Indian Journal of Fibre & Textile Research
Vol. 46, March 2021, pp. 48-51

Moisture management properties of ring vis a vis rotor yarn plated knit structures

Y Jhanji[1,a], Deepti Gupta[2] & V K Kothari [2]

[1]Department of Fashion & Apparel Engineering, The Technological Institute of Textiles & Sciences, Bhiwani 127 021, India
[2]Department of Textile Technology, Indian Institute of Technology Delhi, New Delhi 110 016, India

Received 11 June 2019; revised received and accepted 31 March 2020

The present investigation aims at studying the moisture management properties of polyester-cotton plated fabrics of ring vis a vis rotor yarns. Ring yarn fabrics exhibit higher moisture vapour transmission rate, trans planar wicking, lower wetting time and higher one way transport capacity as compared to rotor yarn fabrics, making the former suitable where body needs to dissipate sweat both in vapour and liquid forms, with respect to fabrics using combination of rotor-spun cotton yarns, which show higher absorbent capacity and would be slow drying with poor one way transport capacity. The study helps us to conclude that yarn spinning system plays an important role in influencing moisture management properties of fabrics intended for next to skin applications.

Keywords: Cotton, Fabric comfort, Moisture management, Plated fabric, Polyester, Ring yarn, Rotor yarn

1 Introduction

Clothing serves as a second skin enabling heat and mass transmission from human body to environment or vice-versa. Thermo-physiological properties of textiles are related to the thermal properties, air permeability and moisture management properties along with the drying ability of the textiles. Several fibre, yarn and fabric constructional variables determine the moisture management properties of textiles. Plated knit structures are characterized by distinct yet integrated inner and outer layers.

The flexibility in selection of contrastingly different fibre and yarn constituents in the two layers of plated fabrics make them suitable and versatile for applications, like intimate wears, sportswear, active wear, etc. The main elements of two-layered plated knitted structures are:

- Inner (next to skin) layer — This layer is in direct skin contact and consists of conductive and diffusive hydrophobic component which helps in removal and transportation of sweat to the outer layer.
- Outer (exposed to environment) layer — This layer is in contact with the environment and consists of absorptive hydrophilic components which provide large area for sweat absorption and evaporation to the outside environment[1-3].

[a]Corresponding author.
E-mail: yjhanji@gmail.com

Fibre parameters, process parameters and yarn production technologies are reported to change the yarn structure and the associated fabric properties. Ring- spun and rotor-spun yarns vary widely in their structures which contribute to the entirely different properties of the two yarns. Ring-spun yarn has an ideal cylindrical helical structure with same number of turns per unit length in each helix, uniform specific volume and maximum packing density in the outermost zone of the yarn cross-section. Rotor-spun yarn has a bipartite structure with an inner core which forms the bulk of the yarn and an outer zone of wrapper fibres occurring irregularly along the core length. Rotor yarn shows maximum packing density in first zone from core. Core part of rotor yarn relatively has dense structure; sheath part has less dense structure with belly-bands[4-6].

Several researchers have studied the influence of various yarn variables like yarn types, yarn spinning systems and fibre variables like fibre fineness, fibre cross-sectional shapes on comfort properties of woven and knitted fabrics. Behera *et al*[7]. compared the comfort properties of ring-, rotor- and friction-spun yarn fabrics and suggested that rotor-spun yarn would be superior to ring-spun yarns in the absence of perspiration.

Lord[8] investigated the relative moisture uptake characteristics of ring and open-end yarns and reported that open end yarn wicked better and more evenly but for a given yarn count, it is elevated to the same volume of water as ring yarn. Erdumlu and Saricam[9] studied the wicking and drying properties of vortex spun yarns and knitted fabrics in comparison with ring-spun yarns and fabrics, and concluded that fabrics knitted from ring-spun yarns wicked and absorbed water more evenly than fabrics knitted from vortex spun yarns.

Manshahia and Das10 studied the effect of filament shape factor of inner and outer side of fabric on moisture management properties and concluded that the fabric, having filament of higher shape factor, exhibited better moisture management properties, viz larger wetting radius, higher one way transport capacity and quick absorption rate.

