TECHNICAL BULLETIN

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NAPPING OF COTTON FABRICS

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INTRODUCTION

Classic cotton fabrics with napped surfaces, such as flannel, moleskin and fleece, have an inherent warmth and softness which is universally appealing, particularly in colder climates. These characteristics give added value to cotton apparel and home textile products.

This technical bulletin defines and describes the mechanical finishing process of napping. In addition, the process of shearing is described. Specifically, the application of these processes to cotton fabrics, both knit and woven, is covered. Industry insiders consider napping to be an art rather than a science; therefore, the information provided in this bulletin is general in scope. The best way to become knowledgeable about the process of napping is through practical experience and trial-and-error experimentation.

DEFINITION OF TERMS

NAPPING - A mechanical finishing process in which fibers are raised on the surface of a fabric by means of teasels or, on contemporary equipment, by rollers covered with steel napper wires. Other names for napping are Gigging, Genapping, Teaseling, and Raising.

SHEARING - This process normally follows napping, and involves the mechanical cutting or trimming of fibers projecting from the surface of the cloth to produce a uniform and level pile.

HISTORY OF NAPPING

Although its origin is somewhat obscure, napping evidently has been done in one form or another for centuries. Before the Industrial Revolution brought mechanization to the textile industry, napping was a hand labor operation. In ancient Egypt, slaves used their fingernails to raise the fabric nap. Later, porcupine twills, iron tips, and the well-known weaver's thistle or teasel were used in hand labor napping operations.

Teasels (bristly flower heads of the *Dipsacus fullonum* plant) were first used in their original state. Then, they were arranged on a workboard which was passed back and forth by hand across the fabric surface to create a pile. The teasels had a gentle action and would break off before they could cause damage to the fabric.

In an early effort to mechanize the process of napping, a machine was developed with a large diameter cylinder to which rows of teasels were affixed. As the cylinder rotated slowly, the fabric surface was exposed to a small segment of the teasel cylinder. The length of fabric being processed was sewn into a continuous circle, and on the next pass, a machine adjustment allowed greater cylinder exposure. With each pass, cylinder exposure was increased, creating a deeper pile.

Later, cardcloth embedded with steel napper wire was affixed to the napping cylinder, further advancing the art of napping. Today, natural teasels are still used on a small scale, primarily in the woolen industry. Metal napper wire is used for cotton fabrics.

NAPPING EQUIPMENT

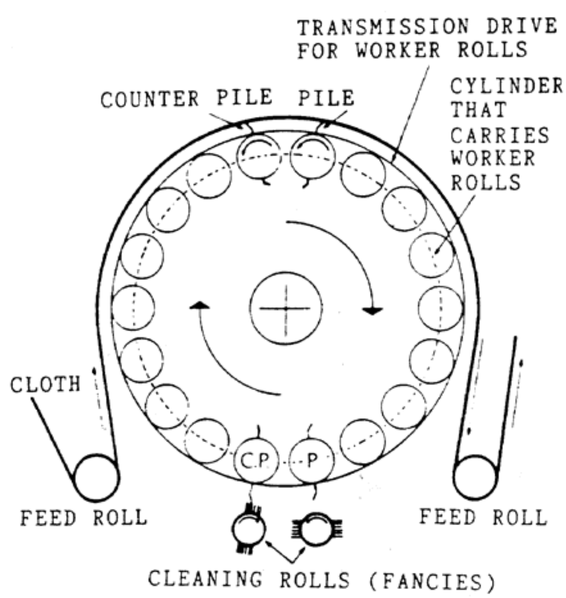
Double Action Napper

The most common type of napping machine throughout the textile industry is the double action napper. This machine is versatile enough to be used for wovens, circular knits, warp knits and nonwovens. The illustration below is an end view schematic of a double action napper. The mechanical design of this machine and others to follow is a planetary mechanism, which refers to the central gear with an internal ring gear (main cylinder) circumscribed by pinions (napper rolls).

