Indian Journal of Fibre & Textile Research
Vol. 32, September 2007, pp. 373-376

Short communications

Effect of yarn twist on wicking of cotton interlock weft knitted fabric

Azita Asayesh[a] & Mohammad Maroufi

Department of Textile Engineering,
Amirkabir University of Technology, Tehran, Iran

Received 8 February 2006; revised received and accepted 10 October 2006

The effect of yarn twist on the wicking rate of cotton interlock weft knitted fabrics has been studied. It is observed that using the yarn linear density of 30tex, the wicking rate decreases with an increase in the amount of yarn twist. An equation '*h*=c*T*+d' is found to be a good estimate of the maximum wicking height (*h*) for cotton interlock weft knitted fabrics measured over yarn twist (*T*). Also, an equation '$h=at^k+bt$' which is a modified version of Washburn-Laughlin's equation, is a good estimate of wicking height (*h*) for these fabrics measured over time (*t*).

Keywords: Cotton, Weft knitted fabric, Wicking, Yarn twist

IPC Code: Int. Cl.[8] D04B

Clothing has an important role in keeping comfort of body by removing sweat. An ideal clothing will remove the sweat quickly until the skin remains free of sweat. The flow of liquid in fibre assemblies, such as yarn and fabric, happens because of capillary forces.[1] The nature of fibres and the structure of the assemblies determine the speed and amount of liquid transport.[2] The liquid sorption mechanism of a fabric is interpreted as a flow of liquid through a system of capillary channels. For the onset of the flow, the main driving force must come from the intrinsic liquid attraction capacity of the fabric itself. The wicking phenomenon is limited to the systems having an affinity between the liquid and the absorbent.

In the field of liquid sorption in a porous area, Washburn has expressed the following equation:

$$h = c_h \, . \, t^{0.5} \qquad \ldots(1)$$

where h is the wicking height (m); c_h, the capillary liquid transport constant

$$\left[c_h = \left(\frac{r.\gamma.\cos\theta}{2\eta} \right)^{0.5} \right];$$

r, the radius of capillary tube (μm); γ, the surface tension of liquid (N/m); θ, the contact angle between liquid and absorbent solid (deg); η, the viscosity of the liquid (Ns/m^2); and t, the wicking time(s).

Laughlin showed the need of correction in the exponent term in Eq. (1) and many researchers suggested that the exponent should be lower than 0.5. Hence, Laughlin generalized the Washburn's equation into the following form:

$$h = c_h \, . \, t^{k} \qquad \ldots(2)$$

where k may have values lower than 0.5 for different types of fabrics.

Eq. (1) shows that the capillary force causes the progress of liquid through a capillary channel.[3] This capillary force depends on the radius of capillary channel and the contact angle between liquid and capillary channel as well as rheological properties of the liquid. Eq. (1) is used to interpret wicking behaviour of textiles.[4]

Researches showed that the yarn and fabric constructional factors such as yarn linear density, yarn twist and weave construction and also finishing treatments such as scouring, bleaching and mercerization affect the wicking rate of fabric.[3-7] In the present work, the effect of yarn twist on the wicking rate of cotton interlock weft knitted fabrics has been studied.

Ten cotton interlock weft knitted structures were produced using different yarn twists and two loop lengths. These were produced from 18G interlock knitted fabrics from a combed, ring- spun single yarn with similar yarn linear density (30 tex). Fabric characteristics are shown in Table 1. In order to remove waxes and fats from cotton fibres and to improve the wetability of fabrics, the bleaching treatment was done on the fabrics. For full relaxation of fabrics, they were scoured using washing machine and dried using centrifuge. Then the fabrics were laid

[a] To whom all the correspondence should be addressed.
E-mail: a_asayesh@aut.ac.ir

Table 1 — Physical properties of fully relaxed cotton interlock weft knitted fabrics

Fabric code	Yarn twist tpm	Yarn linear density tex	Loop length cm	Courses/cm	Wales/cm	Stitch density Loops/cm^2	Thickness mm (20gf/ cm^2)	Weight g/m^2
1	625	30	0.41	15.7	11.4	179	1.28	326
2	675	30	0.41	16.9	11.4	192.7	1.35	353
3	715	30	0.41	17.7	11.4	201.8	1.44	374
4	755	30	0.41	17.7	11.8	201.8	1.57	417
5	875	30	0.41	19.7	11	216.7	1.60	437
6	625	30	0.44	16.1	10.6	170.7	1.48	331
7	675	30	0.44	17.3	10.6	170.7	1.67	381
8	715	30	0.44	16.5	11	181.5	1.53	355
9	755	30	0.44	16.9	11.4	192.7	1.67	397
10	875	30	0.44	16.9	11	185.9	1.74	386