Smita *et al.*[11]. investigated the effect of fibre composition on moisture management properties and peak heat flux (qmax) values of 100% polyester, 100% cotton, 100% modal, and cotton-polyester, modal-polyester blended fabrics. They observed that blending polyester fibre with cotton and modal resulted in improved moisture management properties of the fabrics in comparison to 100% polyester fabric.

Suganthi and Senthilkumar[12] studied the moisture management properties of bi layered knitted fabrics composed of varying fibre types in the inner and outer layers. They observed that the fabric composed of micro-fibre polyester in inner layer and modal in outer layer are suitable as active sportswear, owing to better moisture management property exhibited by the aforesaid fabrics in terms of high wetting radius, absorption rate and spreading speed.

However, literature survey shows that there is lack of systematic study on the influence of yarn spinning systems on thermo-physiological properties of plated knit structures. Yarns made on different spinning systems vary in their structure and packing, which may influence moisture vapour and liquid moisture transmission through fabrics. Therefore, the selected variable is crucial in influencing moisture management properties of fabrics. The present work, therefore, aims at studying the moisture management properties of ring vis a vis rotor yarn plated knit structures.

2 Materials and Methods

2.1 Materials

Cotton and polyester fibres were used for the production of the yarn samples. Cotton carded roving of 0.9 hank was used to spin 24 Ne single ring-spun yarn on blow room. Cotton carded sliver of 0.12 hank was used for the production of 24 Ne single rotor yarn on Trytex rotor spinning machine. Polyester fibre of 1.1 & 3.3 decitex and with circular profile was used to spin 24Ne single ring- spun polyester yarns on 6/S LMW pilot plant ring frame. The three yarn samples in totality were used for the preparation of four single jersey plated fabrics. All the samples were prepared in plating relationship with ring and rotor cotton yarn in the outer and polyester fibres in the inner layer. The fabric samples were prepared on hand operated flatbed knitting machine (Elex, China) with machine gauge of 14, needle bed of 42 inches and 588 needles in each bed. Table 1 summarizes the plated fabric details.

2.2 Methods

The thickness of fabrics was measured on Essdiel thickness gauge at a pressure of 20gf/cm^2. Aerial density of samples was determined according to ASTM D-1059. Fabric porosity was determined using the following equation:

$$\text{Porosity} = \frac{(\rho_o - \rho)}{\rho_o} \times 100\% \qquad \ldots (1)$$

where ρ_0 is the fibre density (kg/m^3); and ρ, the fabric density (kg/m^3).

Moisture vapour transmission rate of the fabrics was tested on moisture vapour transmission cell (MVTR cell) (Grace, Cryov ac division). Absorbent capacity and trans planar wicking of test samples were determined by Gravimetric Absorbency Tester (GATS). Moisture management tester (MMT) (SDL Atlas, Hong Kong) (AATCC Test method 195-2009) was used for testing the liquid moisture transfer properties of the test fabrics. The sensor structure and measuring rings of MMT are shown in Figs 1(a) & (b).

3 Results and Discussion

3.1 Moisture Vapor Transmission Rate

Ring yarn fabrics exhibit higher rate of moisture vapour transmission (7.25 - 9.46 g/m^2/24h) as compared to the rotor yarn fabric samples (6.31 - 8.81 g/m^2/24h), which may be attributed to high porosity

Table 1 — Details of developed plated fabrics

Sample code	PET fibre linear density, dtex	Yarn spinning system
$PCR_{1.1}$	1.1	Ring
$PCRO_{1.1}$	1.1	Rotor
$PCR_{3.3}$	3.3	Ring
$PCRO_{3.3}$	3.3	Rotor

[Outer layer – C (cotton), Inner layer – P (polyester), R – ring, RO- rotor, and 1.1 & 3.3 – polyester fibre dtex].

of ring yarn fabrics (Table 2). Free open spaces in the fabric facilitate easy passage of moisture vapour, owing to diffusion of moisture vapour through air. As diffusion through fibrous material is restricted by fibre diffusivity, the ring yarn fabrics with higher air volume fraction were found to be more permeable to moisture vapour transmission.

