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Research Paper

Effect of Moisture Management Finish on Tensile Strength and Water Transmission of Single and Rib-Knit Cotton Fabrics

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The present study aimed to determine the effect of moisture transmission finish on the performance of knitted cotton fabrics in terms of their tensile strength and moisture transmission behavior. Two groups: single and rib-knit cotton fabrics were collected from Nishat Mills Limited. A moisture management finish was applied onto the collected fabrics. The effect of the applied finish was investigated against their moisture transmission behavior by following the AATCC 195-2009 test procedure. The tensile strength was also evaluated with the ASTM D 5035-11 test method. The difference was studied between finished and unfinished samples. It was concluded that the moisture transmission finish has decreased the absorption rate and spreading speed of water through/in treated fabrics as compared to untreated fabrics. Moreover, breaking load and elongation of knitted fabrics in both directions were also improved with the application of finish.

Keywords: moisture management finish; wicking action; absorbent behavior; single knit; rib knit.

1. Introduction

Moisture management is the management of moisture in the form of water and vapors through the clothing materials worn next to human skin. It refers to the thermo-physical comfort of a wearer [1]. It is important to maintain an adequate balance of heat temperature to provide maximum comfort to the body under various environmental conditions. Textile materials have the capacity to assist in transportation of moisture from the inner environment (skin) to the outer surface of a fabric. An appropriate selection of fibers and yarns prevents sweating and provides comfort through wicking action [2]. Fibers extracted from plant sources such as cotton, bamboo, jute and flax are hydrophilic in nature. They let the water retain in their structure and present bad moisture transmission unless or until coated with some finishing treatment. Moisture remaining on the skin not only creates discomfort for the wearer but also adds weight and makes the body feel cold. This action may cause skin irritation, redness or other conditions. Therefore, it is important to develop a fabric that can manage moisture through its structure and provide comfort.

Moisture transmission is the study of fabrics in terms of their wicking and absorbent behavior [3]. Various physical properties of fibers and fabrics have a strong relationship with the amount of water absorbed by their structure, for example, tensile and abrasive strength, flexibility, elasticity, elongation, rigidity, etc. [4]. The wetting phenomenon in fabrics is dependent on the intermolecular behavior between the total surface area and its capillary action [5]. Fabric gets wet with the liquid, goes into the intersections of yarns, and initiates the capillary action. The liquid travels along narrow areas in the form of capillaries throughout the fabric structure [6].

The absorbency behavior of fabrics is manly depending on their hydrophilic and hydrophobic nature. Hydrophobic fibers do not have an affinity towards water droplets and present a low rate of absorption. On the other hand, hydrophilic fibers attract water molecules and show a high rate of absorption [7]. With the application of moisture management coating, it is possible to convert hydrophobic fibers into hydrophilic ones. It helps in the absorption process from the body, transport it to the opposite fabric surface and release it into the surrounding atmosphere [8, 9]. So, it can be said that moisture management lamination or coating can serve as a useful tool in determining the comfort properties of fabrics [10]. Hence, wetting and wicking play an important role in studying the moisture behavior of any fabric. Other factors affecting comfort properties may include yarn count, yarn fineness, knit structure, interlacing pattern, air permeability and type of moisture finish [11, 12].

Knitting is one of the most used fabric construction techniques. It is a process of the interlocking of yarns made with either natural or synthetic fibers in multiple design variations. Yarn characteristics affect the performance behavior of a finished fabric. Knitted fabrics behave according to the nature of their structure. An extension of yarns in one direction (course) may cause deformation in another direction (wale). It is necessary to know how much force is required to rupture a specific structure in a specific direction [13]. Tensile strength is one of the mechanical attributes required to understand in order to study the durability of fabric in a particular situation [14].

2. Materials and methods

Cotton fabrics manufactured in single and rib-knit were collected from Nishat Textile Mills. Specifications are given in Table 1. The study is experimental

Table 1. Specifications of collected samples.

Fiber type	Sample type	Mass (GSM)	Construction type	Yarn count
Cotton (100%)	Single-knit	150	Circular	32 Ne
Cotton (100%)	Rib-knit	220	Circular	35 Ne

in nature. Pretest-posttest design approach was used. In an experiment with a pretest-posttest design, measurements are made of subjects before and after they receive treatment. The specimens were tested for their performance in terms of tensile strength and moisture absorption, afterward given a moisture management treatment, and re-evaluated for their performance. Specimens from both groups of fabrics were taken to study the effect of moisture transmission through these materials before and after the application of moisture finish.

