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# ENHANCING THE MOISTURE MANAGEMENT PERFORMANCE OF 100% COTTON

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## Abstract

Moisture management means different things to different people. The requirements for moisture management performance vary from product to product and are not standardized. General wearing apparel has one set of requirements for moisture management, which may be summarized as providing comfort in the dry state, via moisture vapor transport. Recreational performance apparel typically requires some wicking properties for movement of liquid moisture or perspiration. Cotton has a whole range of properties that work together to provide comfort for general wearing apparel. A variety of methods have been used to further enhance 100% cotton fabrics to dry faster, wick faster and have other beneficial properties related to moisture management. Development work in this area is continuing, and results on these newer methods are showing potential. Understanding and utilizing appropriate test methods are keys to these developments.

## Introduction

Moisture management concepts and promotional activities are crossing over from recreational performance apparel into general wearing apparel. Moisture management claims are now common in some of the larger or better-known general wearing apparel catalogs and web sites. Because moisture management is important in a variety of ways for many end products, it is worthwhile to begin to separate fact from fiction.

Cotton Incorporated is developing technologies to enhance liquid moisture transport from skin to the outer layer of fabric. One of the key measurements for moisture management acceptance is based on a vertical wicking test; however, it is not known how this test relates to actual performance of a garment when worn. Other types of moisture management tests are presented in this paper along with three technologies for enhancing the moisture management of cotton.

## Moisture Management Test Methods

For the most part there are no standardized test methods to evaluate the different aspects of moisture management. Water drop absorbency or American Association of Textile Chemists and Colorists (AATCC) Test Method 79 – Absorbency of Bleached Textiles is often a quick check of acceptable absorbency for dyeing but it is not sufficient to separate out differences in moisture management properties of fabrics. There is a difference between absorbency and wicking; therefore, it should not be assumed that a highly absorbent fabric would also have super wicking properties. Vertical wicking is typically the test most often cited when demonstrating the moisture management of performance or athletic apparel.

### Vertical Wicking

Throughout the industry there are different versions of this test method often with different minimum requirements depending on the end use of the product. Work is underway to develop an AATCC Test Method for vertical wicking. There is some question as to how this test method relates to comfort, as well as concerns about the impact of gravity, wicking from a cut edge and other issues. For research purposes at Cotton Incorporated, a version of this test is used when evaluating fabrics geared towards athletic performance apparel because the concept of this method is familiar to industry.

In this test, a strip of fabric is hung vertically either in distilled water or in a tinted solution. The movement of moisture is monitored over a period of time and a wicking rate is calculated based on the distance wicked in that time. In industry the duration of the test varies as well as the acceptable wicking rate. Performance of samples can vary greatly depending on when this test is stopped. For example, if you consider the wicking behavior of two samples, A and B, it is possible that during initial wicking sample A out performs sample B, but at longer wicking durations sample B could out perform sample A [Miller 2000]. At Cotton Incorporated the test is run for thirty minutes or until the specimen has wicked a distance of fifteen centimeters (based on a common version of the test used in industry).

It should be noted that scoured and bleached cotton has naturally rapid wicking. Application of finishes may impact the wickability; therefore, research has been focused on not decreasing the wicking of cotton when enhancing other moisture management properties.

**Absorbent Capacity and Rate**

In some cases the ability to absorb water is just one part of the story. How much water is absorbed is a critical factor in other moisture management properties. In general, the more water absorbed by a fabric the longer it takes for that fabric to dry. There are a variety of instruments that can measure the absorbent capacity of materials. A demand wetability tester is used at Cotton Incorporated to measure the total absorption capacity of a specific sample size as well as the rate of absorption.

One goal at Cotton Incorporated has been to reduce the total absorbent capacity of cotton without inhibiting the naturally fast wicking. When comparing cotton fabrics to synthetic fabrics, one of the most important physical parameters influencing how much water (or perspiration) a fabric will absorb is the fabric thickness. The fiber content of the fabric is not the sole controlling parameter. The effect of fiber content is seen in how the fabric is constructed. Therefore, appropriately constructed cotton fabrics can provide moisture management properties.

**Drying Rate and Drying Time**

Drying time and drying rate are of course different. Drying rate is often expressed as mass of moisture evaporated per unit time for a given sample size (i.e., area). Drying time may be defined as the time for a damp or wet fabric to dry to a given end point under a given set of conditions. Drying time depends on how much moisture or perspiration a fabric or garment contains, as well as other factors such as environmental conditions. Drying time, when starting with saturated fabric, and with all else equal (e.g., construction) depends on the absorbent capacity of the fabric. The absorbent capacity as discussed above is mostly dependent on the fabric thickness.

