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Influence of the Weave Factor on the Character of Fabric Wicking Measured by a Multiple Probe Vertical Wicking Tester

Abstract
Various factors such as the raw material of fibre, its linear density, thread density, fabric construction, finish and even the weave type of fabric influence fabric wickability. In this article, the influence of fabric weave, expressed by weave factor P1, on fabric wicking is analysed. Weaves are distributed into two groups,i. e. weaves, the floats of which are distributed in even intervals throughout the entire surface of the fabric, and horizontally striped weaves. The wickability properties of all the fabrics tested were determined using a newly developed multi-probe vertical wicking tester. It was determined that the dependencies of fabric wicking in fabrics of these weave groups on factor P1 are different. After analysing the dependence of the fabric wicking of individual groups on weave factor P1, we observed that the results of the rate of wicking horizontally striped fabrics are higher than those of weaves with evenly distributed floats. The rate of wicking increases with an increase in factor P1 for evenly distributed floats, and the determination coefficient of the equation is high compared with horizontally striped fabrics. After evaluating all the weaves, we can affirm that the dependence between fabric wicking and weave factor P1 was not established.

Key words: *multi probe vertical wicking, weave factor, wickability properties.*

Introduction

All parameters of fabric structure (warp and weft raw material, warp and weft linear densities, warp and weft settings and fabric weave) influence many mechanical and end-use properties. Various scientists have studied the influence of fabric structure on various end-use properties [1, 2]. Eglė Kumpikaitė [3] studied the influence of Milašius weave factor *P1* on fabric breaking strength and extension. The different experiments mentioned above were conducted with the aim of studying various fabric properties, but the properties of fabric wickability, especially their relation to fabric structure, were not investigated in detail. Milašius [4] proposed weave factor *P1*. It is calculated directly from the weave matrix and has excellent correlation with other weave factors.

The calculation of Milašius' weave factor *P*1 is very complicated and time consuming when done by hand. Free access to a file detailing its calculation can be found on the following website http://www.textiles.ktu.lt/Pagr/En/Cont/pagrE.htm [4].

In this research work the influence of Milašius weave factor *P1* on fabric wicking was investigated by a novel method. A variety of techniques and methods were used to study experimentally liquid penetration into fabrics. The first technique used consisted of observing and measuring the liquid rise in a textile structure using a coloured liquid [5]. Perwuelz et al. [6] developed another method based on the analysis of CCD images taken during the capillary rise of a coloured liquid in a yarn structure. The results obtained by the image analysis technique depend on the resolution, the quality of images and the light source. Furthermore, the kinetics of water can be more important than those of dye, and the diffusion coefficient found by this method presents the value of the diffusion coefficient of the dye, not that of the liquid. Moreover, the addition of the dye changes the surface tension of the liquid and modifies its velocity. Hsieh et al.[7, 8] and Pezron [9] in their studies used a balance to measure the impregnation liquid mass variation in a solid structure. However, this method is unable to determine the equilibrium height and quantity of liquid absorbed by the textile at different heights. The method consists of measuring water transport along textile fibres using electrical capacitance [10, 11]. This technique consists of the construction of apparatus with a specially designed electrical amplifier circuit and condenser electrodes, between which sample fibres are set. However, this method is unable to determine the liquid content at different heights, permitting only a global view of the evolution of liquid transport. The last technique is based on the electrical resistance principle, where the liquid height is measured using a single probe. This method is also unable to measure the liquid height at various levels [12]. In this research work the wicking measurement of 12 different weave fabrics were performed using a multiple probe vertical wicking tester [13], and a technique based on the open and closed electrical circuit principle was

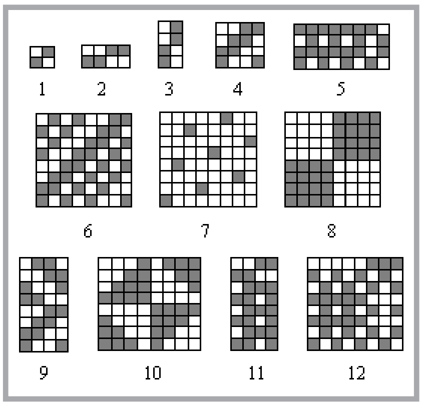

Figure 1. *Weaves used in the experiment: A1 – plain weave (P1 = 1); A2 – weft rib (P1 = 1); A3 – warp rib (P1 = 1.31); A4 – twill 2/2(P1 = 1.26); A5 – weft direction Bedford cord (P1 = 1.27); A6 – fancy twill (P1 = 1.11); A 7 – sateen (P1 = 1.79); A8 – basket weave (P1 = 1.88); A9 – broken twill(P1 = 1.18); A10 – crape weave (P1 = 1.41); A11 – warp direction Bedfordcord (P1 = 1.18); A12 – mock leno (P1 = 1.12).*

used to determine the capillary height of liquid at various levels without dye in relation to time. This technique helped us to do an in-depth study of the wicking behaviour of the fabrics.

