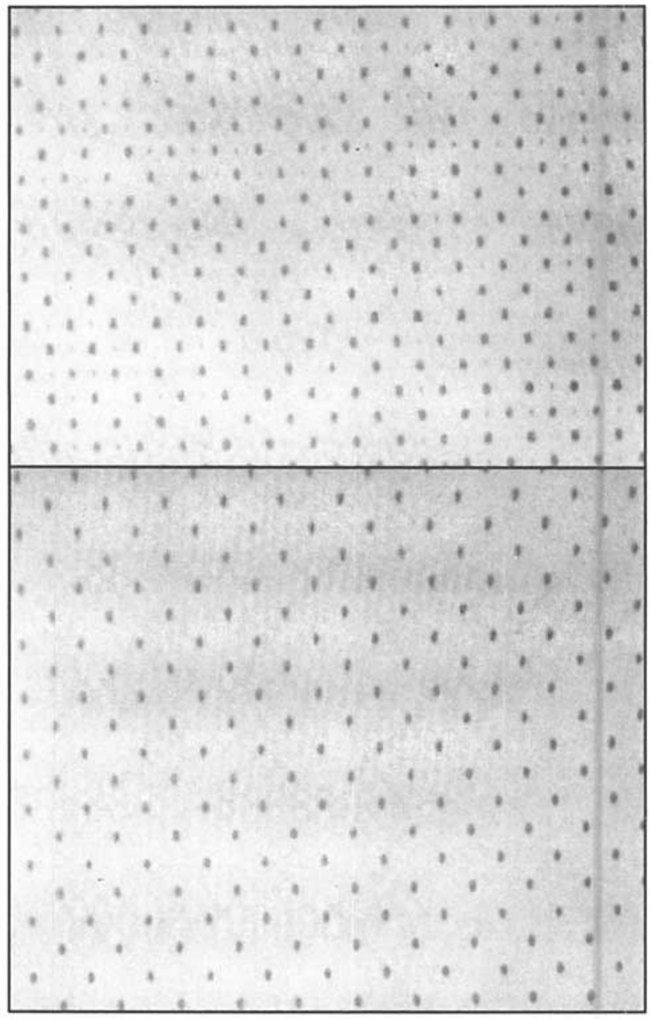
In manufacturing a nonapertured product, the intent is primarily to have the spunlace give the product strength. It can also be used to combine two or more different webs into a composite end product. In this case, little or no mark from the forming wire is desired in the final product. This usually means a fine mesh, smooth top surface in the forming wire. The compromise which has to be considered is that a fine mesh forming wire with small diameter strands will have good product support and minimal wire mark, but durability may be sacrificed, particularly at high waterjet pressures.

A top wire surface with short, tight knuckles, such as two-shed and three-shed weaves, gives good support for fiber bonding. Longer knuckles, such as four-shed and five-shed weaves, frequently have problems with fiber buildup in the wire. Under high waterjet pressures, the longer strand knuckles deflect and tend to pinch fibers.

For nonapertured applications, relatively fine mesh wire designs are used—70–100 mesh (28–39 per cm) in single-layer configuration, both metal and plastic. Multilayer wire designs have also been introduced, which



1. Nonwovens product on forming wire, showing aperture produced by high knuckle



2. Apertured product (top) and forming wire (bottom) used to create it

in some cases work well. In making a change from a metal wire or single layer plastic to a multilayer wire, certain process adjustments may be necessary.