Drying rate and time can be determined in a controlled environment by use of recording balances. The airflow around the samples has an impact as well as the amount of moisture applied. A simple test is used at Cotton Incorporated such that the drying rate and time are determined by weighing a six-inch by six-inch square specimen with one gram of water administered. The initial dry weight of the conditioned specimen is recorded prior to administering the one gram of water and then the weight of the sample is recorded every twenty seconds until it is dry.

**Horizontal Absorbency Spread**

In this test the spread or horizontal wicking of a half milliliter of tinted distilled water is measured after thirty seconds. The tinted water is applied perpendicularly to the surface of the fabric. This orientation mimics the direction of absorption of perspiration from the body if the fabric is somewhat absorbent and the perspiration does not drip or run down the body. There are two behaviors that can be observed by this test. A sample may be absorbent but have poor wicking and the solution will absorb in one spot and drip through the sample. A sample that is absorbent and does wick will create a growing spread of solution horizontally through the fabric. Ideally, a fabric that has larger spread will feel drier to the touch than a sample with a smaller area of spread because the same volume of moisture is concentrated in the second scenario. If the moisture has a chance to spread further across a fabric, it will also evaporate faster from that surface versus a similar fabric with a highly saturated wet spot.

**Cling**

In context of moisture management, cling refers to the sensation that occurs when fabric sticks to the skin because of the build up of perspiration on the fabric and between the fabric and the skin. Imagine putting water between two glass slides and then trying to pull them apart. This effect is due to the interfacial tension, which is defined as a fluidic property similar to surface tension and refers to the affinity of a liquid to a solid surface. The sensation of moisture cling can be reduced by not allowing moisture to collect between the skin and the fabric. Further reduction in cling is obtained by altering the contact of the fabric to the skin, whether by construction or by finishing treatments to change the surface energy of the fabric. A simple method of evaluating the relative cling force of fabrics can be developed by modifying an automated tensile testing machine to pull a wetted fabric across a surface.

## Moisture Management Techniques

Over the last few years, research at Cotton Incorporated has developed several different approaches for enhancing the moisture management of cotton fabrics. These different approaches provide different types of moisture management properties.

**Wicking Windows™**

The first technique presented here is a patent pending technology. Under the patent application there are a variety of "discontinuous" treatments that can be used on cotton-containing fabrics. The result of these discontinuous treatments is the creation of wicking windows in which moisture is absorbed from the body and transferred to the outside of the fabric where it evaporates quickly. This creates a fabric that feels drier on the inside next to the skin. These treated fabrics have measurable improvements in the time and rate of drying as shown in Figure 1. Some applications doubled the drying rate of cotton knits therefore halving drying time.

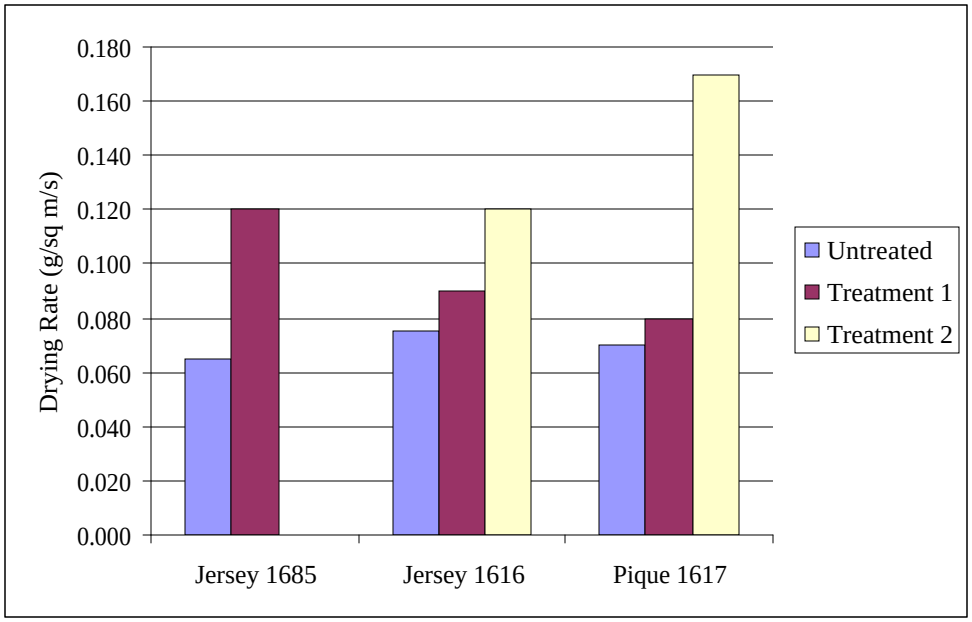


Figure 1. Faster Drying Rate in Treated Cotton Samples.

While improving the drying rate and time, this approach does not inhibit the natural rapid wicking of properly prepared cotton. As such the treatment allows the fabric to maintain rapid or instantaneous water drop absorbency.

