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Wicking dynamics of single jersey knits produced with cotton–polyester core-spun yarns: part I

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This research investigates the effects of core–sheath ratio, yarn twist, and loop length on the wicking performance of single jersey knitted fabrics manufactured from cotton–polyester core-spun yarns with compositions of 100:0, 80:20, and 60:40. A Box–Behnken experimental design combined with linear regression analysis was employed to evaluate the influence of these parameters. The results demonstrate that all three variables significantly affect the wicking behavior of the fabrics. Wicking rates were consistently higher in the wale-wise direction than in the course-wise direction. Increased polyester content in the yarn core resulted in reduced wickability, while higher twist levels similarly led to a decline in wicking rate. The use of cotton–polyester core-spun yarns, which enable a functional separation of hydrophilic (cotton sheath) and hydrophobic (polyester core) components within a single yarn, allowing more precise control and analysis of wicking behavior than conventional blended yarns.

Keywords: Box- behnken design, Core-spun yarn, Cotton, Linear regression, Polyester, Vertical wicking.

1 Introduction

The ability to sustain capillary flow is described as wickability, while the initial behaviour of the fabric, yarn and the fibre is referred to as wettability, and also can be defined as the interaction between the substrate and the liquid before wicking takes place. Thus, the prerequisite of wicking can be expressed as wetting. Wetting is a dynamic process and is the displacement of a vapour interface with a solid liquid interface[1].

Wetting and wicking are the two processes that control the liquid moisture flow through textile materials which can be controlled by the solid and liquid surface energies. In the case scenario of textile material, as water wets the fibre, the water flows through the inter-fibre capillary channel and is forcibly dragged along by the capillary pressure's action.

The critical aspects to assess the comfort performance of textile products are wicking, wetting and moisture vapour transmission properties. In high-wicking properties of clothing, moisture produced from the skin is outspread throughout the fabric to offer a dry feeling. The dispersion of the liquid assists moisture to evaporate easily[2].

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Textile materials are hierarchical porous media. Fabric is the composition of parallel-running yarns. The fibres or filaments oriented along the yarn axis make up the yarns. The effect of capillary rise between yarns within a fabric and between fibres within a yarn constituting the fabric can be considered capillary rise in fabric. The formation of capillary between yarns is termed a macro capillary and the formation of capillary between fibres in yarn is termed as micro capillary. Using the Lucas-Washburn equation, micro capillary, macro capillary, and tortuosity were evaluated for theoretical calculation of capillary rise[3].

The quality of the capillary channels in the inter-fibre spaces and the size of the pores present are greatly influenced by the fibre length, width, shape and alignment. The density and structure of yarns can greatly exert influence on the dimensions and structure of inter-fibre and intra-yarn pore sizes. The distribution is determined by how fibres are assembled into the nonwoven, woven or knitted structure. In larger pores, larger liquid mass can be retained, but the liquid advancement's distance is limited. Fast liquid spreading in fibrous materials is facilitated with small, uniformly distributed and interconnected pores, whereas high liquid retention can be achieved by having a large number of such pores or a high total volume so in fibrous structures, the sizes and shapes of the fibres as well as their alignment influence the wickability[4].

Maximum wickability in satin weave fabrics was due to more number of floats in construction due to their high thickness value, this provides more space to accommodate water, which leads to more water transfer depending on the capillary space availability. Increased values of fabric thickness will affect the capillary action, reduce the liquid pressure and hence, the reduction of final wicking heights in blended knitted fabrics. The increase of GSM resulted in hindering the moisture transmission and decreased the wicking distances. The initial rate of liquid transmission increased due to less resistance posed by occupying air, which increases at a later stage when moisture enters and saturates the fabric. Wale-wise wicking lengths were higher than course-wise lengths[5-6].

An inverse correlation exists between pore size and wicking height. The WER (water evaporation rate) is indicated to be inversely related to the fabric thickness through the results of statistical analysis. Wickability was significantly affected by knitted structure because all tightly constructed fabrics have larger contact angles than loose forms because the surface is more compact. Jhanji et al. investigated that an increase in inner and outer layer yarn linear density of plated knitted fabrics increases wetting time and decreases absorption rate and spreading speed. Transplanted wicking increased in finer count yarns used for inner and outer layers of plated knitted fabrics. Horizontal wicking rate increased in the outer layer of plated knitted fabrics. Wicking and moisture management properties were improved by using finer yarns for the inner layer and course counts for the outer layer[7].