Materials and methods

To conduct the above-mentioned experiments, fabrics, woven on a projectile desk loom, of Polyester/Viscose blend 65/35, 19.5 tex, and 2 ply, warp setting 236 dm^{-1}, weft setting 236 dm^{-1} were used. The fabrics were woven in 12 different weaves, as shown in ***Figure 1***. The weaves were chosen in such a way that they could be woven with the same loom setting. The weave factor *P*1 of all the weaves chosen was changed in the widest possible range (from 1 to 1.9). From the weaves chosen, six weaves (1, 2, 4, 5, 6, 7) had floats evenly distributed throughout the fabric surface, and six weaves (3, 8, 9, 10, 11, 12) were horizontally striped.

Circuit Description

In this circuit (***Figure 2***), the probe is used to measure the water level. A test probe (test lead, test prod) is a physical device used to connect electronic test equipment to the device under test. All the probe leads are pulled high through the resistors and placed at the different heights. Then the probe outputs are attached to a 40106 hex schimitt trigger inverter.

Initially when the fabric is dry, all the probe leads are not in contact with water, hence the probe leads become high, which are then inverted to low through the hex inverter. When the water level is increased gradually, the contacted probes become low, which are then inverted to high by the hex inverter. Then a corresponding output signal is sent to a microcontroller in order to establish the water level. Using lab view software, successive signals from the opening and closing switches in this system are captured by computer to measure the liquid height in relation to time [13].

A test was conducted using a multiple probe vertical wicking tester (***Figure 3***) according to the DIN 53924 method [14]. The fabrics underwent the commercial scouring process. A sample (10” × 1”) was prepared in the warp and weft direction and then placed in a climatic chamber at a temperature of 27 °C and 65% RH. The fabric support was composed of a plexi glass plate where the screws were fixed affix every 1 cm on both sides. Metallic wires were extended halfway from the screw on both sides and touched the front and reverse sides of the fabric at regular intervals of half a centimeter. There were a total of eight probes touching the front side of the fabric and another eight probes touching the reverse side alternately (***Figure 3***). The sample of fabric was suspended vertically with its lower end (30 mm) immersed in a reservoir of distilled water. The fabric selected, initially dry, was kept in a vertical position and partially immersed in a bath containing distilled water. When the liquid rose in the fabric and touched the probes placed every 0.5 cm, the fabric height in relation to time was deduced at different instants experimentally from the signals given by the software program. Five tests were conducted for each sample to compute the average value. The time in seconds required for the water to reach 5 cm at an interval of 1cm along the strip was measured and noted. All wicking measurements were performed at 28 °C - 30 °C temperature (room conditions) and 38 - 40% relative humidity.

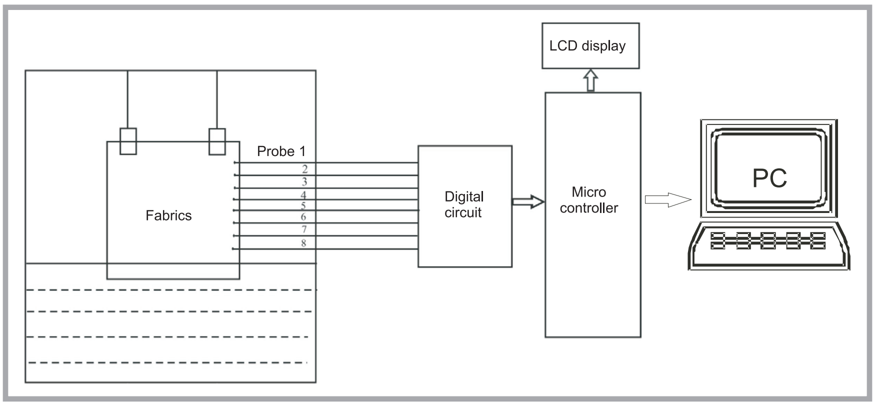

Figure 2. *Experimental system.*

Results and discussion

In order to establish the influence of fabric weave on fabric wickability, vertical wicking tests were carried out using fabrics of two types. The values of weave factor *P*1 for the 12 woven fabrics and the wicking time in seconds (5 cm height) for both the warp and weft directions are shown in ***Table 1*** (see page 62). It was observed that the character of fabric wicking, whose floats are distributed evenly throughout the entire fabric surface, and horizontally striped fabric are different.

