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ORIGINAL ARTICLE

Moisture properties of raised 3-thread fleece fabric knitted with different face and fleecy yarns

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Abstract The sportswear sector in textile industry has expanded on the worldwide and the producers and wearers want to indicate their comfort performance in addition to the aesthetic demands. Sportswear should possess good moisture transmission property. Moisture flow through various materials is a complex phenomenon as in three-thread fleece knitted fabric produced with different face and fleecy yarn material.

So, in this study, nine three-thread fleece fabrics of different composition materials have been studied, where these knitted fabrics are produced in a special circular knitted machine. The developed fabrics are taken to measure, water vapor permeability "WVP", gain%, air permeability, drying time, color difference, immersion time and bursting strength. The test results were discussed statistically with single factor ANOVA. From the experimental results, it has been observed that the difference between face and fleecy yarns material was highly significant for the whole fabric in the water vapor permeability, gain%, color difference and immersion time. Three-thread Fleece fabric knitted with Egyptian cotton for the face and fleecy yarns has the maximum bursting strength compared to other samples having Bamboo and Tencel yarns.

1. Introduction

Moisture management is one of the main performance criteria in today's garment manufacturing and is defined as the ability of an apparel to transfer moisture away from the skin to the cloth's external surface. The human body produces moisture in the form of sweating, this perspiration should be taken away the surface of skin to the attached clothing. The fabric should permit moisture to be transferred from the skin to the weather so as to refresh the body [1].

Moisture transfer is a serious factor in regulation of body temperature. This action prevents perspiration from remaining next to the skin [2]. The moisture in skin and cloths raises the heat loss beside that, it influences the body comfort and general performance [3]. After the human body has stopped perspiring, the fabric should let off the detained vapor to lessen the humidity on the skin surface. Prahsarn et al. [4] investigated the influence of fiber cross section, fabric areal density,

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thickness, and porosity on moisture vapor transference properties of the fabrics.

Zhang et al. [5] concluded that the air and water vapors go through a fabric in various ways. In general, textile fibers, regardless of their chemical structure, are impermeable to air and thus the crossing of air over a fabric can only happen through voids between fibers and between yarns.

Air and water vapor transport properties are mostly associated with heat and moisture transfer features of textile material [1]. The WVP of a fabric acts as a key role in determining the apparel comfort and keeping human body comfort [6]. Water vapor gets into textiles due to water vapor concentration differences, while fibers absorb water vapor related to their chemical structure. Therefore, once fabrics have similar structures but vary in fiber type, it shows dissimilarity in WVP [7]. The WVP is mostly affected by the air gaps circling the fibers in both yarns and fabrics. These air gaps make a resistance to the flow of moisture from one side to the other side of the fabric [8]. The WVP of garment materials is an important property for maintaining clothing thermal equilibrium for the wearer. Garment with high WVP gives the human body an improvement in its ability to offer cooling due to sweat production and evaporation. High WVP is also essential to avoid or lessen water build-up in garment leading to feel uncomfortable [7,9].

There are several important factors affecting the permeability properties of the textile fabrics such as fiber orientation, morphological structure, fiber material, yarn flattening, yarn structure, fabric loop length, fabric thickness, tightness factor and fabric structure [10,11]. The air permeability of the fabrics produced from natural yarns is more than textured polyamide, above elastane knitted socks [12].

The interactions of yarns and fabrics with liquids rely on the chemical structure of the fiber, liquid properties such as viscosity and surface tension. The mechanism by which moisture is transported in textiles (wicking) depends on the fiber-liquid molecular attraction at the surface of fibers, which is determined at most by fiber's diameter, surface tension and capillary pore distribution. Wicking in a fabric can take place in two different ways, transverse wicking (perpendicular to the plane of the fabric) and longitudinal wicking (along the plane of the fabric) and it occurred on a perspiring body [13,14].

The surface energy in a textile fabric depends mostly on the chemical structure of the exposed surface of the fiber, where hydrophilic fibers have a high surface energy and therefore they pick up moisture more easily than hydrophobic fibers. On the contrary, hydrophobic fibers, have low surface energy and repel moisture. As a result, special finishing treatments can be applied to lessen the difference in surface energy between the face and back of the fabric in order to improve its ability to wick [15].

With the advanced technology, new regenerated fibers such as Tencel LF, Tencel STD and Bamboo and their blends with natural cotton fibers are making a comeback in high-performance, outdoor activities.

Tencel "Lyocell" fibers are characterized by their great strength in both dry and wet states. In wet state, Lyocell keeps 85% of its dry strength and considered as the only man-made cellulosic fiber which is stronger than cotton when wet. Tencel fibers absorb moisture and have a high modulus that leads to small shrinkage in water. Therefore garments exhibit good stability when washed. Lyocell fibers are famous by their particular ability to fibrillate in a wet state under the influence of external mechanical processes [16–18]. In addition, fabrics in Tencel are characterized by their silk touch, unique drape and fluidity. Fabrics with Tencel fiber wefts showed better crease resistance and air permeability in comparison with fabrics with cotton and viscose wefts [19].

Natural Bamboo fibers have numerous groves, cracks, voids and micro-holes on the surface that affect the capillary property. Bamboo viscose is now known for its antibacterial properties. The main feature of bamboo material is its unbelievable capability to breathe and genuine coolness, lovely luster, superior drape and extremely comfortable soft feel [20–23].

The Three-Thread Fleece fabrics have relatively high mass and thickness and are widely used as an outdoor garment for active and sportswear. Sportswear should possess good liquid moisture transmission property. So, our goal is to develop an optimized sportswear in order to transport humidity to the outer surface as quickly as possible, to evaporate the humidity as fast as possible for making the skin feel dry. Therefore, in this present study, nine three-thread raised fleece fabrics of different inner and outer layer yarn materials have been studied, where these fabrics are produced in a special circular knitted machine. The developed fabrics are taken to measure water vapor permeability, gain%, air permeability, drying time, color difference and time of immersion.

2. Material and methods

2.1. Material

In this study, 30/1, 100% Tencel LF, Tencel STD, Bamboo and Egyptian cotton yarns were used. Also, 20/1, 100% Tencel LF, Bamboo and Egyptian cotton yarns were used with previous yarns to knit three-thread fleece knitted fabrics. The properties of Tencel LF, Tencel STD, Bamboo and cotton fibers are cleared in Tables 1 and 2. Additionally, the properties of the yarns applied to produce all fleece fabrics are shown in Table 3.

2.2. Fabric manufacture

The structure of the three-thread fleece fabric is formed from back fleecy yarn, binding yarn and face yarn and is shown in Fig. 1. This structure is manufactured on special single-jersey circular knitting machine with 20 gauge, Mayer & Cie, MLBF model, 30-in. diameter, 96 feeders and with total number of needles equal to 1872. The loop length was kept constant at 3.97 mm for all face and binding yarns, and at 1.59 mm for all fleecy yarns. The yarn feeding tension was adjusted at 5 CN.

Furthermore, Fig. 2 shows the development view of the 3 consecutive cam segments and the arrangement of the 4 needles types used for producing this fabric structure.

After knitting process, all gray three-thread fleece fabric samples were finished according to the flowchart indicated in Fig. 3. The information about the experiments studied in this research is revealed in Table 4, where yarn material for face, binding and fleecy yarns is determined for every sample.