TECHNICAL BULLETIN

COTTON INCORPORATED

6399 Weston Parkway, Cary, North Carolina, 27513 • Telephone (919) 678-2220

ISP 1011

METHODS OF IMPARTING SOFTNESS TO COTTON PRODUCTS

This report is sponsored by the Importer Support Program and written to address the technical needs of product sourcers.

INTRODUCTION

To obtain the desired softness in a cotton textile, several factors must be engineered in the product from the beginning. The first consideration is the structural composition of the fabric. Another consideration is how the fabric is mechanically handled during the preparation, dyeing, and finishing processes. Chemicals used in preparation, dyeing, and finishing will likewise affect the aesthetics. Often garments are post-treated not only to control shrinkage of the final product, but also to soften the hand.

Many decisions need to be made to achieve the desired product. Some of the considerations are often based on the product desired, specifications required, cost, and the equipment available at the particular finishing plant.

CONSTRUCTION CONSIDERATION

Several parameters in the construction will have a significant effect on the softness. The micronaire and the staple length of the cotton fiber influence hand. With other factors being equal, lower micronaire gives a softer fabric, and the longer staple length permits the construction of finer count yarns and lower twist, which improve the hand. Of course, a number of other factors must be considered in the selection of the appropriate cotton fiber. Combing, which removes short fibers, helps to produce a yarn that yields a softer hand. Of even more significance is the selection of the spinning system. Although more expensive, ring spinning usually gives the softest yarn and fabric. Improvement in softness is continually being made in other spinning systems. Here again, there is a trade off in softness and other performance characteristics. Finally, the construction of the fabric itself exerts a powerful influence on softness. Although a looser construction favors a softer hand, proper consideration must be made for coverage, strength, and appearance.

MECHANICAL METHODS

One of the first considerations in finishing is whether the fabric will be prepared and dyed in open width or rope form. Although a smoother fabric is usually achieved by processing in the open width, a softer and fuller fabric is achieved by rope processing. This mechanical action in the rope form permits easier movement of the structural components of the fabric thereby softening the goods. In most instances, knits are processed in the rope form, whereas woven fabrics are most often processed open width to minimize wrinkles in the final product. The softness achieved in rope processing of fabrics can be achieved in garments by afterwashing and tumble drying. For garments, this afterwashing and relaxed drying is another way of achieving shrinkage control.

There are several mechanical processes specifically to soften the hand of fabrics. For a “butter” soft hand without much disruption to the surface, sueding or sanding is often used. Here the surface fibers are slightly abraded to produce an increased frequency of shorter length hairs. A more pronounced treatment of this type is achieved by a process called napping. In this case, the surface fibers are pulled to the surface with steel wires of consistent length, density, and aggressiveness. Another approach similar to sueding and napping is brushing with various composite materials such as bristles of nylon or similar material. For more information on napping and sueding, refer to Cotton Incorporated's technical bulletins "Napping of Cotton Fabrics-TRI 3006" and "Sueding of Cotton Fabrics-TRI 3010."

Calendering is a process in which the fabric is squeezed between rollers to flatten the surface. The hand of the fabric will often become softer with a calender, especially after chemical finishing. Compressive shrinkage techniques such as Sanforizing of wovens or compaction of knits will soften the hand. Decatizing is another process involving steaming and physical manipulation of the fabric, which will improve softness.

A newer method of mechanically obtaining a softer hand is by the use of a continuous tumbling machine such as the Biancalani fabric processor. The fabric (wet or dry) is impelled at high speed via forced hot air against a perforated baffle. The results give a non-directional lightly sueded effect, which is extremely soft. In the garment form, similar effects are achieved by stone washing and/or enzyme treatment.

MODIFICATION OF THE FIBER STRUCTURE

The structure of the cotton fiber may be changed to impart softness. In recent years, one of the most dramatic examples of this fiber modification is the development and use of cellulase enzymes. With the proper selection of the cellulase enzyme, concentration, time, temperature, pH, and mechanical agitation, the cotton fiber may be etched to impart a super soft hand. Care must be exercised to avoid adversely affecting other desirable properties. The process lends itself to particular piece goods like knits and to garment washing conditions of knits and wovens. Color reduction and hand improvement of denim garments have been particularly successful.

Another process to alter the cotton structure, which has been quite successful, is anhydrous liquid ammonia. Unlike mercerization that imparts a slightly crispy hand, the liquid ammonia treated fabric is significantly softer. In addition, the liquid ammonia improves stabilization, surface appearance, and abrasion resistance (for durable press goods). However, the process is quite expensive, requires specialized equipment, and is used only for those cotton goods that can demand a premium.