3.2 Trans Planar Wicking

Trans planar wicking of ring yarn fabrics is found to be higher as compared to their rotor yarn counterparts. This may be attributed to the difference in yarn structure of two yarns used in the study. Better fibre alignment, higher degree of compactness due to high packing density might have favoured the formation of large number of continuous and small diameter capillaries in ring yarn fabrics. Rotor yarn on the contrary displays randomness in the internal structure with dense core, less dense sheath and belly bands.

The continuity of capillaries may be disturbed by tight wrappings along yarn length. In the light of above facts, it can be argued that randomness and tight wrapping along yarn length and more open structure as compared to their ring yarn counterpart may disrupt the continuity of capillaries, thereby inhibiting the liquid movement through capillary wicking in rotor yarn fabrics.

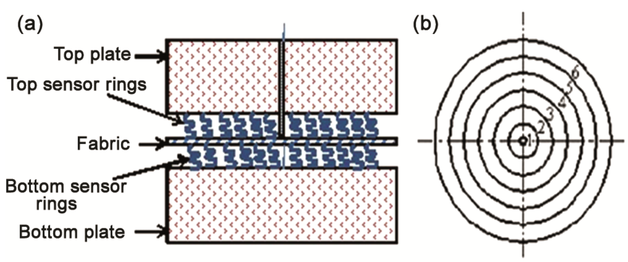

Fig. 1 — Sketch of MMT sensors (a) sensor structure and (b) measuring rings

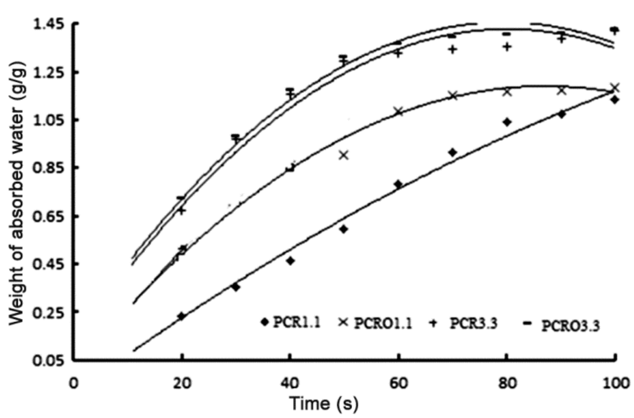

Fig. 2 — Absorbent capacity of plated knitted fabrics

3.3 Absorbent Capacity

Water absorption of the textile fabrics is a crucial property in wearer comfort as it determines the liquid sweat holding capacity of the fabrics. Rotor yarn fabrics show higher absorbent capacity as compared to ring yarn fabrics over a test period of 100 s as shown in Fig. 2. The observed trend may be attributed to high thickness, aerial density and bulk density and hence more water absorption by rotor yarn fabrics as compared to their ring yarn counterparts.

3.4 Moisture Management Properties

Table 3 shows the moisture management indices of test samples. It is observed that top (inner layer) and bottom (outer layer) wetting time are higher for rotor yarn fabrics as compared to their ring yarn counterparts, suggesting that the former would take longer to get wet on initial exposure to test liquid. Figures 3 (a) & (b) show the water content curves for ring and rotor yarn fabrics.

Spreading speed and one way transport capacity, which indicate effectiveness of fabric in liquid spreading and transporting from inner to outer layer, are higher for ring yarn fabrics as compared to those for rotor yarn fabrics. It can, therefore, be concluded that ring yarn fabrics would result in better spreading of test liquid in both inner and outer layers (higher SSt & SSb) and would be more effective in liquid transfer from top (inner/ next to skin layer) to bottom (outer) layer as suggested by higher one way transport capacity.

Table 2 — Physical properties and moisture vapour transmission rate of plated knitted fabrics

Sample code	Thickness mm	Aerial density, g/m^2	Porosity %	Moisture vapour transmission rate $g/m^2/24h$
$PCR_{1.1}$	0.927	248	81.68	7.25
$PCRO_{1.1}$	0.951	255	81.63	6.31
$PCR_{3.3}$	0.974	238	83.46	9.46
$PCRO_{3.3}$	0.985	250	82.56	8.81

Table 3 — Moisture management indices of plated knitted fabrics

Sample code	WTt, s	WTb, s	SSt, mm/s	SSb, mm/s	OWTC
$PCR_{1.1}$	2.91	2.06	2.38	3.44	622.57
$PCRO_{1.1}$	6.75	2.25	1.47	2.56	483.75
$PCR_{3.3}$	3.66	5.16	2.22	2.10	573.32
$PCRO_{3.3}$	7.45	6.23	1.25	1.83	428.62

WTt– Top wetting time, WTb – Bottom wetting time, SSt– Top spreading speed, SSb – Bottom spreading speed, and OWTC– One way transport capacity.