Due to the increase in porosity, the capillary height of the twill fabrics was comparatively higher than that of the plain fabrics. It was also found that weft density was inversely proportional to capillary height. The capillary height, capillary time of fabrics weft density, and weave type were affected by raw material. Comfort qualities of knitted fabric are influenced by their fabric structures, which include interlock, rib, and single jersey. The main reason for this is that the density, loop length, porosity, tightness factor, and porosity of the cloth vary depending on the knitted structure. Pore size and distribution have a tight relationship with liquid absorption. The capillary principle states that smaller pores are filled first and have an impact on the liquid front movement. The liquid flows to the larger holes once the smaller ones are filled. Alterations in routes and disruptions in the fabric's pores had an impact on the vertical wicking qualities, while the absorption and wicking properties were found to be closely correlated with the materials' porosity[8-12].

2 Materials and Method

2.1 Fibres

In this study, MCU 5 cotton fibers with 31mm fiber length, 4.1 µg/in fiber fineness, 22.5 g/tex fiber strength, linear density of 0.17 tex, 8.5% moisture regain, and 6% elongation were used in the sheath (cotton staple fibers). Polyester monofilaments with 50 and 65 deniers were used for the core-yarn spinning process. 100% cotton ring spun and Cotton/polyester core spun yarns with core sheath proportions of 80:20, and 60:40 were created by altering the yarn twist levels. Single jersey knitted fabrics were created by altering the loop length (loose, medium, and tight) in the fabric structures and tested for wicking performance.

2.2 Spinning

The yarn production process begins with fiber mixing, lap production, carding, drawing, rove preparation, and ring spinning. The goal of this study is to optimize and generate three different yarns (100% cotton, 80:20, and 60:40 cotton: polyester core-spun yarns) with a linear density of 14.76 tex by adjusting three twist levels (940, 1020, and 1100 tpm). A ring frame machine was used to produce 100% cotton yarns, as well as core-spun yarns. A Trytex Core Lycra ring frame with a core spin attachment mounted above the drafting unit was employed. In the core spin attachment, a 50 denier polyester monofilament was passed through the front drafting roller to produce 80:20 ratio and 65 denier polyester monofilament was used for 60:40 core spun yarn.

2.3 Knitting

The Box-Behnken design tool was utilized in this investigation. The study's input parameters were cotton and polyester core-sheath ratios (100% cotton, 80:20, and 60:40), twists per metre (940, 1020, and 1100), and loop length (2.5, 2.7, 2.9 mm). Total of 15 fabric combinations were produced to carry out the study.

The materials were knitted using a smart knitting machine with the following specifications: gauge- 32 inches, 24-inch diameter, 4 feeders per inch, 35 rpm speed, and 1800 needles. Single jersey knitted fabric samples were treated to the dry, wet, and full relaxation procedures as specified by the 'Starfish' recommendations. After scouring, the materials were conditioned at 27ºC ± 2 ºC and 65% ± 2% relative humidity for testing.

2.4 Wicking behaviour

The samples' vertical wicking behaviour was evaluated using a vertical wicking tester in line with DIN 53924 norms. Five 12 x 1-inch samples were cut along the course and wale direction and marked with a pen at regular intervals of 0.5cm to measure the height of water flowing over the fabric. The fabric strip was then suspended vertically from the metal stand's top. The screw beneath the beaker was adjusted and raised upwards, and as the fabric came into touch with the distilled water, the height of water travelled along the cloth was measured along the fabrics were recorded every 1 min, 2 min, 3 min, 4 min up to 10 min respectively.

2.5 Data Analysis

There were fifteen single jersey knitted fabrics created using Design Expert software. Box - Behnken, a three-level factorial design with three variables techniques has been utilized in research the study the interactive influence of several variables on the vertical wicking behaviour of knitted fabrics. The relationship between height and time was computed using linear regression analysis. A linear regression is the relationships between the independent variable and dependent variable can be described with a straight line. A linear regression line has the following equation:

$$Y = a + bX \qquad \dots (3.3)$$

Where X represents the explanatory variable and Y represents the dependent variable. The line's slope is b, and the intercept (the value of y when x = 0) is a.

