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WICKING PROPERTIES OF HIGH TWIST PET CREPE FABRICS

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ABSTRACT

Yarn twist has always been an integral part in textile design for its marked influence on the different aspects of those fabrics such as, appearance, handle and functional properties. Part of functional properties is the wicking ability of apparels which is an integral part in its comfort properties. Accordingly, this paper is concerned with the study of the effect of high twist factor yarns of crepe fabrics on vertical and horizontal wicking rates.For this aim, three 100% PET woven samples varying in their twists/m values (1000, 1600, 2400 TPM) for their pick yarns were produced, taking into account that the other production parameters were constant. Results showed that the increase in twist factor increased vertical wicking rates due to the progressive decrease in intra thread spaces. On the other hand, horizontal wicking rate was increased until a specific twist factor, after which the horizontal wicking rate decreased. This can be attributed to the deformation of yarns alignment which directly affects the inter yarn spaces.

Keywords: Crepe, Wicking, High twist factor, High yarn twist, Inter yarn spaces, Intra yarn spaces.

I. INTRODUCTION

Yarn twist has always been an integral part in textile design for its marked influence on the different aspects of those fabrics such as, appearance, handle and functional properties. The different directions of twist, be it S or Z, can be used to obtain fabrics with stripes or checks. The generated twist effects were exploited as far back as the Bronze age (1200 – 1400 BCE). Moreover, the ancient Egyptians created textured fabrics with the use of highly twisted pick yarns which is known nowadays by the crepe fabrics[1]. The end effect of those highly twisted pick yarns when incorporated inside a fabric is a wrinkled or a wavy fabric[2]. High twisted yarns has been increasingly exploited in producing highly decorative and innovative fabrics but little emphasis has been put towards studying their wicking behavior as an important means of providing comfort for the wearer of such types of fabrics.

Comfort can be defined as a pleasant physical, physiological and psychological equilibrium state between the human being and the environment, and apparel plays an important role in achieving this equilibrium. This equilibrium can be achieved by translating metabolic heat generated as a result of any kind of efforts exerted by the wearer into sweat which is equivalent to 60 to 840 ml of water vapour per hour according to the level of exerted effort. Accordingly there is a dire need to prevent perspiration from remaining next to the skin leading to body temperature regulation, improvement of muscle performance and delay exhaustion. It is worth noting that when it comes to high level of activity, synthetic fabric like nylon or polyester are regarded as better performers when it comes to efficiently wicking moisture away from the skin of the wearer compared to fabrics made of natural fibers like cotton[3].

Accordingly, any clothing should be able toevapourate the perspiration from the skin surface and to transfer the moisture from the layer adjacent to the skin to the outer surface of the fabric and eventually allowing the moisture to evaporate in the atmosphere, this is known as moisture management, where the fabric will eventually dry and wearer will feel more comfortable. Mainly Capillary action, also known as wicking, is responsible for drawing the moisture to the outer surface of the fabric. Thus,wicking can be defined as "the ability to sustain capillary flow" or as "A spontaneous transport or of liquid driven into a porous system by capillary forces**"**. The two opposing forces, liquid adhesion to solid surfaces that tends to spread the liquid, and the cohesive surface tension force of liquids lead to the phenomenon of capillarity in porous media, as in textiles. From that can be concluded that this phenomenon is dependent on solid and liquid interfacial properties such as surface tension, contact angle, and solid surface roughness and geometry[3–7].

As a result, the smaller the diameter or the greater the surface energy, the greater the tendency of a liquid to move up the capillary. In textiles structures, narrow capillaries are readily found in the spaces between the fibers. Hence the wicking ability of the fabrics increase with the narrowing of the spaces between the fibers leading to picking up moisture effectively. Fabric constructions made from microfibers excel in wicking moisture due to formation of narrow capillariesdue to the dense packed arrangement of fibers constituting those fabrics. However, capillary action ceases when all parts of a garment are equally wet[6,7].

Water vapour and the liquid water are transmitted through textiles by the following mechanisms[8]:

1) Simple diffusion through inter thread spaces: Diffusion is the main mechanism for transferring moisture that is controlled by the water vapour pressure gradient across the inner and outer faces of the fabric.

2) Capillary transfer through fiber bundles: the liquid water is "Wicked" through the threads and desorbed or evapourated at the outer surface. That determined by the choice of thread and fabric construction which is the main interest of this study.

3) Diffusion through individual fibers: This mechanism involves absorption of water vapour into the fibers at the inner surface of the fabric, diffusion through the fiber structure, and desorption at the outer surface.

It is important to note that the hydrophilic or hydrophobic nature of the fibers paly a detrimental role in water vapour diffusion to occur in fibers[9].

Accordingly, the dimensions and structure of inter and intra thread pores is greatly caused by the density and structure of threads in woven fabrics which for example can be influenced by yarn count or method of spinning or doubling[3,10].Moreover, Inter-thread pores can be similar in size to fibers and in some cases larger than threads. The overall complexity of fabric pore structures must therefore include the complex structural variables, pore size distribution, pore connectivity and total pore volume[3].

