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MATERIAL COMPOSITION AND FABRIC STRUCTURE IMPACT ON MOISTURE MANAGEMENT OF TERRY TOWELS

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Abstract:
Moisture management is a complex process influenced by a variety of fabric characteristics, e.g. type of fibre (hydrophilic and hydrophobic) and structure (density, porosity and thickness). The liquid flow through textile materials is controlled with two processes, i.e. wetting and wicking. They represent a critical aspect of the performance of products such as towels, bathrobes, hygiene disposable materials and medical items.

The wickability can be defined as the ability to sustain the capillary flow, while the wettability can be defined as an interaction between the liquid and the substrate before the wicking takes place.

Ten towels with different material composition and different structure were studied. Long-staple cotton provides quality and durability of towels, but recently has been replaced by the share of polyester, which increases strength, reduces wrinkle and also affects the more favourable price. The purpose of the study was to determine whether this substitution affects the reduction of moisture absorption.

Keywords: *wicking, wetting, moisture absorption, terry towel, moisture transfer.*

1 INTRODUCTION

Natural fibres such as cotton are hydrophilic, meaning that their surface has bonding sites for water molecules. Therefore, water tends to be retained in the hydrophilic fibres, which have poor moisture transportation and release. On the other hand, synthetic fibres such as polyester are hydrophobic, meaning that their surface has few bonding sites for water molecules. Hence, they tend not to get wet and have good moisture transportation and release. Neither natural nor synthetic fibres can perform well in both moisture absorbtion and release at the same time [1].

Terry fabrics have been most often designed and used for home textiles such as towels, bathrobes, bathroom mats, and sport textiles such as sauna towels and clothing. Their most important characteristics are: soft handle, dimensional stability, colour fastness and good absorbency.

Usually, long-staple cotton is used for the production of terry. It provides quality and durability of towels. Recently, it has been replaced by the share of polyester which increases strength, reduces wrinkle and also enables cost savings. The purpose of the research was to determine whether this substitution affects the reduction of moisture absorption of terry towels in various structures and qualities. In a presented preliminary investigation, quick and simple methods were used to evaluate the PES addition to the moisture transfer of terry towels.

2 THEORETICAL

2.1 Moisture transfer properties

Moisture management, i.e. the transport of both moisture vapour and liquid away from the body, is a complex process influenced by a variety of fabric characteristics, e.g. type of fibre (hydrophilic and hydrophobic), porosity and thickness [2]. The liquid moisture flow through textile materials is controlled with two processes, i.e. wetting and wicking. The wetting and wicking behaviour is a critical aspect of the performance of products such as sportswear, hygiene disposable materials and medical items.

Wetting is the initial process, involved in fluid spreading; it is controlled by the surface energies of the involved solid and liquid. Wetting is a complex process further complicated by the structure of fibrous assembly. The curvature of fibres, crimps on fibres and orientation and packing of fibres in fibrous materials make the evaluation of wetting phenomena of fibrous assemblies more complicated. The curvature and roughness of contact surfaces are two critical factors for the wetting phenomena in fibrous materials, which are porous media of intricate, tortuous and yet soft, rough structure. A liquid that fully wets a material in the form of a smooth planar surface may not wet the same material when presented as a smooth fibre surface, let alone a real fibrous structure. Wetting of fibrous materials is important in a diverse range of applications in the textile manufacture such as desizing, scouring, bleaching, dyeing, finishing, cleaning and composite manufacture. Clothing comfort also depends on the wetting behaviour of fibrous structure [3,4].

Wetting can be described by Young's equation [4]:

$$\gamma SV - \gamma SL - \gamma LV \cos\theta = 0 \qquad (1)$$

where γSV, γSL and γLV denotes interfacial tensions between solid/vapour, solid/liquid and liquid/vapour, respectively, and θ is the equilibrium contact angle.

Wicking occurs when a fabric is completely or partially immersed in a liquid or is in contact with a limited amount of liquid, e.g. a drop placed onto the fabric. The capillary penetration of a liquid can therefore occur from an infinite (unlimited) or finite (limited) reservoir. The wicking processes from an infinite reservoir are immersion, transplanar wicking and longitudinal wicking. Wicking from a limited reservoir is exemplified by a drop placed onto the fabric surface [4]. The capillary pressure for a caplillary with a circular cross-section can be described by Young-Laplace equation [4]:

$$\Delta P = 2\gamma_{LV}/R \qquad (2)$$

where ΔP is the pressure difference across the fluid interface, $R = r/\cos\theta$, r is the capillary radius and γ_{LV} is the capillary tension between liquid/vapour.