Apertured spunlace

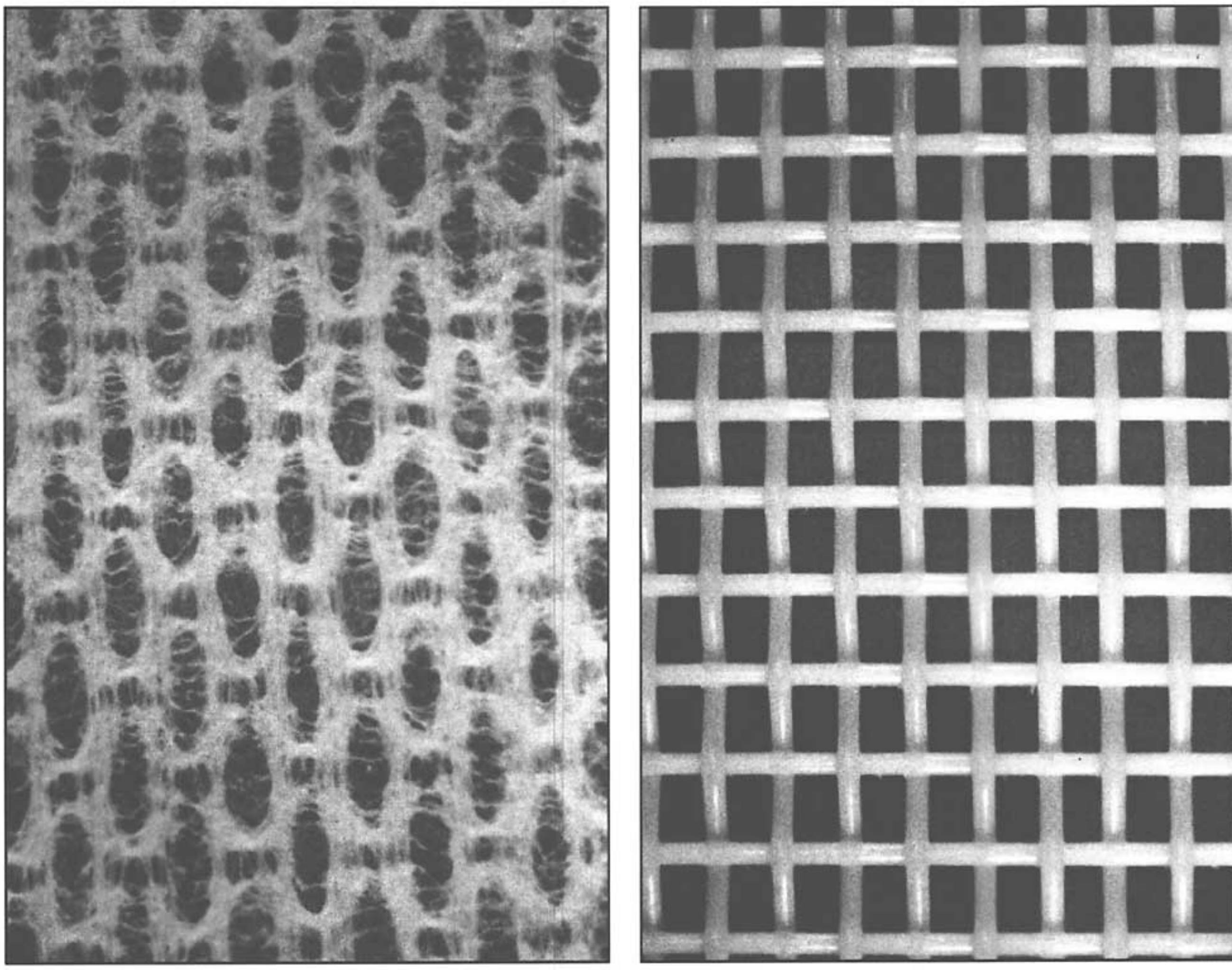
In the apertured nonwovens manufacturing process, a textured product surface with a distinct mark from the forming wire is desired. This is totally opposite to the nonapertured process. This is also an area where very close interaction between the nonwovens producer and the forming wire supplier is important. The surface topography of the forming wire is extremely important and will have a direct influence on what the nonwovens product will look like. The wire supplier thus finds this area of nonwovens manufacturing very interesting and rewarding.

In apertured spunlace, the principle is that whenever there is a high knuckle in the forming wire, there will be a corresponding aperture in the nonwovens web. There used to be a popular misconception that a hole in the forming wire gives a hole in the nonwovens product.