The main cylinder of the double action napper usually carries 24, 30, or 36 napper rolls, and rotates at a constant speed in the same direction as the flow of the fabric. The napper rolls or worker rolls are mounted on the periphery of the cylinder, and each one rotates on its own axis in a direction opposite to the rotation of the cylinder. Every other napper roll is wound with pile napper wire pointed in the same direction as the rotation of the cylinder. The alternate napper rolls are wound with counter pile wire, where the points face the opposite direction.

Different napping results can be obtained by varying the speed of the napper rolls relative to the speed of the fabric. A positive napping action occurs when the points of the napper wire travel at a speed greater than the speed of the fabric. Additionally, the pile versus counter pile roll speeds can be varied. In general, greater pile energy produces a loftier nap, while greater counter pile energy produces a shorter, thicker nap. When the napper roll wires travel at a speed slower than the speed of the fabric, a tucking or felting effect of the fabric pile occurs. When a napped fabric is felted, the raised fiber ends are tucked back into the base of the fabric, producing a smoother fabric with better appearance retention after washing.

Double Action Napper
(End View Schematic)



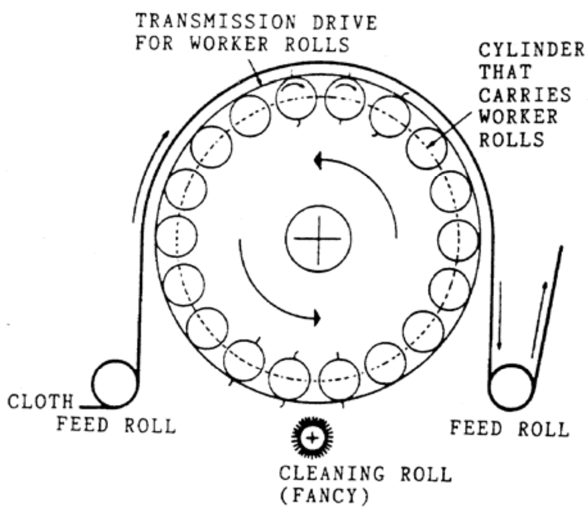
Source: Gessner Company

Knit Fabric Napper

Used almost exclusively in the knit industry, knit fabric nappers are designed to nap fabrics either in tubular form or open width. Generally, knitted fabrics are difficult to keep flat during the initial napping run on any napper other than the knit fabric napping machine.

The knit fabric napper differs from the double action napper in that the main cylinder rotates in a direction opposite to the flow of the cloth. Half of the napper rolls are covered with straight wire, called traveler wire, while the other half are covered with hooked wires. The hooked wire points face the rear of the machine. Both sets of napper rolls rotate on their own axis in a direction opposite the main cylinder direction of rotation. The main cylinder of a knit fabric napper will have between 14 and 24 napper rolls. The hooked wire rolls do the napping, and the traveler wire roll speed is adjusted to control the tension of the fabric on the napper cylinder. Correct tension prevents the formation of wrinkles and reduces edge curling.

Knit Fabric Napper
(End View Schematic)



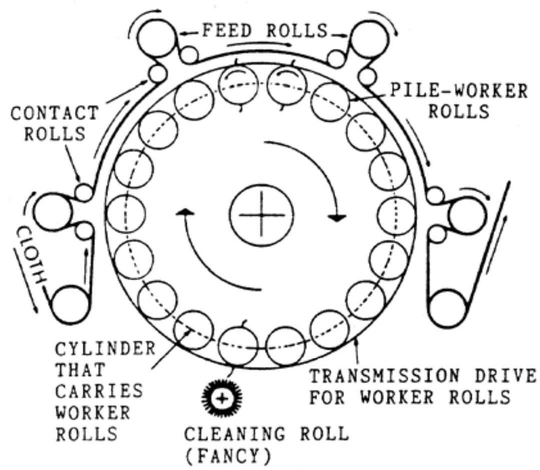
Source: Gessner Company

Single Action Napper

The single action napper, or all pile napper, was designed for a specific purpose and is generally used as a finishing napper. The napping action creates a directional pile with parallel fibers that can be lofty or flat in appearance. Normal procedure is to first nap the fabric on a double action or knit goods napper to establish the amount of pile desired, and then to finish napping on a single action machine to untangle and parallel the fibers.