In our previous study, we evaluated the effect of basic fabric weaves and pick densities of synthetic PET fabrics on vertical and horizontal wicking rates, and their relation to fabric packing factor[3]. In the current study, the effect of different types of PET crepe fabrics with three different high twist factors and their relation to wicking rates is examined to evaluate if high twist rates impact the wicking ability of fabrics or not.

II. MATERIALS AND METHODS

To investigate the effect high twist factors on vertical and horizontal wicking rates of fabrics, three samples were produced as listed in Table 1. All samples were plain 1/1 PET samples of 150 Tex. Warp and pick densities were the same for all samples at 28 warps/cm,and 20 picks/cm. Three levels of highly twisted pick yarns were used 1000, 1600, and 2400 TPM.

All samples were tested for vertical and horizontal wicking according to AATCC test method 197-2011 for vertical wicking of textiles[11]and AATCC test method 198-2011 for horizontal wicking of textiles[12]. For the vertical wicking test the standard specifies either a 20 mm or 150 mm as a measuring distance and for this study the 150 mm method was adopted. Moreover, fabric shrinkage was also calculated for all samples. All results were tested with one way ANOVA for measuring the significance of results.

Table 1 the specifications of test samples

Specifications of crepe fabrics								
Sample no.	**Fiber type**	**Weave type**	**TPM**	**Warp density/cm**	**Pick density/cm**	**Yarn count warp - picks denier**	**Shrinkage %**	**Picks twist direction**
1	PET	plain1/1	1000	28	20	150	3.64	2S:2Z
2			1600				5.12	
3			2400				7.97	

III. MATERIALS AND METHODS

3.1 Vertical Wicking Rates

After analyzing the ANOVA results for vertical wicking, as listed in Annex A1, the vertical wicking resultswere found to be significant ($F=9.689 \geq Fcrit =5.143$).From Fig. 1 it can be observed that the 1000 TPM sample scored the highest vertical wicking rate followed by the 1600 TPM sample. On the other hand, the 2400 TPM sample scored the lowest vertical wicking rate when compared to the other two samples.

This can be explained by the fact that the mechanism of moisture transport in textiles is due the wicking of a liquid in capillaries which is controlled by the capillary diameter; and surface energy of the wicked material. And as surface energy for all samples is the same because all samples are made of PET yarns, then the differences can be attributed to the capillaries diameters. Capillary diameters is attributed to the structure and dimensions of inter and intra thread pores, which is mainly controlled by the density and structure of the threads in the samples themselves. And as the density for all samples is the same, then the differences in wicking rates can be largely attributed to the difference in structure of the pick yarns caused by the different twist rates for each sample type which affects both inter and intra thread pores. The high vertical wicking rate of the 1000

TPM sample can be explained by the abundance of both inter and intra spaces inside the threads and between the threads due to the low compactness of the 1000 TPM pick yarns. Accordingly, as the twist rate increases (1600 TPM samples) the compactness of the pick yarns increase and leads to diminished inter spaces inside the pick yarns. As a result the 1600 TPM sample scores less wicking rate (0.76 mm/sec) when compared to 1000 TPM samples (0.08 mm/sec). Accordingly, 2400 TPM sample scored the lowest vertical wicking rates due to the high twist rate which is translated in the lowest interspaces when compared to the 1000 and 1600 TPM samples.