The initial web can be manufactured using a number of well-known processes, such as carding, air-laid, wet-laid, melt-blown, or spunbond. This web is then carried on top of the forming wire. The high-pressure waterjets go through the web, hit, and are deflected by the high knuckles in the wire. The deflected waterjets force the fibers down from the high knuckle into the open or lower portion of the wire, thus creating a hole in the web. The clarity and definition of the hole is dependent on a number of parameters such as basis weight, fiber type and size, water pressure, and wire knuckle shape. **Figure 1** shows the nonwovens product on top of the forming wire after it has passed under the waterjets. There is an aperture in the product where there is a high knuckle in the wire. **Figure 2** shows the apertured product and the forming wire used side-by-side.

If the strand knuckles in the forming wire are at different height levels, then it is possible to get a nonwovens product with different hole configurations. Thus the plane difference in the forming wire is very important. The plane difference is the difference in knuckle height between a machine-directional (m/d) strand knuckle and a cross-machine directional (c/d) strand knuckle. For example, there could be a well-defined primary hole and a less-defined secondary hole. This is the effect of plane difference. There are almost infinite variations as far as available knuckle patterns for the nonwovens producer to evaluate. Thus it is important for the producer to have

3. Ink prints created from two wire designs



a close relationship with the wire supplier and to discuss in detail what characteristics are being sought. By utilizing different weave patterns and strand geometries, it is possible to come up with differently shaped apertures in the web—round, oval, square, or rectangular, for example. It is also possible to end up with geometric lines of apertures in the product such as straight, interrupted, diagonal, or herringbone shaped.

It is also possible to produce designed characters in the nonwovens product. One method is to utilize watermark technology and make designs on the forming wire, but there are also other methods.

Since the forming wire has such an important role in the spunlace process—producing an exact mirror image in the nonwovens product—the quality and uniformity requirements are exceptional. This has posed quite a challenge to the wire manufacturer.

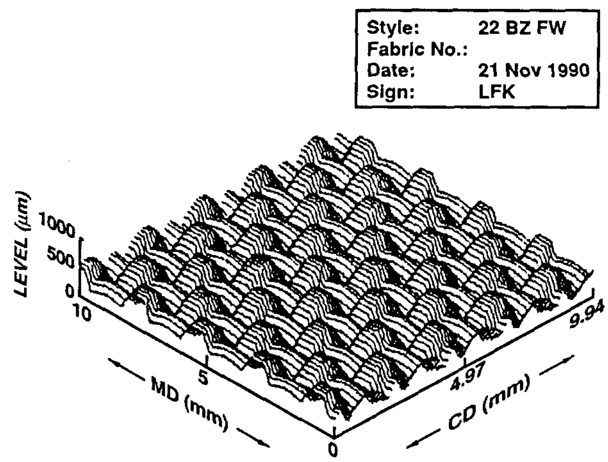
Wire pattern evaluation

Because there is such a direct relationship between wire geometry and nonwovens end product, some initial patterning evaluations can be done in the laboratory. These can range from simply using Silly Putty to make a knuckle impression of the fabric (actually quite interesting), all the way to computer simulation.

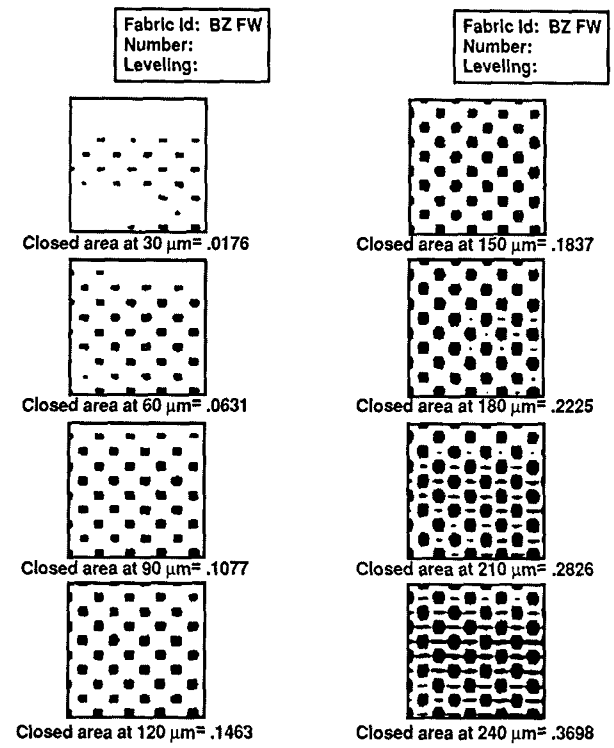
An easy test to do is to make an ink-print impression of the wire surface to be used against the nonwovens fabric. A high knuckle in the wire will give a black dot on the ink-print which may correspond to an aperture in a spunlace product. **Figure 3** shows ink prints from two wire designs, both 20 × 20 mesh (8 per cm) with identical strand diameters. The difference is that one sample is monoplane (m/d and c/d knuckles in plane) and the other sample has a high m/d strand knuckle. In the spunlace process, these two wire designs will give different apertured end products.