3 Results and Discussion

3.1 Wicking behaviour

The wicking behaviour of 100% cotton and cotton–polyester core-spun single jersey knitted fabrics (80:20 and 60:40) was evaluated in both wale-wise and course-wise directions. Linear regression analysis was performed by correlating wicking time with the square of wicking height, and the slope, intercept and correlation coefficient values were determined (Figs 1–6). In all cases, a better linear relationship was observed between the square of wicking height and time than between height and time, confirming the applicability of the Washburn capillary model for vertical wicking in knitted fabrics.

For 100% cotton fabrics, higher wicking rates were observed compared to core-spun fabrics. This may be attributed to the hydrophilic nature of cotton fibres and the presence of well-developed capillary channels within the yarn and fabric structure. The wicking behaviour was significantly influenced by structural parameters such as twist per metre (TPM) and loop length. Fabrics produced from low-twist yarns and having longer loop lengths exhibited higher wicking rates due to reduced compactness, lower tightness factor and increased porosity[13].

In the case of 80:20 cotton–polyester core-spun knitted fabrics (Figs 3 and 4), a reduction in wicking rate was observed with an increase in polyester

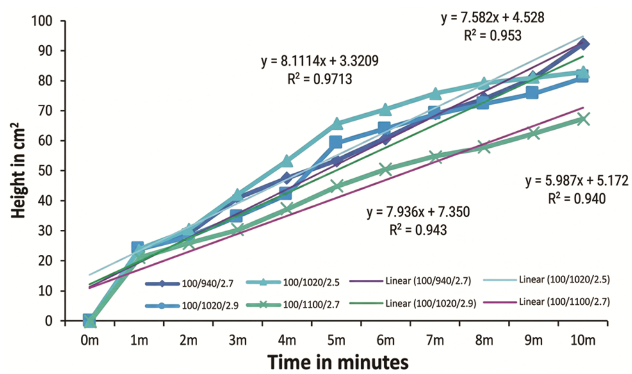

Fig. 1 — Wicking behaviour of 100% cotton knitted fabrics in a wales-wise direction (Square of height and Time)

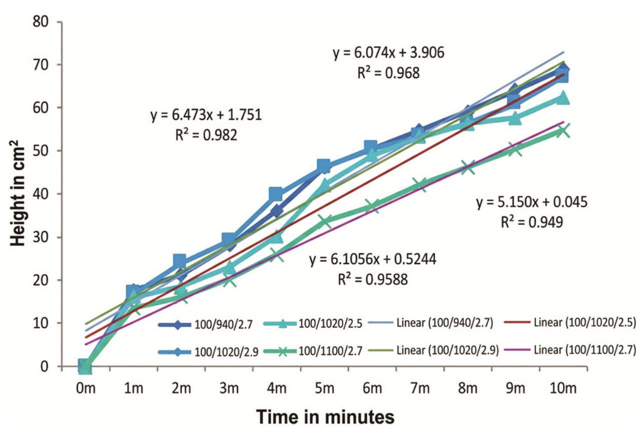

Fig. 2 — Wicking of 100% cotton knitted fabrics in a course-wise direction (Square of height and Time)

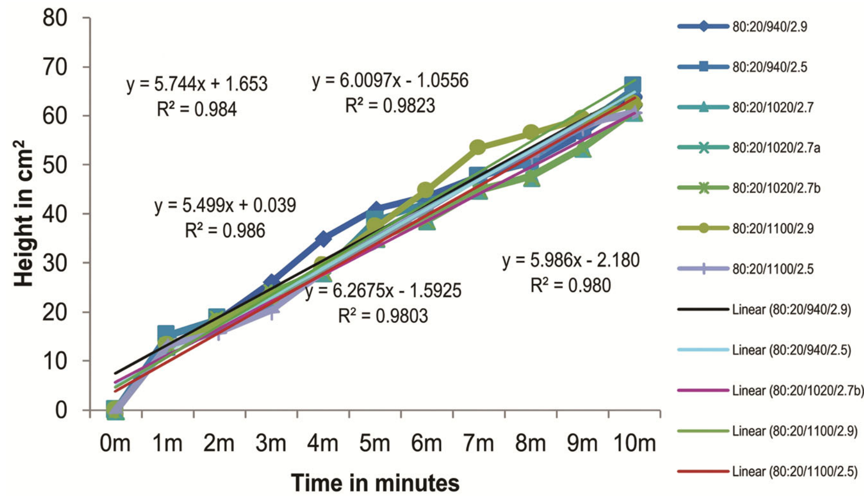

Fig. 3 — Wicking of 80:20 cotton: polyester core-spun knitted fabrics in a wales-wise direction (Square of height and Time)