In addition to improvements in drying, this technique provides reduction in moisture cling. The treated samples have much lower cling than untreated cotton or synthetic performance fabrics. This is due, in part, to the treatment driving the moisture from the inside to the outside of the fabric so that no moisture layer builds up between the fabric and skin. Results as compared to various purchased synthetic athletic garments are shown in Figure 2.

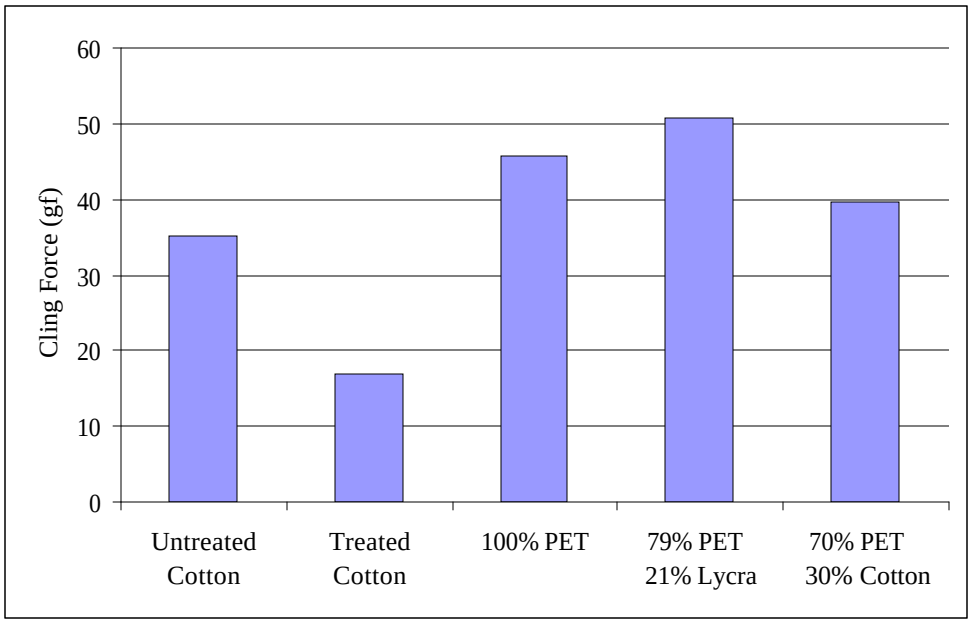


Figure 2. Cling Force of Treated Cotton Compared to Purchased Synthetic Performance Apparel.

**Thin Fabrics by Pressure Calendering**

Research work on this approach to moisture management was performed in part at North Carolina State University (NCSU) College of Textiles as part of the Importer Support Program. Moisture management performance, as defined under this approach, is rapid wicking but having a reduced absorbent capacity and rapid drying, for end uses where moderate-to-heavy perspiration is likely. The goal was to show that 100% cotton performance fabrics could be developed using thin fabrics and various chemical treatments. The fabric structures and treatments were selected with commercial feasibility in mind and five fabrics were produced to duplicate the fabric construction of a synthetic benchmark performance fabric as closely as possible with 100% cotton. In order to further reduce the thickness of the finished cotton samples, calendering was investigated as a mechanical finishing option. The fabrics were finished without curing then calendered at 10kN, followed by curing using heat.

After cold calendering at 10kN, the thickness of the cotton fabrics was determined to be around 1.00 mm. The wicking results of the calendered cotton fabrics exceeded both the wicking requirements for high performance moisture management fabrics (15 cm in less than 30 minutes) and the wicking performance of the synthetic benchmark fabric. The Gravimetric Absorbency Testing System (GATS) at NCSU was used to measure the demand wetability of the test fabrics. GATS is similar to the instrument used at Cotton Incorporated, in that it measures the ability of the material to take up liquid spontaneously in the direction perpendicular to the plane of the fabric and then spread the moisture laterally within the plane of the fabric. A number of parameters can be determined using the GATS test, but the key value discussed here is the absorption capacity, C (grams absorbed at equilibrium) for a sample of standard surface area. Figure 3 shows the relationship between absorbent capacity and thickness. Because the fabrics were thinner, the absorbent capacity was smaller and therefore the drying time of those samples was reduced compared to fabrics without calendering.