An instrument called a perthometer is available which can analyze the wire topography in great detail. These results can then be used to discuss with the spunlace producer what factors in wire topography are important and what changes to make in order to obtain the desired end product.

Figure 4 shows a computer-generated topography of an actual wire. The perthometer has a very small needle which traverses over and across a wire sample. As the level of knuckle plane changes (between m/d knuckle and c/d knuckle), the needle is displaced up or down. These displacements are saved in the computer for later analysis. These data can be looked at in many different ways.



4. Computer-generated topography of a forming wire



5. Variations in number of wire support points at different levels into the wire

One can look at the geometric shapes of the knuckle such as round or square. One can look at the number of wire support points at different levels into the wire, as shown in **Fig. 5**. The same information is shown in graph form in **Fig. 6**. In spunlace, this may then be the way that apertures are formed in the nonwovens product. However, if a fine mesh fabric is analyzed, the information may also be used to minimize wire mark and maximize fiber support, if desired. It is thus important that the wire supplier and the nonwovens producer discuss this information thoroughly, since it may have an important impact on the end product.

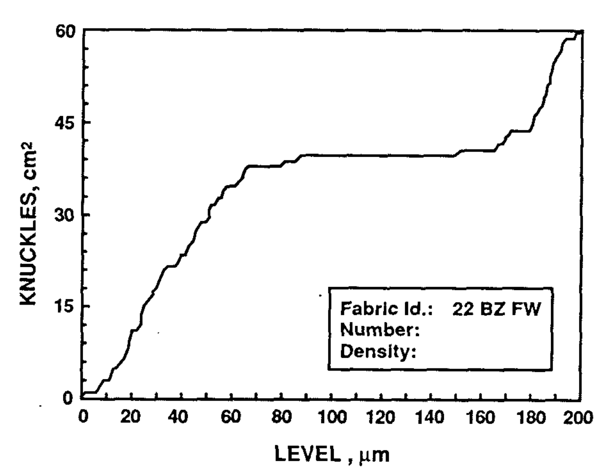
Wire topography analysis is an important tool. Using this information properly may save a lot of money on expensive production machines. Since each producer process is different, however, it is a good idea to correlate some of this theoretical information with actual pilot or production experience.

The perthometer can also be used to look at product samples and then put these data in relation to data from the wire sample used to make the product.