INFLUENCE OF DYES

Most dyes do not have a significant impact on the softness of the finished fabric. However, the use of pigment dyes in heavy prints or solid shades can have an adverse effect on the aesthetics. A binding polymer must be used to ensure durability of the color. To achieve acceptable softness, afterwashing at the mill or by the consumer is often advised.

USE OF SOFTENERS AND HAND MODIFIERS

Purpose of Softeners

The cotton fiber naturally contains an excellent softener, which aids in the production of the yarn and fabric. To properly dye and finish the fabric, this natural wax softener must be removed.

Softeners or lubricants must again be applied during processing to achieve various properties. Some of the purposes of these added softeners include the following:

- To aid in processing (prevent crack marks during dyeing, assist in compaction [compressive shrinkage], sueding, napping, garment manufacturing, etc.).
- To impart softness, smoothness, fullness, suppleness, and appearance of the fabric.
- To improve tear and abrasion resistance.

Methods of Application

The type of operation and equipment available at the particular mill will dictate the method of application. A dye bath lubricant will be added to the dye bath. In some cases where the fabric is exhaust dyed, the final softener may be exhausted onto the fabric at the end of the dye cycle. In most cases, the softener is applied on a separate machine such as a padder, pad/vacuum, spray, or foam applicator. Where garments are wet processed after manufacturing, the softener is usually applied by exhaustion or metered addition (spray). If the fabric is treated with a durable press resin, the softener is applied simultaneously with the resin by whatever method used.

Selection of the Appropriate Softener

There are several requirements a softener must meet to be suitable for application. To achieve the desired properties, a blend of different softeners is often used. Listed are some of these considerations.

- If the softener is to be applied by exhaustion, a certain type of softener (usually cationic) must be used.
- The softener must be compatible in the application bath and must be applied uniformly and efficiently.
- The softener must impart the desired softness.
- Other desirable properties of the fabric should not be adversely affected. These properties include sewability, shade change, whiteness retention, durability, abrasion resistance, tear, tensile, seam slippage, soil release, comfort, and cost.

Types of Softeners

The different types of softeners may be classified as anionic, cationic, nonionic, and in some cases, combinations (i.e., some silicones). All types have a unique application for various end uses. Understanding their different properties will assist in the proper selection. Often a blend of different softeners is required for optimum performance. At the same time, certain types of softeners are not compatible with each other. For special hands, other options may be exercised.

- Anionic Softeners

  Anionic softeners are negatively charged. Perhaps one of the first anionic softeners was soap prepared by hydrolyzing animal fat with lye. Later sulfated oils, tallows, and fatty alcohols were developed. These sulfated anionic softeners were less sensitive to hard water and acids than regular soap. They make the fabric pliable and flexible without making it slick. Furthermore, they exhibit good stability to heat and alkaline conditions, they have good rewetting properties, and they have excellent fabric to metal lubrication. These properties make these softeners useful for napping, shearing, Sanforizing (a form of compressive shrinkage), and preventing crack marks during preparation.

The polyethylene softeners are partially oxidized to give them some anionic properties. In the emulsification process, nonionic or cationic emulsifiers may be used. Note that polyethylene softeners are often classified as either nonionic or cationic based on the type of emulsifier. Some of the important benefits of polyethylene include excellent sewability, durable abrasion resistance, good hand, and non-yellowing. This important softener with a cationic emulsifier may be exhausted from a dilute bath.

Although useful, anionic softeners have limitations. They do not have the softness desired on most fabrics. Except for polyethylene, they have limited durability to laundering and dry cleaning. A purely anionic softener will not exhaust from a dilute bath due to the repulsion of partially anionic cotton; thus it must be applied by other methods. Anionic softeners are more likely to foam; therefore, this must be considered for some processing machinery. Baths consisting of a cationic emulsion and an anionic softener are not stable unless special stabilizers are used.

- Cationic Softeners

Cationic softeners are positively charged in contrast to the anionic softeners. Since cotton has a partial anionic charge, the cotton and the cationic softener have a mutual attraction to each other. This property permits exhaustion of the cationic charge from a dilute bath. Particularly, cationic softeners are frequently exhausted onto cotton knits at the end of the dye cycle and during various garment wet processing procedures. These cationic softeners provide excellent softness and have some durability to laundering and dry cleaning. Although usually exhausted, the cationic softener may also be applied by other methods such as padding, foaming, and spraying.