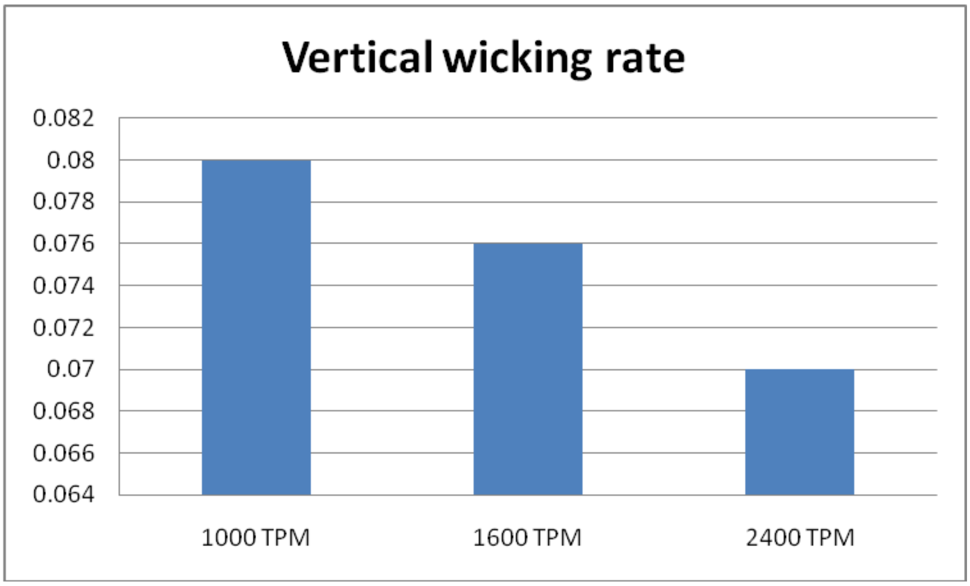

Fig. 1 Vertical Wicking Rates of 1000 – 1600 – 2400 TPM samples

3.2 Horizontal Wicking Rate

After analyzing the ANOVA results for vertical wicking, as listed in Annex A2, the horizontal wicking results were found to be significant ($F=6.685 \geq Fcrit=5.143$). As listed in Fig. 2, the 1600 TPM sample scored the highest horizontal wicking rate, followed by the 2400 and 1000 TPM samples respectively. The high horizontal wicking rate of the 1600 sample can be attributed to the less number of air spaces inside the yarns constituting this sample and hence the reduced availability for water molecules to be accumulated or absorbed which leads to greater wicking rates when compared to the 1000 TPM sample. The reduced number of available air spaces inside the yarn is thought to be a direct result to the effect of the high twist factor of the 1600 TPM yarns which leads to the production of more compact yarns when compared to the 1000 TPM yarns. Although this rational should dictate that the 2400 TPM sample should score the highest wicking rates among all the tested samples for its compact composition, but this was not the case. This can be explained by examining the shrinkage of the 1000, 1600, 2400 TPM samples as listed in Table 1. It can be observed that the shrinkage is at its peak for the 2400 TPM sample at 7.97%, followed by the 1600 and 1000 TPM yarns at 5.12% and 3.64% respectively. This high shrinkage is translated into the formation of the highly thought after wavy effect of the crepe fabrics, but at the same time leads to the formation of additional air pockets between the yarns due to the miss alignment of the yarns because of their high shrinkage rates. The additional air pockets means that there are additional sites for water to be accumulated in, and hence the remaining available water for spreading is greatly reduced when compared to the other two samples.

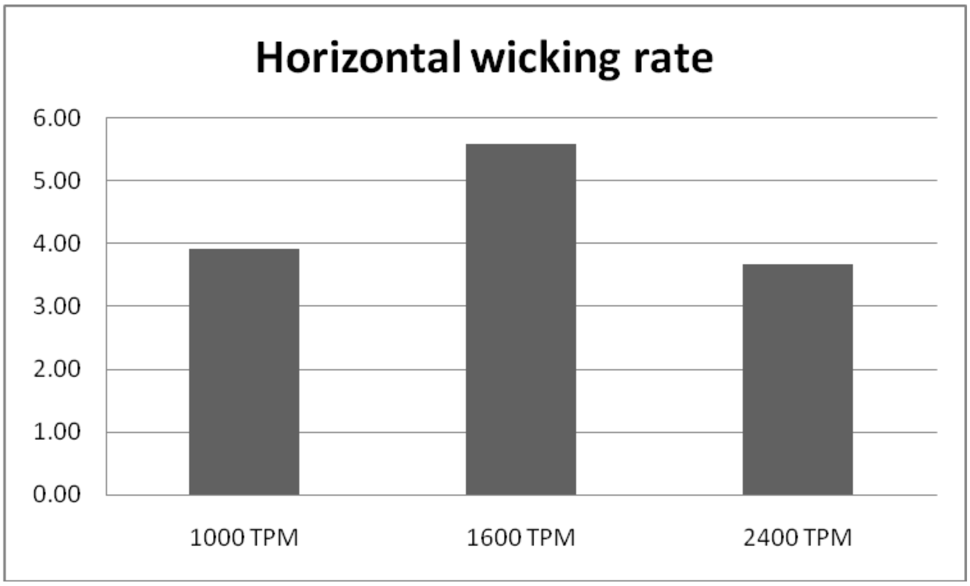

Fig. 2 horizontal wicking rates of 1000 – 1600 – 2400 TPM samples

IV. CONCLUSION

In this study woven crepe PET textile samples varying in their twist factor were chosen to determine the effect of high twist factors on horizontal and vertical wicking rates.

After statistically analyzing the data, the results can be summarized as follows:

1. Vertical wicking rate was found to be greatly influenced by twist factor, as with the increase of the twist factor the vertical wicking rate increased. This can be attributed to the fact that the increased twist rate lead to a more compactyarn and accordingly more narrow capillaries were created leading to higher vertical wicking rates.
2. Horizontal wicking rate increased with the diminishing of both inter and intra thread spaces until a specific twist factor. After this point the horizontal wicking rate decreased due to the distortion in the alignment of yarns inside the fabric.

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Annex A1

Anova Single Factor for vertical wicking rate

Horizontal wicking rates of 1000 – 1600 – 2400 TPM samples

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	3	0.241111	0.08037	1.37E-05
Row 2	3	0.229444	0.076481	1.37E-05
Row 3	3	0.208889	0.06963	1.03E-07

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000177	2	8.87E-05	9.689139	0.013215	5.143253
Within Groups	5.49E-05	6	9.16E-06			
Total	0.000232	8				

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Annex A2

Anova Single Factor for horizontal wicking rate

Horizontal wicking rates of 1000 – 1600 – 2400 TPM samples

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	3	11.77	3.923333	0.820633
Row 2	3	16.78	5.593333	0.308233
Row 3	3	11	3.666667	0.344433

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.566822	2	3.283411	6.68583	0.029713	5.143253
Within Groups	2.9466	6	0.4911			
Total	9.513422	8				