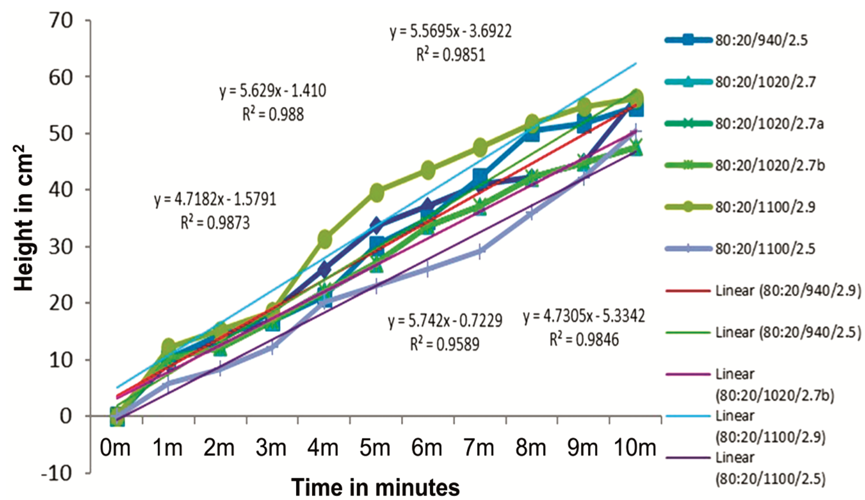

Fig. 4 — Wicking of 80:20 cotton: polyester core-spun knitted fabrics in course-wise direction (Square of height and Time)

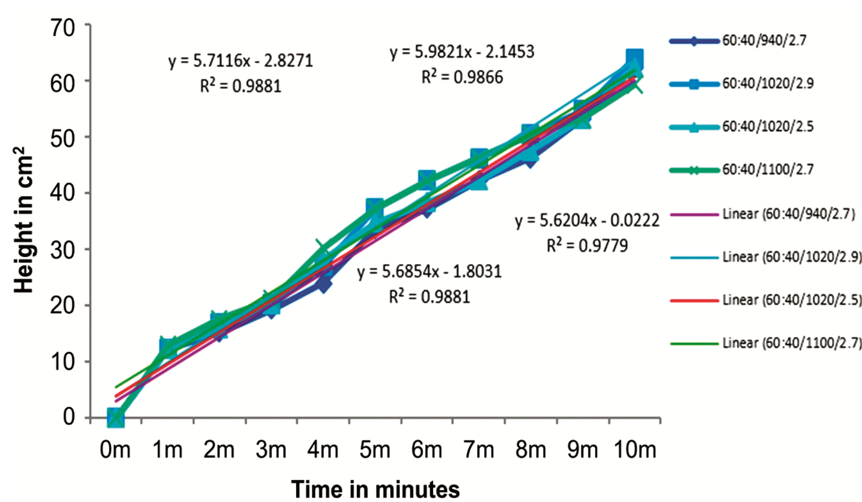

Fig. 5 — Wicking of 60:40 cotton: polyester core-spun knitted fabrics in wales-wise direction (square of height and Time)

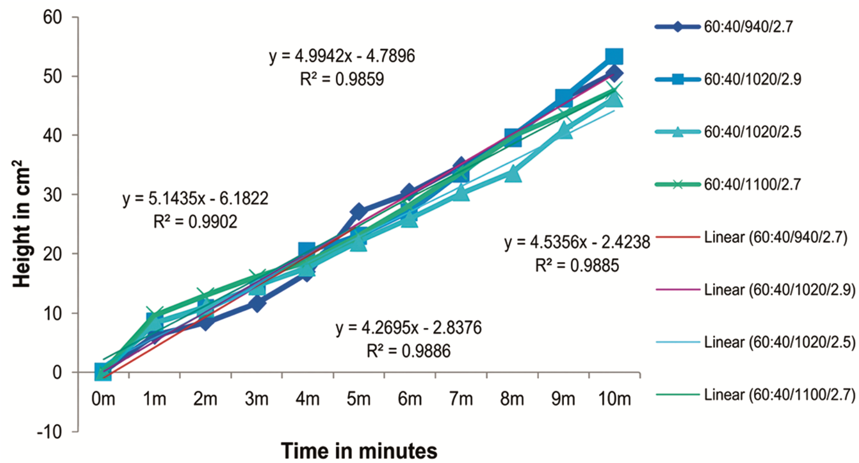

Fig. 6 — Wicking of 60:40 cotton: polyester core-spun knitted fabrics in course-wise direction (square of height and Time)