The wickability can be defined as the ability to sustain the capillary flow, while the wettability can be defined as an interaction between the liquid and the substrate before the wicking takes place. Hence, it could be said that wetting is a prerequisite of wicking. [5]

It is assumed that water is retained by a fabric in only three places:

- in the spaces designated by weave intersections (the so-called "fabric water"),
- in the capillary space between individual fibres within a yarn (the so-called "yarn water"), and
- within the fibres themselves (the so-called "fibre water").[6]

2.2 Terry towels

Terry is produced by three systems of yarns: ground warp, weft, and pile warps. The pile can be formed on one side or on both sides by the pile warps. As one sided pile terry fabric has a low water absorbing capacity, it is not so popular. Pile characteristics have an important effect on the structure of terry fabric and others usage properties. The raw material used for weft, ground warp and pile warp as well as pile height provide the main parameters for the design of the fabric properties. The main characteristics of the yarns used in terry fabrics are high absorbency, high strength in wet, good washability and soft handle. When high quality is required, two or more ply yarns are used. The use of two-ply yarns also improves visual appearance of the terry towels. The pile loops generally consist of more highly twisted yarns which, while very absorbent, are quite abrasive and thus actively stimulate the skin during drying [7-10].

The goal of every producer is to develop a cost effective product and to enhance quality and comfort. The main criteria for enhanced quality and comfort of terry towels are: better and faster absorption, higher strength, extended service life, quicker drying time and increased softness. Some of these improvements could be achieved by special microfiber weft insertion. Traditionally, terry products are woven using spun cotton or poly/cotton yarns in the weft direction. Centium Core^{TM} terry products replace these spun natural fibre weft yarns with microfiber polymer multifilament yarns that have been engineered to impart both high strength and controlled shrinkage characteristics. Weft direction tensile strength increases by over 100% vs. traditionally constructed terry products and lasts substantionally longer. Replacing cotton weft with microfiber multifilament core weft offers the possibility to relative component mass redistribution and increase of absorbent cotton pile warp and all that without increasing the overall product weight. The weight of pile warp in a standard terry fabric represents 60% of total weight, since Centium Core technology allows 10 % higher weight of pile warp. More weight in pile warp provides longer loops, more volume and better comfort [11].

3 EXPERIMENTAL

3.1 Testing methods

The wetting was evaluated with the sinking test method, i.e. by measuring the time required for a piece of fabric to sink completely from the surface layer of water in a beaker. A sample of 3 × 3 cm was cut from the fabric and placed onto the surface layer of water in a 500 ml beaker. The wetting time was estimated with a stop watch as the time interval between the moment of immersion and the moment when the sample sunk under the water level [5,12]. Each experiment was performed at least five times. The sinking time of about 5 sec is generally considered satisfactory for well-prepared cellulosic materials [13].

The wicking was evaluated by the drop test [13,14], i.e. by measuring the time required by a water droplet to spread to the edge of a circle with diameter 1 cm. The specimen with absorbing (face) side up was flatted without tension. Drop of 1% Prussian blue solution was placed on the fabric surface from a height of 2.5cm with the help of pipette. A stop watch was started as soon as the drop fell on the fabric and stopped no sooner the coloured water reached the edge of the marked circle. This was termed as ‘drop absorbency time’. Each experiment was performed at least five times.

3.2 Samples’ preparation

Nine industrially produced terry fabrics samples with different weight and structure were investigated. The mass per unit area of samples was from 500 g/m^2 to 700 g/m^2 which places them among the high-quality materials, since the quality of the towels is estimated by weight. Some of the samples were prewashed during the production process which affected the initial wetting and wicking processes as the cotton and cotton blended materials were investigated. Measurements of the moisture transfer properties were made before and after three cycles of machine washing and drying according to standard ISO 5077, so the results of washed samples are more comparable.

Table 1: Terry fabrics´ properties

Terry fabric designation	Raw material composition	Weight (g/m^2)		Thickness (mm)	
		unwashed	washed	unwashed	washed
1	90 % Co / 10% PES	526	/	3,40	3,70
2	90 % Co / 10% PES	575	/	4,22	3,49
3	100% Co	564	597	4,16	4,09
4	Centium: 70% Co/30% PES	575	591	4,15	4,37
5	Centium: 70% Co/30% PES	570	563	3,80	3,68
6	100% Co	700	704	4,10	4,43
7	100% Co	516	518	3,24	3,31
8	100% Co	585	594	3,64	3,64
9	100% Co	532	519	3,59	4,19

4 RESULTS AND DISCUSSION

The examined samples can be classified into three groups: pure cotton samples, samples containing 10% PES and samples produced by Centium Core Technology with 30% PES. The research was focused on wetting and wicking phenomena of the samples 4 and 5 with increased percentage of PES (the Centium Core Technology) compared to other samples produced with minor percentage of PES or pure cotton.