Figure 4 shows that Fabrics with evenly distributed floats wick more slowly,

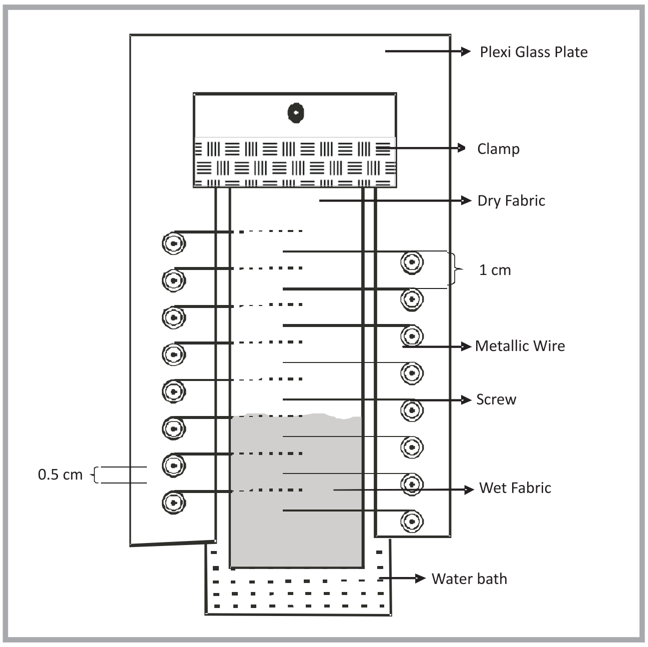

Figure 3. *Principle of measuring liquid transport.*

Table 1. *Values of weave factor P_1 and wicking time for different weaves.*

Fabric code		P1	Vertical wicking time in seconds (5 cm height)	
			warp direction	weft direction
Evenly distributed floats	A1	1	92	91
	A2	1	59	57
	A6	1.10	89	83
	A4	1.26	75	70
	A5	1.27	73	80
	A7	1.78	49	48
Horizontally striped fabrics	A12	1.12	54	42
	A9	1.17	43	44
	A11	1.17	44	40
	A3	1.30	80	63
	A10	1.41	40	43
	A8	1.88	49	52

whereas horizontally striped fabrics wick faster, except for warp rib fabric (A3). It is thought that this happens because the floats of threads in horizontally striped fabrics are placed on the edge of the horizontal stripes and are distributed throughout the entire fabric surface. This irregular structure may be the reason why the rate of wicking is higher for the horizontally striped fabrics. As regards the rate of warp and weft way wicking, slight variations can be observed, and in some cases the rate of weft way wicking is higher than that of warp way wicking, which may be due to the tension variations of warp and weft threads.

On the basis of the test, the effect of the fabric weave factor P1 on fabric wicking were analysed for both the warp and weft directions. The efect of weave factor *P*1 on fabric wicking in warp direction in fabrics woven with evenly distributed floats and horizontally striped weaves is shown in ***Figure 5***. As weave factor *P1* increases, the rate of wicking also rises for evenly distributed floats, which is due the increase in floats in the fabrics. The determination coefficient of dependence (R^2 = 0.975) for weave factor P1 and fabric wicking is high for evenly distributed floats. However, in this case we ignored the points of warp and weft rib weaves because they are non-standard, and their results significantly distort the resulting dependencies. Brierley [15] and Galuszynski [16] considered rib weaves as specific instances, to which the formulas and regularities valid for other weaves do not apply.

Slight variations can be observed in the rate of wicking for horizontally striped fabrics. The significant influence of weave factor P1 on fabric wicking are not found, and the determination coefficient of dependence (R^2 = 0.001) is low for horizontally striped fabrics.

Fabric weft direction wicking on weave factor *P1* in fabrics woven with evenly distributed floats and horizontally striped weaves is shown in ***Figure 6***. The same trend occurs in the weft direction also. As weave factor *P1* increases, the rate of wicking also rises for evenly distributed floats. The determination coefficient of dependence (R^2 = 0.946) for weave factor *P1* and the fabric wicking is high for evenly distributed floats.