content. Although polyester contributes to strength and dimensional stability, its hydrophobic nature reduces the overall liquid transport capability of the yarn. However, the influence of structural parameters remained consistent with that of 100% cotton fabrics. Low-twist yarns and loosely structured fabrics showed comparatively higher wickability, indicating that fabric geometry plays a dominant role alongside fibre composition[14].

For 60:40 cotton–polyester core-spun knitted fabrics (Figs 5 and 6), the decrease in cotton content further reduced the wicking performance. Higher slope and intercept values were obtained for the square height–time relationship, indicating improved linearity of regression analysis. The wickability was found to depend on fibre characteristics, yarn structure and fabric structural parameters. Fabrics with lower porosity and tighter structures exhibited slower vertical wicking due to restricted capillary pathways. Among the 60:40 samples, fabrics produced with medium twist and relatively loose structures demonstrated higher wicking heights, suggesting an optimum balance between yarn compactness and capillary continuity[15-18].

Overall, the results indicate that both fibre composition and structural parameters significantly influence the wicking behaviour of single jersey knitted fabrics. While increasing polyester content reduces wickability due to its hydrophobic nature, structural modifications such as reduced twist and increased loop length can partially compensate by enhancing fabric porosity and capillary action in both wale-wise and course-wise directions

3.2 Wicking behaviour of knitted fabrics using slope values

The participatory effects of the core ratio, TPM and the length of the loop on the wicking behaviour of knitted single jersey fabrics were derived at wale-wise and course-wise directions using slope values (Table 1). The experimental and interactive studies were carried out using "Design Expert" software. These variables' effect and response surface equations were determined. The ANOVA quadric model was employed for statistical analysis, and the findings are given in Table 2, indicating statistical significance with a high F-value and low p-values.

The statistical validation of the developed quadratic models is presented in Tables 2–4. Analysis of variance (ANOVA) revealed that the models are

Table 1 — Box – Behnken Design using slope values

S. No	Sample Code	Slope(cm^2/min)	
		Wale	Course
1	100C-940-2.7	8.111	6.473
2	100C-1020-2.9	7.936	6.074
3	100C-1020-2.5	7.582	6.105
4	100C-1100-2.7	5.987	5.150
5	80C:20P-940-2.9	5.744	5.629
6	80C:20P-940-2.5	6.009	5.569
7	80C:20P-1020-2.7	5.499	4.718
8	80C:20P-1020-2.7	5.499	4.718
9	80C:20P-1020-2.7	5.499	4.718
10	80C:20P-1100-2.9	6.267	4.742
11	80C:20P-1100-2.5	5.986	4.730
12	60:40/940/2.7	5.711	5.143
13	60:40/1020/2.9	5.982	4.994
14	60:40/1020/2.5	5.685	4.269
15	60:40/1100/2.7	5.620	4.535

Table 2 — Analysis of variance

	Degrees of freedom	F-value	*p*-value	TER 1	Remarks
Wale wise	9	19.96	0.0021	TER 2	Significant
Courses	9	256.12	< 0.0001	TER 3	Significant

statistically significant, as indicated by high F-values and low p-values. Furthermore, the adequate precision ratios (13.3413 and 50.670), being substantially higher than the desirable value of 4, indicate an adequate signal-to-noise ratio and validate the suitability of the developed response surface models for predicting the influence of core ratio, twist per metre and loop length on the wicking behaviour of single jersey knitted fabrics.

