LIQUID MOISTURE TRANSPORT PERFORMANCE OF TEXTILES

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Abstract: *The main purpose of this study is the data base creation of different textiles moisture management performance for design multilayer textile composites with predicted liquid moisture transport properties. In this paper are the results of studies the influence of fabrics structure and its raw composition on the liquid moisture transport performance of textiles. Moisture management property of the textiles was examined using MMT instrument.*

Keywords: *textiles, multilayer textiles, liquid moisture transfer.*

1 INTRODUCTION

The multilayer textile composites can be obtained by bonding the individual textiles in one multilayer structure. Such composites consist of textiles with various functional properties of different structure and different fibrous composition [1].

The main purpose of this study was the data base of moisture management performance of the modern technical textiles creation. These textiles can be used for design of multilayer textile composite with predicted liquid moisture transport properties, for example, quick absorbing of moisture and quick transport, distribution; reliable accumulating in textile composite volume. At the same time these liquids do not have to penetrate in external environment. Some test methods are known to measure liquid water absorbency and water vapor transport in textiles. These methods characterize by different aspects of moisture management characteristics, namely: diffusion ability, wicking, water vapor permeability, drying time etc. However, these methods are unable to characterize the behavior of dynamic liquid transfer in to textiles [2, 3].

In this work the liquid moisture transport properties were characterized by using the Moisture Management Tester (MMT). The method allows to measure quantitatively liquid moisture transfer in one step in a fabric in multidirections, where liquid moisture spreads on both surfaces of the fabric and transfers from one surface to the opposite. The essence of this method is described in detail in works [4, 5].

2 EXPERIMENTAL

2.1 Materials

In previous investigations, we have studied 31 textiles using more than 35 indicators, with the help of which we can evaluate the ability of textile materials to interact with moisture, heat, vapor, etc [6]. According to these results we chose 6 textiles with different structures, compositions and physical properties (Table 1, Figure 1). Before investigation, the samples were put into the condition room with controlled temperature (T) 21±1°C and relative humidity (RH) 65±2% (refer to ASTM D1776) for at least 24 hours.

2.2 Methods

Structural characteristics of textiles were determined by standard methods in accordance with ISO 3932–76, ISO 3933–76, ISO 3801–77.

Hygroscopic and water-repellent properties of textiles were determined by methods in accordance with Ukrainian standard DSTU GOST 3816 2009 (ISO 811 81).

Moisture Management Tester (SDL Atlas) was chosen as testing equipment for textile dynamic wicking process visualizations. This method allows to quantitatively measuring liquid moisture transfer in one step in a textile in multidirections, where liquid moisture spreads on both surfaces of the textile and transfers from one surface to the opposite. Ten moisture management indexes are using to characterize the moisture management properties of textile [4, 5].

Table 1 Basic structural parameters and physical performance of textiles

Properties		Sample code					
		S	*Pq*	*E*	*A*	*L*	*BA*
Type of textile		knitted fabric			two-layer knitted fabric	woven fabric	
Pattern		tuck	tuck	plain	double	twill 3/3	twill 2/3
Linear density [tex]	warp	12.0	19.1	35.2	Cotton 12.6	12.4	20,4
	weft				PP 14.8	17.2	13.3
Density of weave (knitting)	warp	230	245	315	132	800	650
	weft	135	120	230	90	340	430
Fiber type [%]		PP-100	Cotton-100	Viscose-100	PP-40/Cotton-60	PES-100	PES-100
Surface density [g/m^2]		95	207	330	183	160	180
Thickness [mm]		0.7	0.8	0.8	1.6	0.3	0.3
Hygroscopicity *H* [%]		1.1	14.5	15.5	8.9	1.5	1.4
Water absorption *Wa* [g/m^2]		270	315	650	1060	185	0
Vertical capillarity *C* [mm]		158/136	177/175	143/139	23/148 // 22/131	197/177	0/0
Water resistance W_R [Pa]		–	–	–	–	–	4310