The main cylinder of the single action napper rotates in the same direction as the flow of the fabric. There are 20 to 24 napper rolls in the cylinder rotating on their own axis in a direction opposite to the direction of rotation of the main cylinder. All of the napper rolls are covered with napper wire with points facing the rear of the machine which are called pile rolls. Another distinguishing feature of the single action napper is the presence of cloth contact rolls positioned around the outside of the main cylinder, which create from two to four tangent contacts on the cylinder. Without these contact rolls, the fabric would be permitted to hug the entire cylinder with the wire ends all pointed in the same direction, and the fabric would be torn as soon as napping began.

Single Action Napper
(End View Schematic)



Source: Gessner Company

<u>Combination Nappers</u>

There are nappers available that combine the features of two, or all three, of the napper types mentioned above. These combination nappers perform as well as an individual unit, and time requirements for changing from one operation to another are minimal. Because of their versatility, combination nappers are considered an excellent choice for small napping operations.

ZERO POINT

The napping machine can be set so that the wire rolls track exactly with the fabric, and the surface of the fabric is not worked at all. This is known as the "ZERO POINT", and it serves as a point of departure. Modern napping machines are equipped with indicators which simplify the process of identifying the zero point. It is necessary to know where this point takes place, at varying cloth speeds, so that the speed of the wire rolls may be adjusted up or down from this point to achieve the desired effect. In addition to the cloth speed, other factors which may affect the determination of the zero point include the texture and the hardness of the fabric.

NAPPER WIRE

The most critical component of the napping system is the napper wire clothing on the worker rolls, since it is the wire which comes in contact with the fabric to raise the pile. Improperly sized or shaped wire and/or poorly maintained worker rolls will hinder machine performance and efficiency. Napper wire clothing is also commonly known as cardcloth, since it was originally developed for use on carding machines used in raw fiber preparation.

There are many variables in napper wire clothing. The shape of the wire point, both surface and side, is very important, and there is no single shape that is optimal for all types of napping. Factors to be considered include wire size, wire shape, the angle through the foundation, the pitch angle, the position of the knee, the overall height, and the density of the wires.

Napper Wire Terminology

- Wire Shape

    Round Card Wire

    Double Convex Card Wire

    Angular Card Wire

    Single Convex Card Wire

- Point Shape

    Sharp Point

    Half-Sharp Point

    Dull Sharp Point

- Wire Size

    This number indicates the wire diameter. The following chart gives the American, English, and French numbering systems.

COMPARISON OF CARD WIRE NUMBERS
(Nearest Equivalent)

DIAMETER (inches)	(mm)	AMERICAN	ENGLISH	FRENCH
.0085	.0022	# 37	# 35.5	# 30
.009	.0023	36	34.5	29.5
.0095	.0024	35	34	28
.010	.0025	34	33	26
.011	.0028	33	32	24
.012	.0030	32	31	22
.0132	.0034	31	30.5	20
.014	.0036	30	29	18
.015	.0038	29	28.5	--
.016	.0041	28	28	16
.017	.0043	27	27	14
.018	.0046	26	26	12
.020	.0051	25	25	10
.023	.0058	24	24	9
.028	.0071	22	22	7
.034	.0086	20	--	--

Since wire shape is not always round, wire size may be given as two numbers, for example 30/34, or 28/32. For a double convex wire, these numbers measure the narrow and wide diameters.

- Wire Density

The number of points per square inch determines whether wire clothing is open set or closed set. An open set wire will penetrate through the fabric while a closed set will not.

Improper application of napper wire to the napper rolls will destroy the flexing action of the wire, which is critical for good machine performance. Wire applied to the napper rolls with correct constant pressure will perform as designed.