The response surface equation obtained for the wicking behaviour of cotton: polyester core-spun knitted fabrics in the wale-wise direction is as follows:

Table 3 — Fit Statistics in wale-wise direction

Std. Dev.	0.2005	R^2	0.9729
Mean	6.02	Adjusted R^2	0.9242
C.V.%	3.33	Predicted R^2	0.8667
	CHEPTER	Adeq Precision	13.3413

Table 4 — Fit Statistics in course-wise direction

Std. Dev.	0.0454	R^2	0.9978
Mean	5.27	Adjusted R^2	0.9939
C.V.%	0.8605	Predicted R^2	0.9654
		Adeq Precision	50.6708

$$5.73-0.8058*A-0.2861*B-0.0384*C+0.1990*AB-0.0135*AC-0.0263*BC+0.5624*A^2-0.0454*B^2+0.0271*C^2$$

The response surface equation obtained for the wicking behaviour of cotton: polyester core-spun knitted fabrics in the course -wise direction is as follows:

$$5.31-0.7316*A-0.1758*B-0.0616*C-0.1990*AB+0.0073*AC+0.0095*BC-0.1644*A^2+0.0204*B^2+0.0706*C^2$$

Figures 7 and 8 show the interactive effects of core-sheath ratio, twists per meter (TPM), and loop length on the wicking behaviour of cotton–polyester core-spun knitted fabrics in both wale-wise and course-wise directions. Loosely structured fabrics with low twist and 100% cotton cores exhibited the highest wicking slope values, followed by 80:20 and 60:40 cotton: polyester core-spun fabrics. The results indicate that increasing the polyester content reduces the wicking rate. Loosely structured fabrics absorbed water more rapidly and allowed greater spreading compared to highly twisted and compact fabrics, consistent with previous studies[19–25].

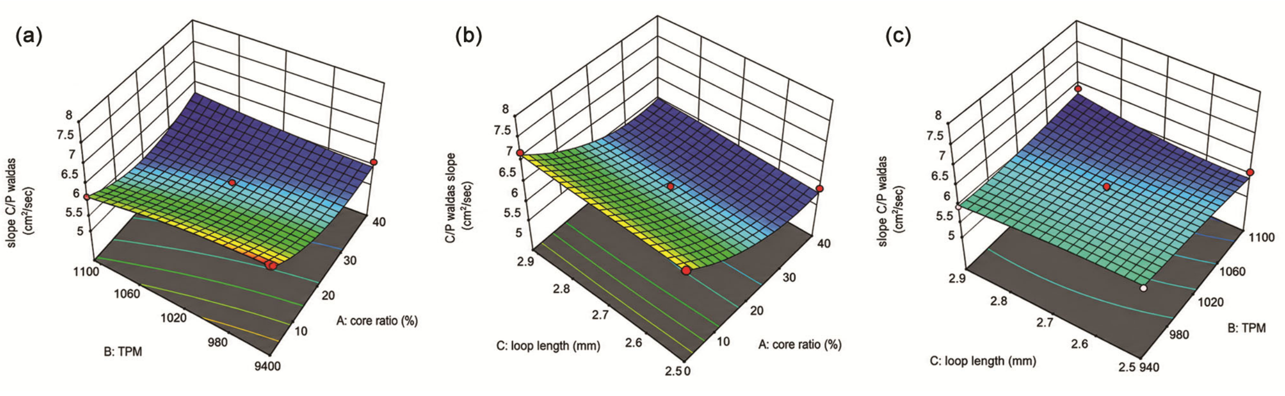

Fig. 7 — Wicking behaviour of jersey structures at wale-wise direction.