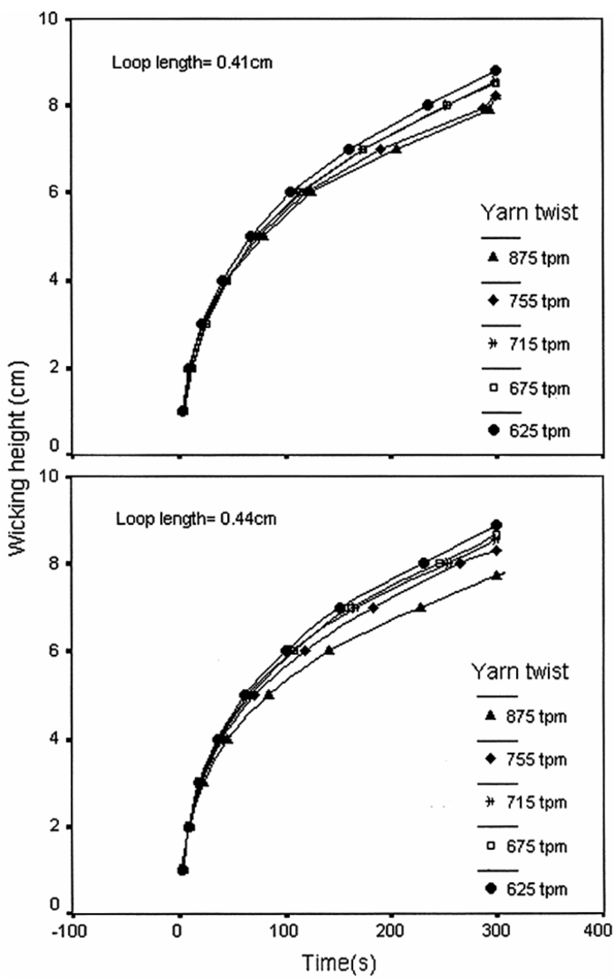

Fig. 1 — Wicking height versus time for different yarn twists of fully relaxed cotton interlock weft knitted fabric

on a flat horizontal surface until dried and their wrinkles were removed without stretching.

After full relaxation, the wicking rate of the samples was measured using strip test. For this purpose, strips (20×150mm) parallel to the wale direction were cut from each sample. Strips were marked along their length at intervals of 10mm using a pen to make the measurement of the movement of water through the fabric easier. In order to make sure that the lower edge of the fabric strip was in contact with water, a weight of 2.7g was mounted on the lower edge of the strip. Then the strip was hung vertically with the lower edge of it (5 mm) dipped in the water. The time that water wicked through the fabric strip was recorded for marked intervals. The duration of each experiment was 5 min. The experiment was performed under laboratory conditions (24°C, 42% RH) using distilled water.

The effect of yarn twist on the wicking rate of fully relaxed cotton interlock weft knitted fabrics is shown in Fig. 1. The amount of yarn twist affects the wicking rate of cotton interlock weft knitted fabrics and by increasing the amount of yarn twist, the wicking rate decreases. The decrease in wicking rate can be attributed to decrease in size of capillary channels between fibres as a result of increasing yarn twist.

The wicking of a liquid in a porous area depends highly on the geometrical factors of the media such as capillary radius and the twist of the media. By

Table 2 — Correlation of wicking height (h) with time (t) according to Model C(h=at^k) and Model D(h=at^k+bt)

Fabric code	Coefficients of Model C			Coefficients of Model D			
	a	k	R^2	a	k	b	R^2
1	0.819	0.419	0.99452	0.607	0.547	-1.68×10^{-2}	0.99909
2	0.746	0.431	0.99198	0.500	0.607	-2.51×10^{-2}	0.99897
3	0.764	0.427	0.99351	0.541	0.576	-1.98×10^{-2}	0.99897
4	0.865	0.397	0.99260	0.622	0.534	-1.65×10^{-2}	0.99863
5	0.857	0.396	0.99345	0.657	0.505	-1.23×10^{-2}	0.99740
6	0.924	0.399	0.99398	0.713	0.509	-1.42×10^{-2}	0.99848
7	0.888	0.402	0.99479	0.678	0.515	-1.41×10^{-2}	0.99914
8	0.940	0.389	0.99367	0.713	0.506	-1.45×10^{-2}	0.99878
9	0.891	0.395	0.99482	0.681	0.507	-1.33×10^{-2}	0.99913
10	0.866	0.387	0.99199	0.653	0.506	-1.37×10^{-2}	0.99783

R^2 — Coefficient of determination; and a,k and b— Constants.