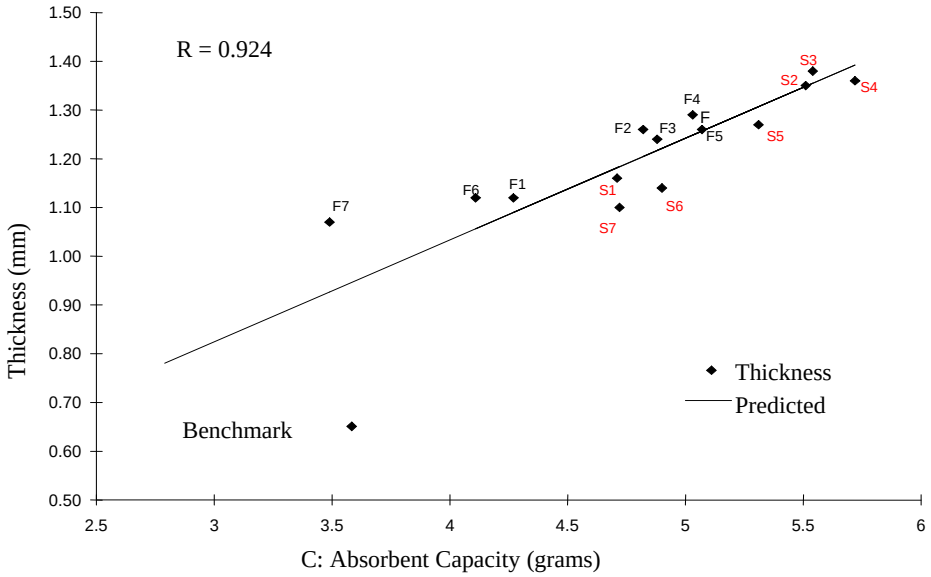


Figure 3. Absorbent Capacity versus Thickness.

**Improved Wicking**

Also initially funded by the Importer Support Program, the goal of this approach to moisture management was to produce increased wicking by a simple inexpensive application technique. The process is pad-dry-cure with slight modifications to typical chemistries, processing time and temperature. The result of this approach is rapid spread of moisture within the plane of fabric (x-y directions). This approach has been evaluated on cotton knit fabrics and current research has shown some potential on woven fabrics with further research in progress. Vertical wicking on cotton knit is shown in Figure 4. A fifty percent increase in wicking was achieved before home launder-tumble drying (HLTD) compared to untreated fabric and further improvements are possible with optimization.

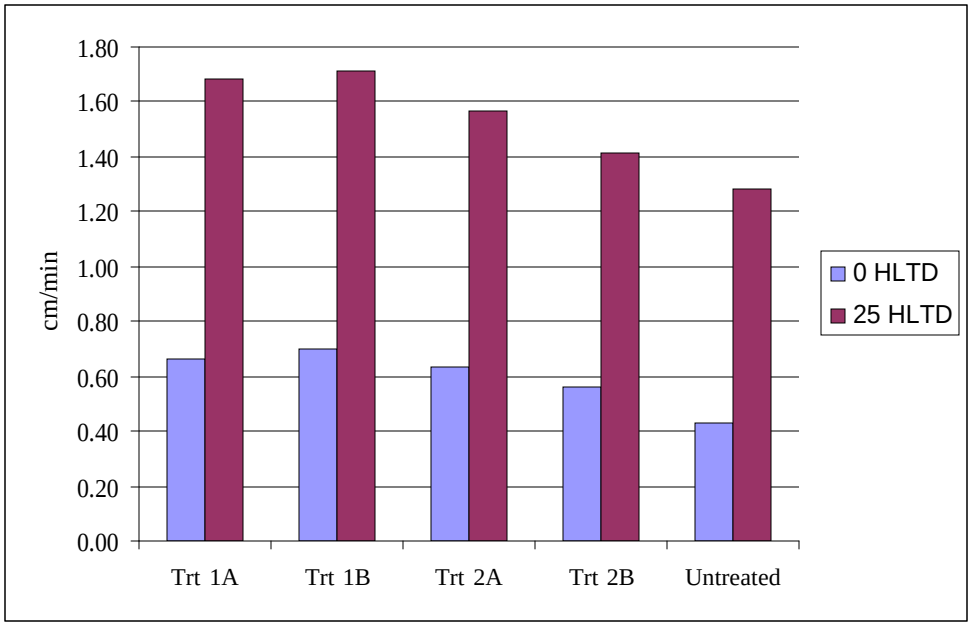


Figure 4. Vertical Wicking Rate of 100% Cotton Knit Fabric.

Initial results indicate that this treatment approach further enhances wicking as measured by the horizontal absorbency spread test. As such it is expected that fabrics treated with this process will also exhibit faster drying

compared to untreated fabrics. Application of this approach on woven fabrics would likely provide improvement in wicking at a level suitable for enhancing the moisture management of everyday apparel.

## Summary

Extensive research on enhancing the moisture management of cotton fabrics has been done and will likely continue in the future. Three different techniques have been developed that provide improvements in different areas of moisture management ranging from super wicking to reduction of moisture cling. Understanding the appropriate test methods is critical to evaluating the moisture management properties of various fabrics. Research will continue to improve methods already used in industry as well as develop newer methods of evaluating the properties of these fabrics.

## References

Miller, B. 2000. Critical Evaluation of Upward Wicking Tests. International Nonwovens Journal, 9(1): 35-40.