Moisture management finish was applied onto the specimens in the form of coating over their surface. The fabrics were prewashed and treated with a wetting agent comprised of ethoxylated alcohol at 2% concentration. Silicone softener was added to the bath to give a lasting and soft handle. It helped to promote wickability and strong water absorption qualities. It had a pale yellow color and exhibited good acidic pH stability. A mixture of amino silicone polyether copolymer with hydrophilic polymer was made with a ratio of 1:1, and pH was set at 5.5. The liquor pick-up ratio was 70%. The temperature was kept at 140°C for 5 minutes. Fabric specimens were coated and padded with a padding mangle. Drying was done at 100°C for 1–2 minutes in a hot air chamber.

The specimens were conditioned prior to testing by following directions given in ASTM D 1776 [15]. The samples were evaluated for their resistance against water through AATCC 195 [16]. Five specimens from each sample with dimensions of 80×80 mm were cut diagonally with the help of a template so that different sets of length and width yarns were included in the sample. The test solution was prepared by dissolving 9 gm of sodium chloride with 1 liter of distilled water. The specimen was placed on the lower sensor in moisture testing machine with its front surface on the top. The top sensor was released to rest it on the specimen. The door of the tester was closed, and the timer was set at 20 seconds to dispense the prepared solution. The measuring time was recorded on the electronic device attached to the tester. The specimen was then removed by lifting the upper sensor.

Specimens were then evaluated for their tensile strength by following the ASTM D 5035 [17] test method. Five specimens from a lengthwise direction and three from a crosswise direction were taken. The size of each specimen was 38.1×152.4 mm. The tensile testing machine was used at a speed of 300 mm per minute. The jaws were flat and smooth. The faces in the same clamp and the matching jaw face of the other clamp were held parallel to the machining centers with regard to one another. The specimen was clamped in the jaws of a tester. After aligning the specimen accurately, the force was applied by moving the clamps apart from each other. It was ensured that tension was applied uniformly throughout the sample. The electronic device attached to the tester recorded the maximum force used to rupture the specimen in both directions.

3. Results and discussion

A clear difference can be seen in the tensile strength on the pretest and posttest in both directions (Table 2). The samples became stronger after the application of a moisture management finish. Lengthwise yarns were more durable as compared to the crosswise yarns in both single and rib knits. The structure manufactured by following rib knit was stronger than single knit. The mechanical behavior of knitted garments in terms of their tensile strength is dependent on yarn type, knit structure and knit technique used to manufacture it [18].

Table 2. Maximum breaking force of treated and untreated fabrics.

Sample	Direction	Max. breaking force [N] Pretest (untreated group)			Max. breaking force [N] Posttest (treated group)		
		Mean	SD	Standard Error	Mean	SD	Standard Error
Single	Lengthwise	205	2.41	1.07	245	1.75	0.78
	Crosswise	121	1.25	0.55	135	2.37	1.05
Rib	Lengthwise	315	2.56	1.14	359	1.79	0.80
	Crosswise	61	2.36	1.05	73	2.56	1.14

The elongation rate in Table 3 also suggests the tensile behavior of tested samples in terms of their elongation rate. It was determined that due to the coating, knitted fabrics elongate more than the unfinished samples. A knit with 100% cotton and a blend of cotton with Lycra. It was observed that blended

Table 3. Elongation of treated and untreated fabrics.

Sample	Direction	Elongation [%] Pretest (untreated group)			Elongation [%] Posttest (treated group)		
		Mean	SD	Standard Error	Mean	SD	Standard Error
Single	Lengthwise	159	1.54	0.68	172	2.35	1.05
	Crosswise	129	2.10	0.93	135	1.58	0.70
Rib	Lengthwise	98	1.87	0.83	105	1.26	0.56
	Crosswise	325	2.11	0.94	337	2.15	0.96

fabric had high elongation score at the breaking point compared to cotton. A blending ratio is a key indicator to determine the properties of the end product [19]. Single knit elongated more in the lengthwise direction, whereas rib knit presented a high percentage of elongation in their crosswise direction.

It can be observed in Table 4 that there is a significant difference between the moisture management behavior of single-knit and rib-knit on top and bottom surfaces. According to the test, scores ≥120 suggest no wetting time for both sides of the tested fabric. Whereas the range of 20–119 depicts slow wetting. Finished fabrics display better moisture transmission behavior than unfinished fabrics. One possible reason is the surface smoothness caused by the moisture finish. It was observed that finishing treatment using caustic soda increased the efficiency of moisture transmission in single-knit fabrics. This was due to the increase in softness and fineness caused by alkaline hydrolysis [20]. In an unfinished fabric, the content of bamboo fiber increased its absorption rate but showed a decrease in scores of wetting time, spreading speed and overall moisture capacity. Bamboo fiber is cellulosic in nature and has similar properties to that of cotton fiber. It has many micro gaps in the structure to allow air passage and make it breathable [10]. The single-knit structure was better at bottom side by presenting less wetting.