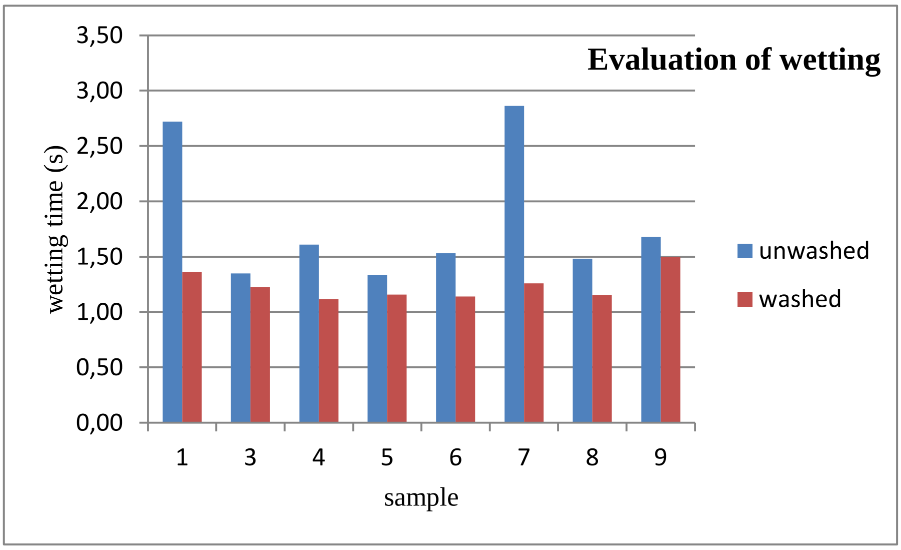

Figure 2: Wetting evaluation chart

The unwashed samples 1 and 7 exhibit the longest wetting time, over 2,5 sec. Furthermore, the difference between the wetting time of unwashed and washed samples is bigger than with the other samples. The wetting time of all the washed samples is 1-1,5 sec (cf. Figure 2), which means that all the investigated terry fabrics can be ranked as satisfactory absorbent. The samples 1 and 7 have the lowest weight per unit area and thickness, but only the sample 7 contains PES. Washed samples show very small differences in the wetting time so it can be concluded that there is no noticeable difference in wetting ability between cotton samples and samples containing PES.

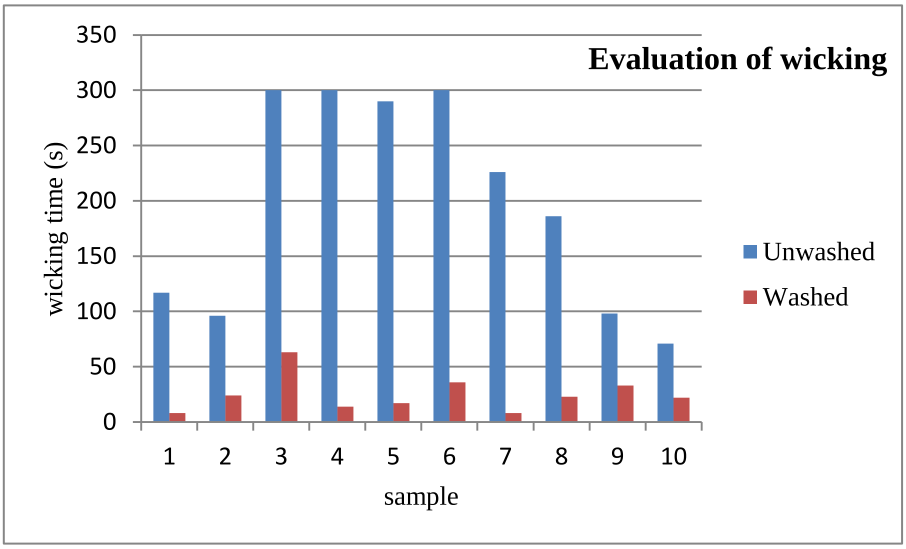

Figure 3: Wicking evaluation chart

The drop test shows how big is the impact of residual sizing on the wicking of samples. After three cycles of machine washing and drying, the wicking time is reduced by 80% and more. The maximum wicking time was exhibited by unwashed samples 3,4,5 and 6 of which samples 4 and 5 contain 30% PES (cf. Figure 3). For the washed samples, the maximum wicking time was exhibited by samples 3 and 6 containing pure cotton. The wicking time has been decreased by 80% for the washed sample 3 and by almost 90% for the washed sample 6.

5 CONCLUSIONS

The obtained results suggest that the share of polyester in terry towels has quite little impact on the rate of wetting and wicking. Moisture management is mainly influenced by the quality of cotton yarn, yarn structure and fabric construction. Multifilament polyester weft yarns hidden among warp yarns in the compact terry structure do not significantly affect the reduction of moisture absorption. On the other hand, the higher proportion of cotton yarns within the loops increase volume and softness of towels and provide more comfort. For further investigation, more complex methods for evaluating moisture absorbency in will be applied, eg. wicking strip test method which enables the assessment of the wickability in warp and weft direction, respectively.

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