FUNDAMENTALS OF NEEDLE PUNCHED COTTON

Mike Pate
Foster Needle Company
Manitowoc, WI

Needlepunched nonwovens are created by mechanically interlocking the fibers of a carded or an air laid batt (web), or of a spun bond material. This mechanical interlocking is achieved with thousands of felting needles repeatedly penetrating the web or spun bond.

Figure 1 helps illustrate the needle felting process. As the needle beam raises and lowers the felting needles, the blades of these barbed needles repeatedly pass into and out of the fiber batt (web). Each barb fills with fibers on the downward movement and carries these fibers the depth of the penetration. When the needle beam retreats upward, the fibers are released from the barbs. Reorientation of these carried fibers from a horizontal to a vertical plane within the web will result as this motion is repeated. Generally speaking, as the number of penetrations per square inch is increased, as are fabric dimensional stability and density.

The batt is pulled through the needle loom by what are called draw rolls. The material passes through the needle loom between two plates: a stripper plate which is on the top and a bed plate which is on the bottom. Needles go through corresponding holes located in the stripper and bed plates. As the needle beam moves up and down, the draw rolls pull the material through the loom while the needles penetrate the batt and perform the interlocking process.

Although there are more than 1000 types, sizes and variations, all felting needles will fit the shape of those shown in *Figure 2*. All will have most of the six common features:
The Crank is the 90 degree bend on the top of the needle. The crank provides for needle location in the board of the loom. Perhaps more importantly, each barb will have a precise distance from the crank. When making penetration depth adjustments, barb to crank distances must be equal from needle to needle.

The Shank is that portion of the needle that fits directly into the needle board.

The Intermediate Blade is used on double reduced needles. This section makes them more flexible and somewhat easier to place into the boards.

The Blade is the working part of the needle. It is the blade of the needle that penetrates the fiber batt. The most common shape of the blade is triangular, with three edges into which barbs can be formed.

The Barbs are the most important part of the needle. It is the barbs which engage fibers during penetration through the batt and perform the interlocking function. Felting needles can have one, two or as many as 36 barbs. There are many variations in barb placements and spacing. Most felting needles will have two or three barbs per edge.

The Points seem self explanatory. But there are long points, short points, polished points, ball points, chisel points and beveled points. Each can offer a different effect for a given application.

Needlepunching is no newcomer to the nonwovens industry. The process itself was established before the turn of the century. However, early felting needle looms and the fabrics they produced were extremely crude in their design and engineering. The early needle looms were also quite slow, capable of only 100 strokes a minute. The main products produced during those early years were paddings and waddings made of jute, sisal and animal hair. These pads were used primarily for spring insulators in the mattress and furniture industry and for carpet underlay in commercial applications or for the home furnishings industry.

Since these early days, however, needle felting technology has advanced greatly. Today's modern felting needle looms have the capability of 2000 strokes a minute.

The felting needles that produce today's highly technical felts have also become more engineered and advanced. Uses for today's highly technical needlepunched fabrics include space shuttle exterior tiles, geotextiles, filtration, papermaker felt and synthetic leather.

The fibers used in the needling process have also become more advanced over the years. In the 1940's and 1950's natural fiber such as coir, sisal, wool and animal hair were the predominant fibers being needled. Today, man-made fibers such as polyester, polypropylene, aramid fibers, glass fibers, teflon fibers, ceramic fibers, mineral fibers and nylon have replaced many of the natural fibers used years ago.

Let us now take a closer look at some of these features and their variations that have a relationship to various nonwoven physical properties.

Rounded Barb Styles

Undeniably, the barbs are the most important single element of the felting needle. It is the barb or barbs on the blade of the felting needle that carry and interlock fibers during the stroke of the needle and penetration of the fiber web. Therefore, it is easy to understand the relationship that barb design and shape can have on fiber damage and on nonwoven physical properties.

Several needle manufacturers now produce what are called rounded barb styles. This barb style can be seen in *Figure 3*. All edges are rounded and the barb face is formed so that only rounded smooth edges engage fiber. This minimizes any fiber damage caused by the barb itself.

In contrast to the rounded barb styles is the conventional or cut barb. Illustrated in *Figure 4*, the cut barb has been in use since the first felting needles were produced.