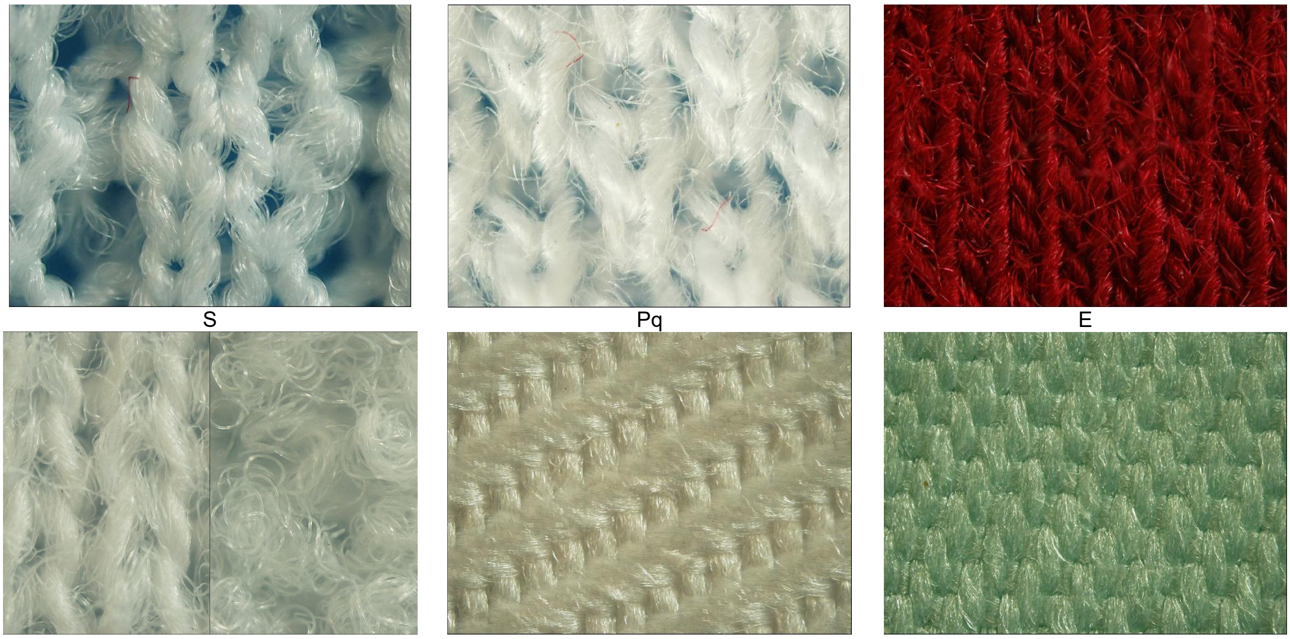

Figure 1 The structure of textiles (Scale x 50)

3 RESULTS AND DISCUSSION

The liquid moisture transport performance of textiles and water content curves for the top (UT) and bottom (UB) surfaces of the individual textiles are shown in Figure 2 and Table 2.

Sample “BA” has a water repellent finishing so water did not spread out over the top surface and did not penetrate through the fabric

Table 2 Liquid moisture transport performance of textiles

Properties		Fabrics sample code										
		S		*Pq*		*E*		*A*		*L*		*BA*
		mean	*S.D.**	*mean*	*S.D.**	*mean*	*S.D.**	*mean*	*S.D.**	*mean*	*S.D.**	*mean*
Wetting Time [sec]	T**	5.2	0.9	22.7	5.4	9.1	1.1	3.4	0.4	6.6	0.8	-
	B**	5.2	0.8	11.6	1.7	9.3	1.0	119.9	0.0	6.8	0.8	-
Absorption Rate [%/sec]	T**	59.7	0.8	26.3	2.3	57.6	5.2	43.9	1.1	60.2	0.9	-
	B**	64.8	1.5	44.6	2.4	64.7	5.3	0.0	0.0	72.9	5.3	-
Max Wetted Radius [mm]	T**	21.7	2.9	13.3	2.8	13.3	2.0	25. 0	0.0	25.0	0.0	-
	B**	21.7	2.9	15.0	0.0	13.3	2.0	0.0	0.0	28.3	2.9	-
Spreading Speed [mm/sec]	T**	3.2	0.7	0.6	0.1	1.3	0.1	4.2	0.2	4.3	0.3	-
	B**	3.3	0.7	0.8	0.1	1.3	0.0	0.0	0.0	4.4	0.3	-
One-Way Transport Capability [%]		55	9	257	22	78	4	-649	26	108	6	-
Overall Moisture Management Capability		0.46	0.05	0.44	0.09	0.32	0.01	0.00	0.00	0.56	0.05	-