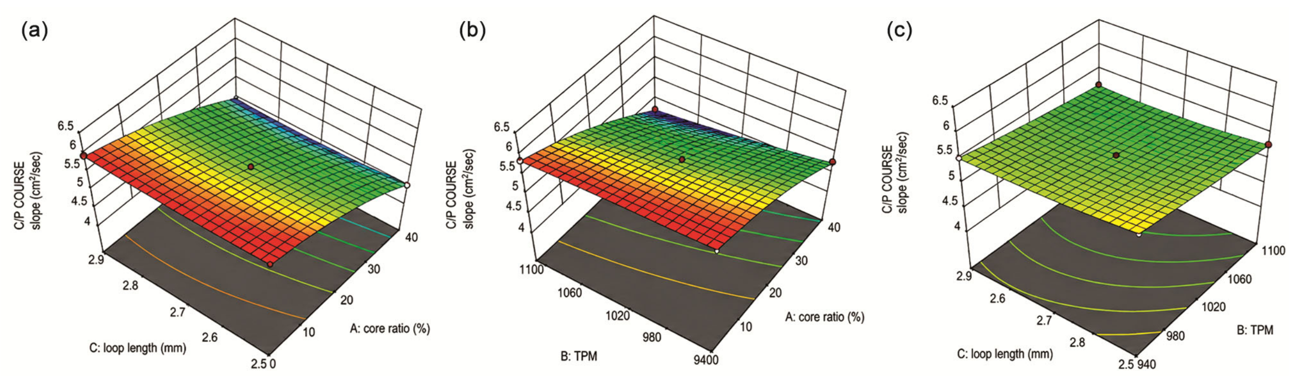

Fig. 8 — Wicking behaviour of jersey structures at the course-wise direction

4 Conclusion

From this study, it was further observed that the wicking rate is higher in the wale-wise direction compared to the course-wise direction, which can be attributed to the more effective capillary action along the wales. A strong linear relationship was found between the square of wicking height and time, indicating that water absorption follows a predictable capillary flow behaviour. The wicking rate decreased with increasing polyester content in the blend. Similarly, as the yarn twist increased and the loop length became longer, the wicking rate declined, although the overall trend of wicking remained consistent in both wale-wise and course-wise directions.

Among the cotton–polyester core-spun knitted fabrics, 100% cotton fabrics exhibited the highest wicking values, followed by 80:20 and 60:40 cotton: polyester fabrics.

Overall, these results highlight that fabric structure, yarn composition, and knitting parameters such as twist and loop length significantly influence the capillary-driven transport of water. Loose and low-twist structures facilitate rapid absorption and spreading, while higher polyester content and tighter structures impede wicking. These findings provide critical insights for designing cotton–polyester core-spun knitted fabrics with optimized moisture management properties.

References

1 Fangueiro R, Filgueiras A, Soutinho F & Meidi X, *Text Res J*, 80 (2010) 1522.
2 Pan N & Gibson P, *Thermal and Moisture Transport in Fibrous Materials* (Woodhead Publishing, New York), 2006, 126.
3 Chatterjee A & Singh P, *J Textiles*, 4 (2014) 1.
4 Duru S C & Candan C, *Textile Apparel*, 26 (2016) 280.
5 ParveenBanu K & Manokari S L, *Int J Sci Res*, 3 (2014) 1147.
6 Bajaj S & Bains S, *J Text Apparel Technol Manage*, 2018, 126.
7 Yanılmaz M & Kalaoğlu F, *Text Res J*, 82 (2012) 820.
8 Jhanji Y, Gupta D & Kothari V K, *Indian J Fibre Text Res*, 42 (2017) 183.
9 Atasağun H G, Okur A Y Ş E, Akkan T & Akkan L Ö, *J Text Inst*, 107 (2016) 1483.
10 Benltoufa S, Fayala F, Cheikhrouhou M & Nasrallah S B, *AUTEX Res J*, 7 (2007) 63.
11 Wong K K, Tao X M, Yuen C W M & Yeung K W, *Text Res J*, 71 (2001) 49.
12 Saricam C, *J Eng Fib Fabr*, 10 (2015) 1.
13 Fan J & Hunter L, *Engineering Apparel Fabrics and Garments* (Woodhead Publishing Ltd, New York), 2009, 230.
14 Sitotaw D B, *J Text Apparel Technol Manage*, 10 (2016) 1.
15 Havlová M & Špánková J, *Fibres Text East Eur*, 25 (2017) 86.
16 Bhattacharya S S & Ajmeri J R, *Int J Eng Res Dev*, 10 (2014) 16.
17 Mallick P & De S S, *J Nat Fibres*, 2021, 1.
18 Chu C, Hu C, Sun Y, Yan H, Zhang Y & Ning F, *J Eng Fib Fabr*, 16 (2021) 1.
19 Kumar R K & Chinnammal S K, *Int J Innov Technol Explor Eng*, 9 (2019) 3864.
20 Das A & Ishtiaque S M, *J Text Apparel Technol Manage*, 3 (2004) 1.
21 Wang Y, Qiao Q, Ding Z & Sun F, *e-Polymers*, 21 (2021) 263.
22 Zhu G, Militky J, Wang Y, Sundarlal B V & Kremenakova D, *Fibres Text East Eur*, 23 (2015) 137.
23 Raja D, Koushik C V, Ramakrishnan G & Babu V R, *Fibres Text East Eur*, 20 (2012) 72.
24 Kumar B & Das A, *Fibers Polym*, 15 (2014) 625.
25 Bivainyte A & Mikucioniene D, *Fibres Text East Eur*, 19 (2011) 64