Slight variations can be observed in the rate of wicking for horizontally striped fabrics. The significant influence of

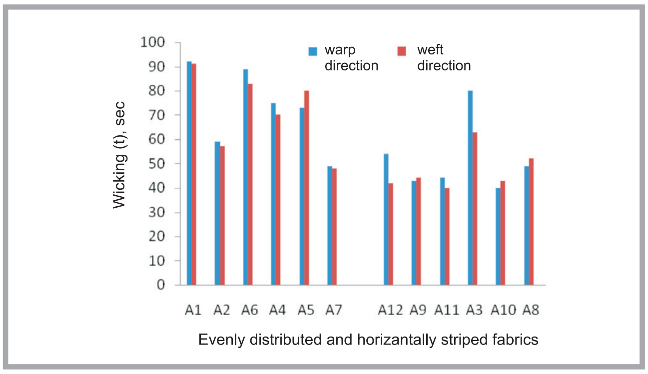

Figure 4. *Effect of the types of fabrics on wicking.*

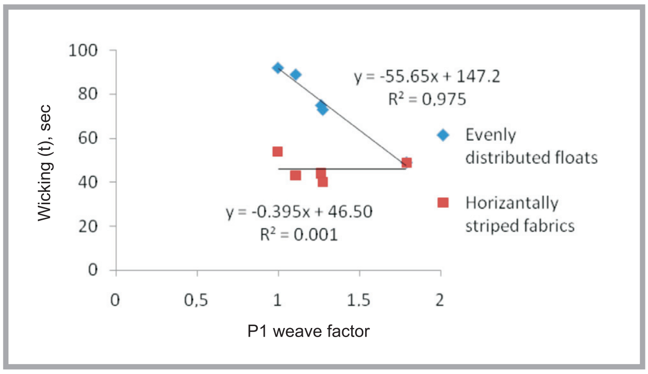

Figure 5. *Effect of weave factor on fabrics wicking (warp direction).*

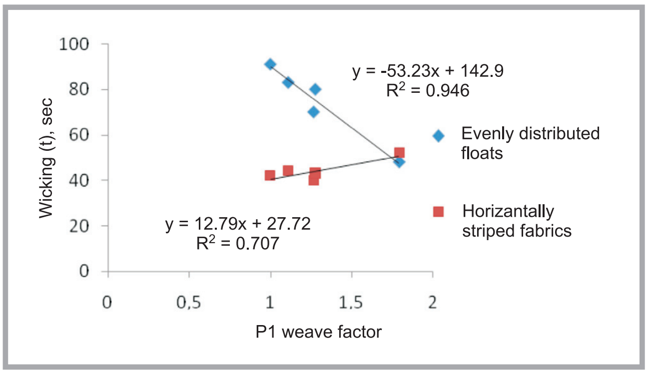

Figure 6. *Effect of weave factor on fabrics wicking (weft direction).*

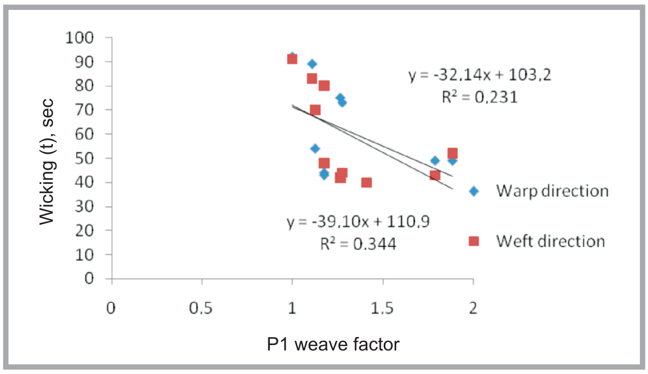

Figure 7. *Overal effect of weave factor on fabrics wicking.*

weave factor *P1* on fabric wicking are not found, and the determination coefficient of dependence ($R^2 = 0.707$) is low for horizontally striped fabrics.

After summarising all the weaves, the overall dependence was established, shown in ***Figure** 7*. In this dependence, the rate of wicking increases as weave factor *P*1 increases. The determination coefficient of dependence is low. Therefore we can assert that, after summarising all the weave points, the relation between fabric wicking and the fabric weave factor *P*1 was not established. The underlying reasons for these results are difficult to explain at this point.