As with other softeners, the cationic softeners have certain limitations. Many of them have poor yellowing resistance, particularly at high levels of application. The lightfastness of the color in some cases may be adversely affected. They are generally not compatible with anionic finishing components in the same bath. Other limitations may include adverse effects on soiling and soil removal and unwanted water repellency.

- Nonionic Softeners

In contrast to the anionic and cationic softeners, nonionic softeners have no electrical charge. They are usually produced by reaction of fatty acids or fatty alcohols with ethylene oxide. These softeners are compatible with either anionic or cationic emulsions in the bath. Unlike the cationic softeners, nonionic cannot be exhausted from a dilute solution. Being widely used, they are noted for giving a dry, pliable hand and exhibiting good resistance to discoloration.

- Silicone Softeners

  Silicone softeners have been around for years but were not widely used because of their expense and tendency to come out of solution to form oily spots on the treated fabric. More recently, the chemistry and the stability of baths containing the silicone have improved considerably. At the same time, the finisher has discovered how to blend the various silicones with conventional softeners to make them more efficient.

  Silicones available today are quite varied in their properties. Some are available in micro-emulsions, which are quite stable in application baths. Various functional chemistries can be chosen from epoxy and non-reactive systems to different amine structures. Most silicones are nonionic; however, some of those with amine functionality may be exhausted because they are cationic. The hand may be varied from dry and slick to soft and buttery. Although silicones have traditionally been hydrophobic, hydrophilic silicones are now available. These newer silicone technologies may incorporate more than one type of chemistry in the same molecule (i.e., amine chemistry for softness along with epoxy chemistry for hydrophilicity). Most of these silicones are quite durable to home laundering. They improve the tear, abrasion resistance, sewing, drape, and durable press properties, but may reduce the tensile strength.

- Other Hand Modifiers

  Often there is a need not to have a soft and pliable fabric but to have some durable "body" (firmness) to the fabric. Usually this is accomplished by adding a polymer to the finishing bath. One of the most common hand modifiers is polyvinyl acetate. Others may include stiff acrylics and polyurethanes. In some cases, the fabric may be backcoated and, in other instances, laminated to another fabric to give a composite with the desired body and performance.

  For some fabric constructions, it is necessary to add an anti-softener (often called an anti-slip agent) to prevent seam slippage in the garments. Colloidal silicate has been demonstrated to be an effective agent for this purpose. It is frequently applied with a binder that aids in controlling seam slippage.

Evaluating the Effectiveness of Softeners

Softeners have the potential of affecting a wide variety of properties of cotton fabrics. Commonly available test methods can be used to measure the effect on mechanical properties, sewability, shade, and fastness of the color. For hand, testing is largely subjective. An important test for softeners is to compare the treated to the untreated. One technique that has attempted to be more precise in giving an objective measure of hand is the Kawabata method. Although this test procedure is interesting from a scientific perspective, it has not found a significant commercial acceptance.

CONCLUSIONS

The hand desired in a fabric is best engineered from start to finish. Considerable attention has to be given to the selection of the cotton fiber, the spinning process, and fabric construction. The manner in which the fabric is prepared, dyed, and finished will impact the final aesthetics.

Last but not least is the proper selection of the softener or hand modifier. Some of the important considerations include how the softener is to be applied (exhausted or applied directly by pad, spray, or foam), the hand desired, performance demanded including durability, and the effect on other properties of the fabric (strength and color). Several finishing agents are commonly required to meet these requirements.

Importer Support Program

The Cotton Board and Cotton Incorporated are funded by U.S. upland cotton growers and importers of cotton and cotton products (this includes raw cotton, piece goods, and finished apparel). A percentage of the importer funds are devoted for importer specific programs organized under the Importer Support Program. Examples of projects funded from this fund include training schools, educational programs, focus groups, economic meetings, and research initiatives.

Selected technical issues have been identified by importer members as relevant to their business. This report is a condensed, less technical report of those issues intended to provide the reader with basic, yet useful information on the topic.

For more information contact:

ELIZABETH KING
VICE PRESIDENT
IMPORTER SERVICES
COTTON BOARD
PHONE: 973-378-7951
FAX: 973-378-7956
eking@cottonboard.org

DENNIS P. HORSTMAN
SENIOR DIRECTOR
ACCOUNT MANAGEMENT
COTTON INCORPORATED
PHONE: 919-678-2336
FAX: 919-678-2231
dhorstman@cottoninc.com

Visit our website at: www.cottoninc.com

COTTON INCORPORATED