Table 4. Moisture transmission behavior of fabrics.

Specifications	Single-knit		Rib-knit	
	Top	Bottom	Top	Bottom
Wetting time [s] Pretest	75.26	65.32	68.95	59.87
Wetting time [s] Posttest	105.28	115.93	101.25	98.56
Absorption rate [%/s] Pretest	45.23	52.45	38.65	51.25
Absorption rate [%/s] Posttest	14.85	21.56	15.26	18.95
Spreading speed [mm/s] Pretest	3.19	3.56	3.58	3.95
Spreading speed [mm/s] Posttest	0.95	0.16	0.68	0.25
One-way transport capacity – OWTC [%] Pretest	85.76		75.36	
One-way transport capacity – OWTC [%] Posttest	375.26		345.87	

The rate of absorption largely depends on the type of fiber from which the fabric is manufactured. Natural fibers such as cotton and bamboo have better absorbency action and wicking behavior than synthetic fibers such as nylon and polyester [21]. Rib-knit presented better moisture transmission characteristics than single knit. One of the possible reasons is the construction type and mass of the fabric. Higher mass assists in better moisture transmission through the fabrics and creates much comfort for the wearer [2]. The construction and structure of knit have a great impact on moisture transmission through the fabrics.

It was studied that single jersey and rib knit in loose form had high rate of wicking score compared to tightly knit structures. Close-knit provided great contact angle as its surface was more compact than knit with slack structure [22].

The scores also vary for the absorption rate of both groups of fabrics. Scores were better for the posttest group as compared to the pretest group. They covered the range from 10–20, which depicts slow absorption. On the other hand, the pre-test group exceeded the said time period and quickly made the surface wet by absorbing the water on front and reverse sides of the tested fabrics. Wetting of fiber has a strong relationship with its surface-free energy. The higher the surface area, the higher will be the wettability of fabric [23]. In another study, it was concluded that scores of the absorption rate of the bottom side were higher than the top for the knitted pile yarns made with 30 Ne [7]. A similar phenomenon was observed in this research for single and rib-knit.

Spreading time also exceeded for the unfinished fabrics in the pretest group and finished specimens did not spread the globule of water on both sides as their range was less than 1.0. Samples from the pretest group were poor in resisting wetting as their spreading time was more than 3.0 mm/s. The reason behind the results is the hydrophilic nature of fibers which fail to repel water and let it spread more quickly. Whereas the application of finish makes the fabric hydrophobic and assists in repelling water. Moisture management coating on fabrics improved the absorbency action of fabrics and helped in quick evaporation. This characteristic assists in creating comfort for the wearer [8]. The absence of hydrophilicity in a yarn is due to the absence of polar regions in a fiber. The absorption behavior of a fabric depends on the fabric geometry, its type and orientation size throughout its length [24]. In another study, a fabric was manufactured by using hydrophilic yarns as the inner layer and hydrophobic as the outer layer to induce better wicking properties and improve moisture transmission [25]. Moisture management finish comprised of either hydrophilic polysiloxane or polyurethane to improve its efficiency in moisture transmission through knitted fabrics [26]. The spaces present among component fibers and yarns in a fabric structure create capillaries to assist in the transportation of liquid away from the surface area [22].

As per the guidelines of the test procedure, scores ranging from 300–400 for OWTC are excellent. A significant difference can be observed in the performance of treated and untreated groups. The samples comprised of the pretest group presented poor performance as their range was even less than 100. Single-knit was made with 32 Ne, and pile-knit was manufactured with 35 Ne. It was observed that single-knit with less yarn count produced greater OWTC than fabric with a high yarn count. The same was observed in another research showing that pile-yarn with 24 Ne presented a higher score on OWTC than yarn with 30 Ne [7]. The high score for OWTC was due to the micro-circulatory structure of yarn, which helped in transferring liquid from the internal environment to the external atmosphere. This will help in creating comfort and ease during wear [21].

4. Conclusion

The effect of moisture management finish was studied in reference to its transmission characteristics before and after application on single and rib-knit fabrics. It was concluded that there was a significant difference between the performance behavior of finished and unfinished fabrics. Samples manufactured in rib-knit were better at their tensile properties. On the other hand, single-knit fabrics were better at their moisture transmission behavior than rib knit. Textile technologists are making endless efforts to develop fabrics with innovative coatings and finishes to meet the functional requirements of their consumers. The findings of this study may assist textile makers in reviewing their construction specifications of knitted fabrics to create comfortable clothing.

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