Conclusion

After weaving fabrics on a projectile desk loom from P/V 19.5 tex twisted 65/35 blended yarn in different weaves and conducting vertical wicking on these fabrics, we came to these conclusions:

1. The character of fabric wicking in weaves with evenly distributed floats and horizontally striped weaves is different.
2. The wicking rate of fabrics in weaves with evenly distributed floats is lower than that of fabrics in horizontally striped weaves.
3. As weave factor *P1* increases, the rate of wicking also shows a tendency to rise.
4. A correlation is observed between weave factor *P1* and the rate of wicking for evenly distributed floats in both the warp and weft directions.
5. The influence of weave factor *P1* on the rate of wicking was not established for horizontally striped fabrics for both the warp and weft directions.
6. The overall dependence of fabric wicking on weave factor *P*1 was not established.

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References

1. *Milašius V., Milašius R., Kumpikaitė E., Olšauskienė A.; "Influence of Fabric Structure on Some Technological and End-use Properties"; Fibres & Textiles in Eastern Europe, Vol. 11, No. 2 41), 2003, pp. 48-51.*
2. *Wang F., Xu G., Xu B.; "Predicting the Shearing Rigidity of Woven Fabrics", Textile Research Journal, Vol. 75(1), 2005, pp. 30-34.*
3. *Kumpikaitė E.; "Influence of Fabric Structure on the Character of Fabric", Fibres and Textiles in Eastern Europe, Vol. 16, No. 3(68), 2008, pp. 44-46.*
4. *Milašius A., Milašius V.; "New Representation of Fabric Weave Factor" Fibres and Textiles in Eastern Europe, Vol. 16, No. 4(69), 2008, pp. 48-51.*
5. *Kawase T., Sekoguchi S., Fujii T., Mingawa M.; "Spreading of liquids in textile assemblies", Part II, Textile Research Journal, Vol. 56(10), 1986, pp. 617- 621.*
6. *Perwuelz A., Mondon P., Cazé C.; "Experimental study of capillary flow in yarns", Textile Research Journal, Vol. 70(4) 2000, pp. 333-339.*
7. *Hsieh Y., Yu B.; "Liquid wetting, transport, and retention properties of fibrous assemblies,Part I: Water wetting properties of woven fabrics and their constituent single fibres", Textile Research Journal, Vol. 62(11), 1992, pp. 677- 685.*
8. *Hsieh Y., Yu B.; "Liquid wetting, transport, and retention properties of fibrous assemblies, Part II: Water wetting and retention of 100% and blended woven fabrics", Textile Research Journal, Vol. 62(12), 1992, pp. 697-704.*
9. *Pezron I., Bourgain G., Quéré D.; "Imbition of a fabric", Journal of Colloid Interface Science, Vol. 173, 1995, pp. 319-327.*
10. *Ito H., Muraoka Y.; "Water transport along textile fibres as measured by an electrical capacitance technique", Textile Research Journal, Vol. 63(7), 1993, pp. 414- 420.*
11. *Tagaya H., Haikata J., Nakata K., Nishizawa K.; "Measurement of capillary rise in fabrics by electric capacitance method", Sen-i Gakkaishi, Vol. 47, 1987, pp. 422-430.*
12. *Nath J., Patil P. G., Shukla K.; "Design and development of multipurpose absorption rate meter", Journal of Agricultural Engineering, Vol. 38(2),2001, pp. 34-140.*
13. *Ramesh Babu V., Koushik C. V., Lakshmi Kantha C. B., Subramaniam V. S.; "Capillary rise in woven fabrics by electrical principle", Indian Journal of Fibre and Textile Research, Vol. 36, 2011, pp.99-102.*
14. *Das Brojeswari., Das A., Kothari V K., Fangueiro R., Araujo M.; "Effect of fibre diameter and cross-sectional shape on moisture transmission through fabrics", Fibres Polymers, Vol. 9, No.2, 2008, pp. 225-231.*
15. *Brierley S.; "Cloth Settings Reconsidered", The Textile Manufacturer, Vol. 58, 1953, pp. 534.*
16. *Galuszynski S.; "Fabric Tightness: A Coefficient to Indicate Fabric Structure", The Journal of the Textile Institute Vol. 1, 1981, pp. 44-49.*

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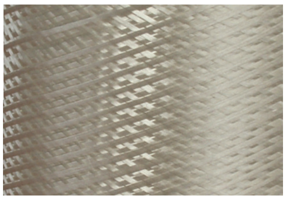

Multifilament chitosan yarn