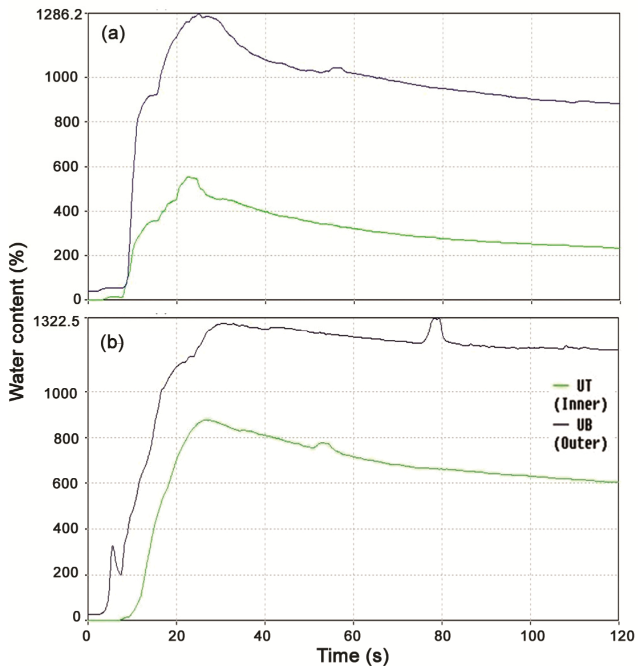

Fig. 3 — Water content vs time curve for inner (top) & outer (bottom) layers of (a) ring yarn fabrics and (b) rotor yarn fabrics

4 Conclusion

The study proposes development of plated knit structures with outer layer composed of two different yarn structures and the comparison of developed fabrics for their moisture management properties. Ring yarn fabrics exhibit higher moisture vapour transmission rate, trans planar wicking, lower wetting time, higher spreading speed and one way transport capacity as against their rotor counterparts, thereby suggesting that ring yarn fabrics would result in better spreading of test liquid in both inner and outer layers. The former would be more effective in liquid transfer from top (inner/ next to skin layer) to bottom (outer) layer. The findings of the study help us to conclude that plated knit structures with ring yarn in the outer layer are suitable choice where body needs to dissipate sweat both in vapour and liquid form with respect to fabrics using rotor-spun cotton yarn in the outer layer, as the latter shows higher absorbent capacity, poor one way transport capacity and would be slow drying fabrics.

References

1 Geraldes M, Lubos H, Araujao M, Belino N J R & Nunes M F, *Autex Res J, 8* (2008) 30.
2 Bivainyte A & Mikucioniene D, *Fibres Text East Eur*, 19 (2011) 64.
3 Vishal K & Rajesh D, *Trends Text Eng Fashion Tech.* DOI: 0.31031/TTEFT.2019.05.000606.
4 Kumar R C, Kumar A P, Senthilnathan P, Jeevith R & Anbumani N, *Autex Res J,* 8 (2008) 100.
5 Ozturk M J, Nergis B & Candan C, *Text Res J,* 81 (2011) 324.
6 Basu A, *Indian J Fibre Text Res*, 34 (2009) 287.
7 Behera B K, Ishtiaque S M & Chand S, *J Text Inst*, 1 (1997) 255.
8 Lord P R, *Text Res J,* 44 (1974) 516.
9 Erdumlu N & Saricam C, *J Text Inst*, 104 (2013) 1284.
10 Manshahia M & Das A, *Fibers Polym*, 15 (2014) 1221.
11 Smita Honade B, Neeraj S, Jagadananda B , Vijay R, Amit D & Ganesh J, *Indian J Fibre Text Res J*, 44 (2019) 24.
12 Suganthi T & Senthilkumar P, *J Ind Text*, 47 (2017) 1447.