The napper wire clothing supplier is the best source of information on the many types of wire clothing available. The supplier can provide guidelines and recommendations on which wire type is best suited to particular fabric constructions and equipment.

SHEARING

Usually, shearing follows napping and is done open width. Napped fabrics are sheared for the following reasons:

- To clear out random length fibers and produce a uniform, level pile
- To reduce the height of wild fibers and prevent pilling or surface distortion
- To produce a certain hand
- To improve the color and appearance of the fabric
- To produce sculptured effects

The shear utilizes a scissor cut action on raised pile fibers. Raising brushes help the surface fibers stand up so that the shear blade can make a uniform cut. The shear has a helical blade which revolves against a stationary ledger blade, and fibers which pass between the two blades are sheared off.

Successful shearing requires sharp blades and proper setting of the blades to the fabric. This blade-to-cloth adjustment governs the length of surface fiber remaining on the cloth. Depth of cut can be recorded from dial settings, which assist in reproducing future production runs of the same quality.

FABRIC CONSTRUCTION

The development of a good napped fabric construction requires a balance between strength requirements and density of the nap. Generally, napping reduces the strength of a fabric, since the fibers that were pulled up to form the nap no longer contribute to fabric strength. This strength loss must be anticipated and compensated for when fabric constructions are developed.

Napped fabric constructions should be designed to allow the napper wires easy access to the fibers which will form the nap. This is done by using a low twist yarn and/or by floating or looping the yarn. In a typical fabric construction, the fibers which form the nap generally run across the width of the fabric, perpendicular to the flow of the napper wires, so the napper wire tips can reach in and grab the fibers.

Woven fabric constructions for napping include plain weaves with soft twist filling, 2/2 and 1/3 twills, five and eight harness sateens, and sateen variations with separate ground and pile fillings. These constructions are used in familiar napped cotton products such as flannel shirtings and sheetings and moleskins.

With wovens, consideration must be given to the construction of the selvage. The selvage should not be woven too tight or too loose, and fabric tension should be uniform. Sometimes, uneven tension can be corrected by padding the fabric with strong longitudinal tension.

The most common type of knitted cotton fabric construction for napping is fleece. Fleece fabrics are made by laying-in pile yarn on the back of a single jersey fabric using tuck stitches. Since the laid-in yarn never knits, weaker low-twist yarns may be used. Fleece is used in the ubiquitous "sweat" garments and bathrobes. Other knitted fabrics which may be napped include interlocks, ponte di romas, jerseys, and piques, but these are much less common. One knitted pile fabric to note is velour, which is not napped but is a sheared terry construction.

FIBER LUBRICATION

Fiber lubrication is an important consideration in the napping of cotton fabrics. With adequate lubrication, the fibers in the yarn are able to slide more freely during the napping operation, and the pile can be more easily formed. In some cases, cotton fabrics can be napped in the greige (loomstate), where the natural waxy content of the cotton fiber acts as a natural lubricant. In other cases, the fabric can be padded with a napping lubricant or softener. A wide variety of suitable products is available from textile chemical suppliers, and some of these products have the dual benefit of providing a soft finished hand.

Temperature and humidity in the napping environment may also affect fiber friction, and subsequently napping performance may be altered. Moisture content of the fabric is another important variable which affects lubricity. All of these factors should be considered in the production of quality napped cotton fabrics.

RESEARCH AND TECHNICAL SERVICES

Cotton Incorporated is the research and marketing company of American cotton growers. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.

- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to the grower and his mill customers.

- Computerized fiber management techniques result from in-depth fiber processing research.

- Product Development and Implementation operates programs leading to the commercialization of new finishes and improved energy- and water-conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.

- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.

- A fiber to yarn pilot spinning center allows full exploration of alternative methods of producing yarn from specific cotton fiber profiles for various products.

- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for testing, including High Volume Instrument testing capable of analyzing micronaire, staple length, strength, uniformity, color, and trash content.

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