It is made with a chisel-like tool that cuts into the blade's edge. All surfaces of the cut barb are flat and all edges are sharp. As fibers are engaged, they must lie across two sharp edges and one flat surface. The conventional cut barbs can be effective but not without causing fiber damage higher than necessary. The cut barb represents a compromise between the barb's fiber carrying capacity and the barb's fiber destruction characteristics. The higher the fiber carrying capacity, the higher the fiber destruction. With the use of conventional cut barbs this relationship is unavoidable.

Applications where the rounded barbs are most advantageous are those where fabric strength is extremely important and those where either the fiber is very delicate or where excessive fiber damage is especially detrimental to the useful life of the fabrics.

Fiber compaction is greater with higher barb angles because the fibers do not slip off the barb face during penetration through the fiber batt. The majority of the fibers that fill the barb are carried for the entire stock. As a result, fabrics can be made stronger and more dense than if the barb angle had been lower.

Lower barb angles allow for fiber slippage as the needle penetrates the fiber batt. Fabric made with lower barb angles will be more lofty and thick; they will generally have a better hand and be of lesser strength than if barb angles had been higher. The decision to use higher or lower barb angles depends on the fabric being produced.

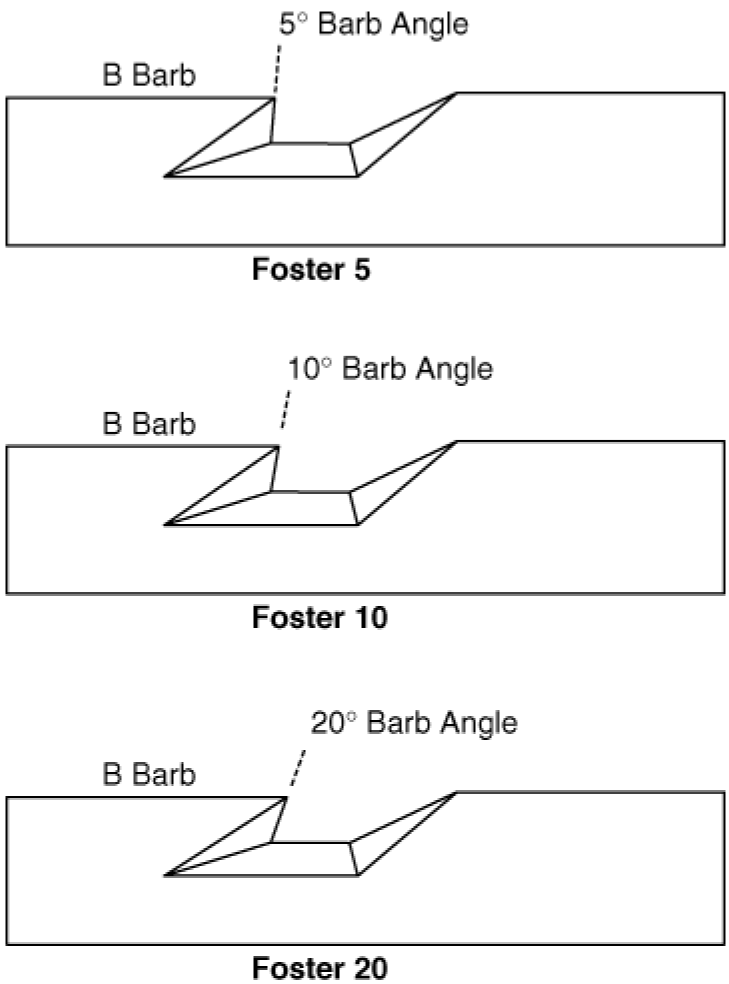

Figure 5: Selection of barb angles

<u>The Barb Angle</u>

The barb angle can also be referred to as the rake or undercut angle. The barb angle is critical to the effectiveness and efficiency of the barb. Very simply, the barb angle is the amount of degrees by which the fiber engaging surface is displaced from a vertical position. Some felting needle producers offer a selection of barb angles ranging from zero degree barb angle through 20 degree barb angle and greater. An example of this can be seen in *Figure 5*.

It is thought by some that to gain high tensile strengths it is necessary to use high kickup, thereby densifying and compacting more fibers per stroke. This is not necessarily true. High kickup can cause varying amounts of fiber damage. High kickup can literally rake and break fibers, thus lowering tensiles and nonwoven physical properties. Higher tensiles can generally be achieved by lowering the amount of kickup and increasing the amount of needle penetrations per square inch. Fewer fibers will be carried each stroke. However, the total fibers of the web are treated in a much more gentle manner.