** T- top; B – Bottom; * S.D. – S. Deviation

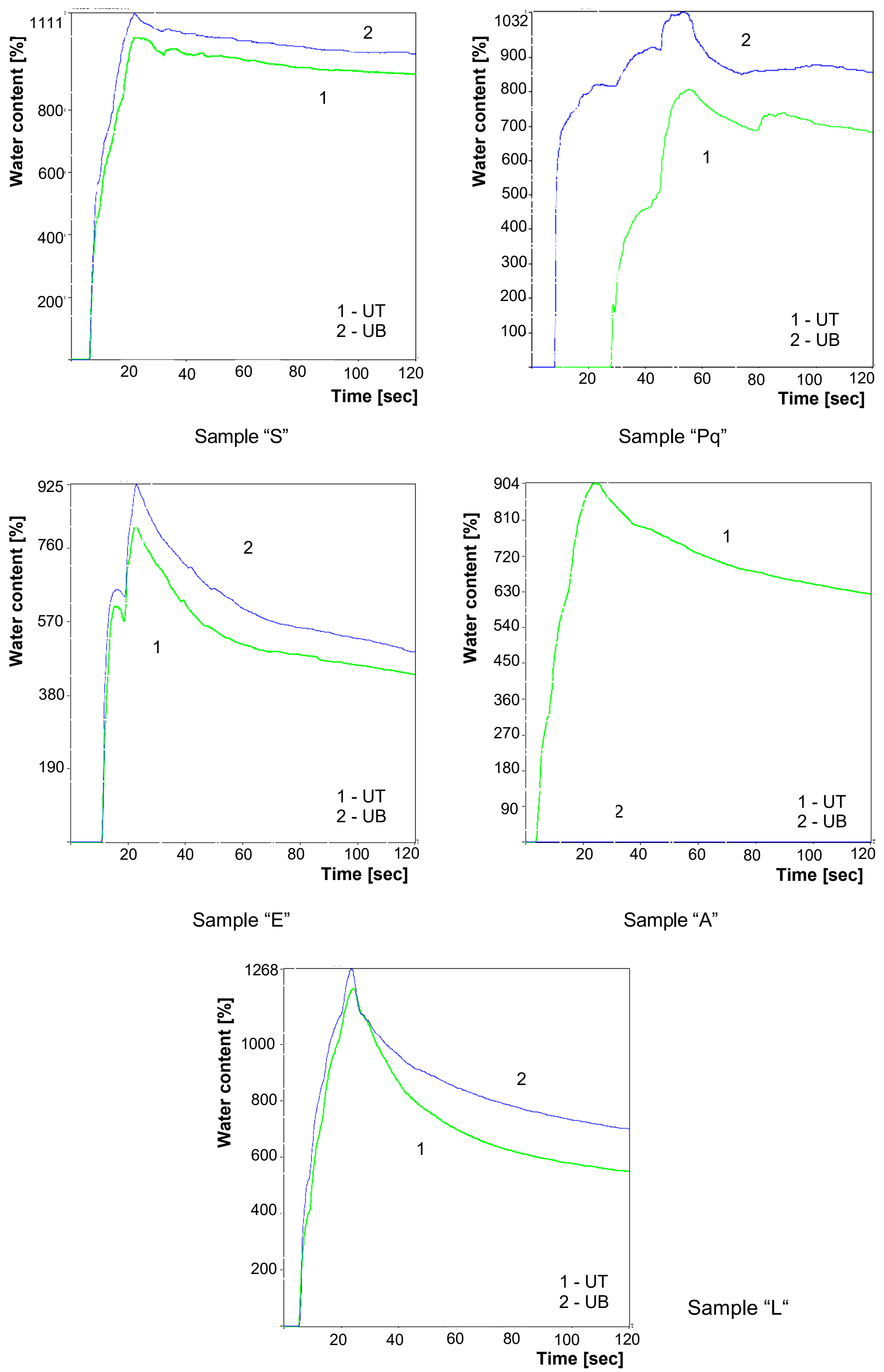

Figure 2 MMT water content curves of the textiles
1 – UT – water content curves of the top surfaces of the textiles
2 – UB – water content curves of the bottom surfaces of the textiles

For sample “S” and sample “L”, the water content of the top and bottom surfaces increase very quickly during the pumping time (starting at around 6 seconds). Then the water content on top and bottom surfaces for sample “S” remained almost stable with little change after reaching a maximum, while those of sample “L” decreased gradually until the end of the test. For sample “A”, the relative water content on top layer increased abruptly from 0 to more than 900, but on bottom surface remained zero. For sample “E” the trend of the water contents of the top and bottom surfaces was the same.

Figure 3 shows the top surface absorption rate (TAR) and bottom absorption rate (BAR) of each textile. TAR and BAR are the maximum moisture absorption rates of the top and bottom surfaces of the fabric respectively. Samples “S”, “E”, “L” had the same mean BAR and TAR, indicating that the liquid evenly distributed on the top and bottom surface of these textiles. The sample “A” had the zero BAR and the highest means TAR, indicating that all liquid was distributed only on the fabric top surface.