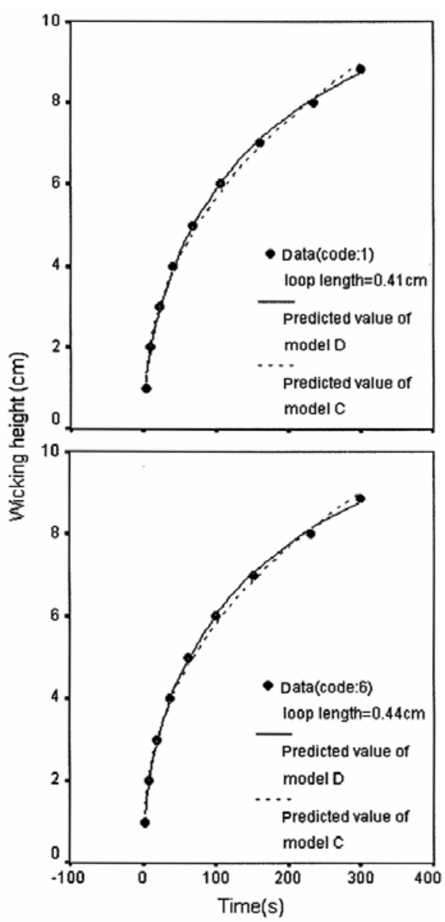

Fig. 2 — Comparison of Washburn-Laughlin equation (Model C) with modified equation (Model D) for wicking height

Table 3 — Comparison of maximum wicking height in cotton interlock weft knitted fabrics with mathematical models

Fabric code	Maximum wicking height, cm			
	Actual	Estimated (Model C)	Estimated (Model D)	Estimated (Model h=cT+d)
1	8.82	8.97	8.73	8.71
2	8.53	8.73	8.44	8.60
3	8.55	8.71	8.46	8.50
4	8.23	8.31	8.11	8.41
5	8.23	8.19	8.04	8.14
6	8.87	9.03	8.77	8.90
7	8.65	8.80	8.57	8.66
8	8.55	8.69	8.45	8.48
9	8.28	8.45	8.25	8.29
10	7.72	7.88	7.63	7.74

increasing the yarn twist, the radius of capillary channels and their continuity decrease.[3,4,6]

In order to find a mathematical model to express the relationship between wicking height (h) and time (t), the statistical software (spss) was used. Tables 2 and 3 and Fig. 2 show that an equation (h=at^k+bt) (Model D), which is a modified version of Washburn-Laughlin's equation (h=at^k) (Model C) is a better

Table 4 — Correlation of maximum wicking height with yarn twist according to Model h=cT+d

Loop length cm	c	d	R^2
0.41	-2.28×10^{-3}	10.137	0.75653
0.44	-4.64×10^{-3}	11.801	0.99179

c and d — Constants.

estimate of wicking height for cotton interlock weft knitted fabrics measured over time.

Also, using spss, it is found that an equation of the form $h = cT + d$ is a good estimate of the maximum wicking height (h) for cotton interlock weft knitted fabrics measured over yarn twist (T). The values of R^2 (coefficient of determination) in Table 4 and maximum wicking height in Table 3 confirm the above findings.

It has been found that by increasing the amount of yarn twist, the wicking rate decreases. This may be attributed to the decrease in the size of capillary channels between fibres as a result of increasing yarn twist. An equation of the form (h=cT+d) is a good estimate of the maximum wicking height (h) for cotton interlock weft knitted fabrics measured over yarn twist (T). Also, it has been found that an equation of the form ($h=at^k+bt$), which is a modified version of Washburn-Laughlin's equation, is a good estimate of wicking height (h) for these fabrics measured over time (t).

References

1 Kissa E, *Text Res J*, 66(10) (1996) 660.

2 Ansari N & Haghighat Kish M, *J Text Inst*, 91(3) (2000) 410.

3 Maroufi M, *An investigation into some physiological properties of cotton interlok weft knitted fabrics*, Ph.D. thesis, Leeds Universitey, UK, 1997.

4 Ansari N, *The effect of the structure of fibrous assemblies on wicking*, Ph.D thesis, Textile Engineering Department, Amirkabir University of Technology, Iran, 2000.

5 *Mehta P, Wool Science Review 60* (International Wool Secretariat, Technical Center, UK), 1992, 23.

6 Hollies N R S, Kaessinger M M & Bogaty H, *Text Res J*, 26 (11) (1956) 829.

7 Hsieh Y L, Thompson J & Miller A, *Text Res J*, 66 (7) (1996) 456.