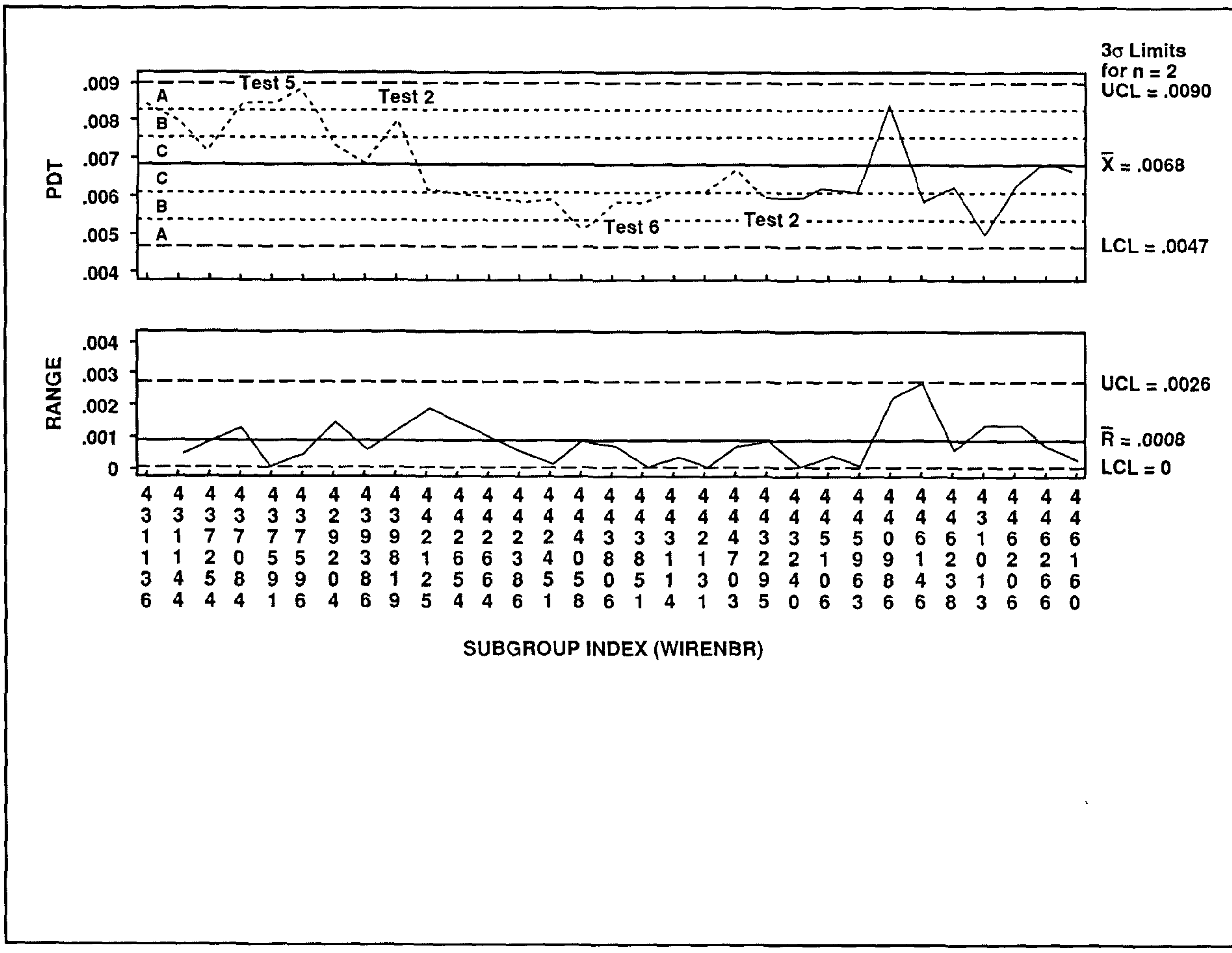
Wire quality considerations

We have explained how the forming wire is directly related

6. Graphic representation of numbers of wire support points at different levels into the wire



7. SPC chart of knuckle heights of certain wires in a design



to the nonwovens product in spunlace. This means, of course, that the quality and uniformity of the forming wire is very important to the final quality of the nonwovens product. Since wire topography is critical, it is necessary for the forming wire supplier to have his process in control. **Figure** 7 is a statistical process control (SPC) chart showing knuckle height for a number of individual wires in a particular wire design. When this information is available, it becomes meaningful to relate any problems during spunlace back to the uniformity of the forming wire. The nonwovens producer must know what level of consistency his supplier can meet. Knuckle height, for example, is not easy to control by the wire manufacturer.

The mirror image effect of the nonwovens product from the forming wire means that the quality level for forming wires for spunlace must be exceptional.

Summary

For the forming wire supplier, the spunlace field is probably the most exciting but at the same time the most demanding. The impact of the forming wire to the nonwovens producer is critical. It is crucial that the supplier and the producer work very closely together.

Since spunlace production is frequently proprietary, the wire supplier and the producer must have a relationship of trust so that confidentiality is not compromised. This is extremely important in order to develop new products.□

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