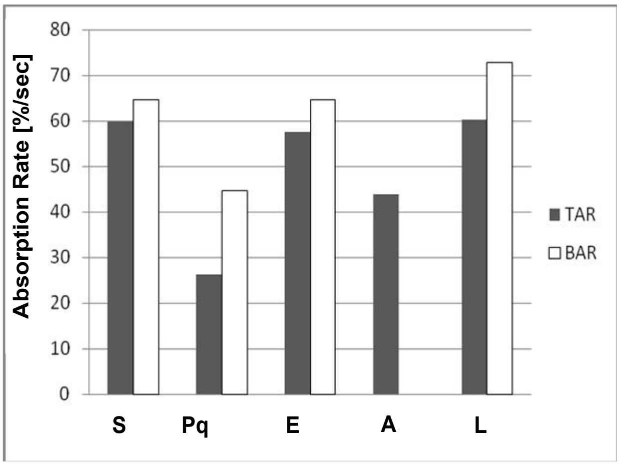

Figure 3 The TAR and BAR of the investigated textiles

Figure 4 shows the top surface maximum wetted radius (TMWR) and bottom surface maximum wetted radius (BMWR) of the textiles. TMWR and BMWR are defined as the maximum wetted ring radius at the top and bottom surfaces respectively. It can be seen that samples “Pq” and “E” had the smallest top and bottom surface wetted radius. For sample “L” and “S” the TMWR and BMWR are nearly the same as are the top and bottom surface water contents. However, for sample “L” the TMWR and BMWR were higher than that of the other samples of textile. In case of the sample “A” the top water content was higher than that of the bottom surface (BMWR = 0 mm). It indicates that liquid was distributed only in the top layer of the textile. Sample “BA” has a water repellent finishing so water did not spread out over the top surface and did not penetrated through the fabric.

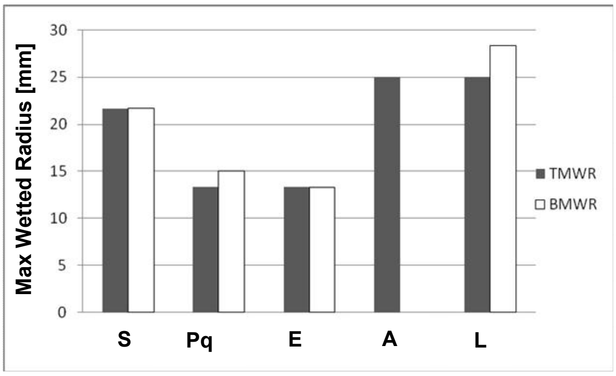

Figure 4 Maximum wetted radius of the top surfaces and maximum wetted radius of bottom surfaces of the fabrics

Figure 5 illustrates the top surface spreading speed (TSS) and the bottom surface spreading speed (BSS). These dates indicate the spreading speeds of the liquid on top and bottom textile surfaces to reach the maximum wetted radius. As one can see from these figures, sample “Pq” had the smallest TSS and BSS among all the textiles. It indicates that the liquid moisture was assembled only on the top surface of the fabric and was not absorbed by the fabric. Sample “A” had only TSS. It indicates faster spread on the top surface of the textile.

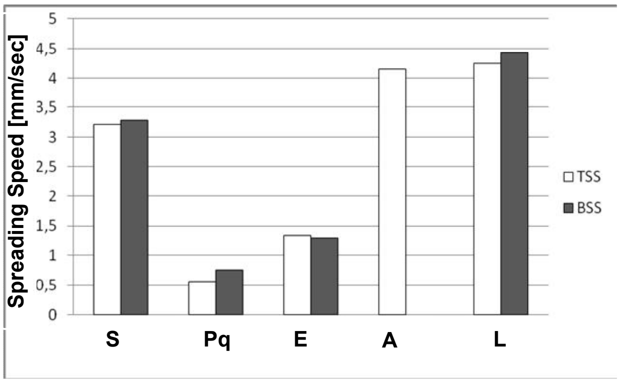

Figure 5 The spreading speed at the top surface (TSS) and the bottom surface (BSS) of the textiles

4 CONCLUSION

As a result of our investigation is creation of data base of moisture management performance of the textiles.

Based on received values of indexes, the investigated textiles are classified into categories:

- water proof fabric – sample “BA”;
- slow absorbing and slow drying fabric – sample “A”;
- fast absorbing and slow drying fabric – sample “E”;
- fast absorbing and quick drying fabric – samples “S”, “Pq”, “L”.

Presented classification gives the opportunity to design multilayer textile composites with predicted and requested liquid moisture transport properties. The requirements to textile composite dictate the order of initial textiles arrangement in multilayer structure. For example, for medical textile with higher liquid absorption and higher liquid resistance performances the order of initial textiles arrangement in multilayer structure is as follows: the first layer have to provide quick absorption and quick transport of water; the next layers must have to provide good liquid distribution ability through layer surface and liquid accumulation and the last one have to serve as good barrier against liquid penetration.

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