When very high tensiles and fine surface conditions are not a necessity, high kickup may be ideal. High kickup is excellent for needling waste fibers or "shoddy" fibers, which are often used in the production of paddings and waddings. These products often require only average strengths and fine surface requirements are not a concern.

<u>Kickup</u>

As can be seen in *Figure 6*, kickup is the protrusion of the barb above the edge into which it is formed. Kickup can be engineered so that it is very high or in decreasing size so that there is actually no protrusion at all. The use of a particular kickup level will often be determined by the physical properties being produced in the fabric.

Open Barbs have been the answer to a continued and even increased barb efficiency at higher loom speeds. Modern felting needle looms are being designed to operate at ever increasing speeds. As these speeds are increased, it becomes more difficult to maintain uniform barb loading. Often times, a barb with a throat of conventional design will move past fibers at higher loom speeds, which may have loaded at lower loom speeds. The net result is that some of the advantages of increasing loom speeds could be lost due to decreased barb efficiency.

Even at lower loom speeds the Open Barb can show advantages. It may be used to increase needling efficiency without reverting to a barb with a more damaging kickup level. They may also be used in a tacking operation where a high degree of fiber transport is required in the fewest number of penetrations. Areas where the Open Barb has shown the most advantages are in the needling of ceramic fibers, certain geotextile products and in the production of shoulder padding.

The Open Barb

The development known as the Open Barb is directed towards the attempt to provide a desired barb with an open throat area for more ready fiber accessibility. *Figure 7* shows two needle blades; one with conventionally throated barbs, the other with the Open Barb design. The Open Barb eliminates the metal preceding the barb face. By removing this material, the throat becomes substantially parallel to the axis of the needle blade and free from fiber loading restrictions.

The Pinch Blade

The Pinch Blade is the only commercially available and functionally superior alternative to the traditional triangular blade. As shown in *Figure 8*, the Pinch Blade differs in it's physical shape; it is very nearly a diamond shape cross section. There are only two barbed edges and these are directly opposite each other.

There are four main advantages Pinch Blade needles have over triangulated bladed needles: more effective fiber transportation, improved needle strength, superior fabric surface qualities and less damage to warp yarns and woven backings.

More effective fiber transportation is possible with the Pinch Blade because of two main reasons. First, the two rows of barbs work independently. Each barb in each row of a triangular bladed needle will partially needlepunch the same fibers, which are also being engaged by barbs on adjacent rows. With the Pinch Blade, the opposed location of the two barbed rows assure that separate fiber loads are being needlepunched by each row. Secondly, the two edges of the Pinch Blade into which the barbs are placed have a narrower cross section than found on the edge of a triangular blade. This narrower edge allows for a narrower fiber engaging surface.

Pinch Blade needles offer improved needle strength as a result of reduced deflection when penetrating the fiber batt. The two barbed rows of the Pinch Blade pull directly against one another, thus stabilizing the penetration of the needle and reducing the tendency for needle deflection. Improved fabric surface qualities is due to the shape of the hole made by the Pinch Blade. The two rows of opposed barbs produce an eyelid effect as they penetrate the fiber batt, transport the fibers and then withdraw from the fiber batt. This eyelid shaped hole closes less noticeably than holes left by a triangular blade.

The Conical Blade

As *Figure 10* illustrates, the Conical Blade is produced so that the entire working blade is tapered from the smallest diameter at the point to the largest diameter at the shank or the intermediate portion. The Conical Blade is designed for certain felting situations that place large levels of stress and strain on the needle's blade section, which can cause varying amounts of needle breakage.

The Conical Blade shape allows the smallest diameter to more easily penetrate the web. Then, as resistance increases, the heavier portion has entered the web. The heavier diameter section of the Conical Blade will better withstand the stresses and penetration resistances, thus preventing excessive needle breakage.

The triangular blade Conical has proved successful in paddings, waddings and underlay fabrics made with recycled and regenerated fibers. These fabrics can employ varying amounts of deniers, fiber lengths and fiber types. When this is combined with some amounts of unshredded fabric pieces, a higher amount of breakage will occur to those needles that are not of the Conical design. Another design, the Pinch Blade Conical, has been successful in the production of various technical felts, including geotextiles and synthetic leather.

Of course, Conical Blade needles are not ideal for all applications. They can result in a more visible needle pattern on the fabric surface due to the greater thickness at the top of the blade.