International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 02 | Feb 2022 www.irjet.net p-ISSN: 2395-0072

The Effect of Fabric Construction Parameters and Scouring on the Moisture Transmission Properties

Dakuri Arjun[1]*, Siddam Anjali[2], J. Hayavadana[3]

[1,2]Department of Textile Technology, University College of Technology, Osmania University, Hyderabad

---

Abstract: To effectively regulate human perspiration, the liquid moisture transfer of textile structures has been researched. This article discusses the effect of knit fabric attributes, scouring procedures on moisture management properties. For the study, three distinct blend proportions were used: 50/50 polyester/cotton, 50/50 polyester/viscose, and 50/50 polyester/modal. Fabric samples were scoured and assessed for constructional criteria such as stitch density, loop length, porosity, tightness factor, and tightness factor. According to the standard test technique, the control and scouring fabrics are tested for air permeability, vertical wicking, horizontal wicking, sinking, drop test, and spray test. The results showed that the 50/50 polyester/modal single jersey knit fabric outperformed the test textiles in terms of comfort and moisture transfer.

Keywords: Moisture, air permeability, stitch density, loop length, vertical wicking, horizontal wicking, porosity

1. INTRODUCTION

Clothing acts as a barrier to the outer environment as well as a carrier of heat and moisture from the body to the surrounding environment. Clothing physiology, as defined in terms of comfort, performance capability, and overall wearer well-being, entails the process of interactions between the human body and its clothing system. The most significant property of functional clothing is that it creates a steady microclimate near to the skin to maintain the body's thermoregulatory system even when the external environment and physical activity alter drastically [1, 2]. In clothes design and manufacture, comfort is the most important factor to consider. Aside from cloth thermal characteristics, which primarily offer thermal balance to the human body, moisture Transport qualities are important for ensuring comprehensive physiological safety [3, 4]. Thermo-physiological comfort is a distinct feature of clothing use comfort that is related to the heat and moisture transport capabilities of clothing and how it aids in maintaining body heat balance through clothes during varying levels of exercise [5, 6]. The mechanism of moisture transfer through garments under transient humidity conditions influences the wearer's dynamic comfort. Moisture can be transported through clothes as vapor or liquid [7]. Moisture management refers to the controlled transfer of water vapor and liquid from the skin's surface to the atmosphere via the fabric [8, 9].

Fabric moisture management is primarily impacted by fiber type, yarn construction, and fabric construction [10, 11]. Yarn density and structure can have a significant impact on the dimensions and structure of inter-and intra-yarn pores. How fibers are joined into woven, nonwoven, or knitted structures also influence pore size and distribution [12]. According to a recent study, loosely woven fabric samples with a higher proportion of entrapped air had good air permeability but poor moisture management capabilities. Capillary pressures are primarily responsible for the movement of liquid in fiber assemblies such as yarn and fabric [13]. This capillary force is affected by the radius of the capillary channel, the contact angle between the liquid and the capillary channel, and the liquid's rheological qualities [14]. Moisture transfer in textiles is one of the most important variables influencing physiological comfort, especially in underwear and athletics. When the metabolism is high, people sweat, and perspiration spreads all over the skin; in this instance, garments should transmit the perspiration outside to make people feel more comfortable. Wicking is a common way to express moisture transport. Wicking is the spontaneous transfer of a liquid through a porous medium caused by capillary forces [15]. Wickability refers to the ability of a fabric or yarn to maintain capillary flow, whereas wettability refers to the initial behavior of a fabric or yarn in contact with liquid [16]. Wang and Zha [17] examined the wicking properties of yarns and discovered that the wicking behavior of yarns improved with the increased cross-sectional area due to a greater number of capillaries in yarn. Furthermore, another study found that increasing the cross-sectional area of the yarn and decreasing the liquid viscosity boosted wicking velocity [18]. Zhou et al. [19] hypothesized the total moisture management ability of knitted fabrics made of pure wool, wool/polyester, and wool/cotton blends with varying structures. They reported that wool/cotton blended materials outperformed other fabric combinations. Supuren et al. [20] evaluated the moisture management characteristics of double-face knitted fabrics made of cotton and polypropylene substances and found that the fabric made of cotton (outer layer) and polypropylene (inner layer) offers a high level of comfort and is suitable for summer, active, and sportswear. Jhanji et al. [21] studied the impact of yarn count on moisture management qualities of polyester-cotton knit constructions in the inner and outer layers, as well as the difference in yarn count between the two layers. The perspiration transfer rate and sweat spreading on the surface of the outermost layer are affected by the yarn counts of the inner and outer layers. The increase in inner and outer layer yarn counts improves wetting time and spreading speed. In this study, the effect of knit fabric parameters and the scouring process on the moisture management properties were investigated.

2. METHODOLOGY

2.1 Materials

Polyester/ cotton, polyester/ viscose, and polyester/ modal knitted blend fabrics are used for the study. Sodium hydroxide, sodium carbonate, soap solution are the ingredients used as scouring agents. The specifications of the materials are mentioned in Table 1. The fabric specimens are purchased from the local market

2.2 Methods

Before testing, the textiles samples are conditioned for 24 hours at standard ambient RH (65 ± 2%) and temperature (27± 2^0 C). Initially, experimental sample fabrics were scoured to eliminate dirt and grease from the manufacturing process. Samples of 40cm × 40cm size were treated for 30 minutes at 40^0 C with 3% NaOH, 3% Na_2CO_3, and 2% soap solution. Fabric samples were washed and dried after treatment. The Arial density of a fabric sample is measured by IS: 1964-1970. Fabric weight is measured using a circular knife cutting machine and an electronic balance. The thickness of cloth is one of its fundamental qualities, indicating its warmth, heaviness, or stiffness in use (Saville 2004) and evaluated as per (AS 2001.2.15–1989). The standard test technique ASTM-D 737 was utilized to determine the air permeability of the chosen material (Midha et al 2013). Drape meter for assessing drapability following ASTM –D3691 standard. The whole volume of fabric was measured and the total volume of fiber in the sample was calculated to assess porosity. The difference between these two values is referred to as air space, and when expressed as a percentage of total volume, it yields porosity. Porosity was calculated based on the following formula:

$$P = \frac{100(AT-\frac{W}{D})}{AT} \qquad (1)$$

Where; P = porosity, %; A = area of the sample, m^2; W = weight of the sample, g ; T = thickness of the sample, cm; D = density of fiber, g/cm^3.

To determine loop length, results from the course and wales per unit length were used. The yarn diameter was calculated based on the yarn count used. Yarn diameter was calculated based on the formula (Karaguzel 2004):

$$d = 2\sqrt{\frac{4T}{\pi\rho 10^5}} \qquad (2)$$

Where; d = diameter, cm; T = yarn density, Tex ; ρ = fiber density, g/cm^3.

Loop length was determined based on the formula (Peirce 1947):

$$l = \frac{2}{c} + \frac{1}{w} + 5.94d \qquad (3)$$

Where;

l = length of yarn in one loop, cm; c = number of courses per cm; w = number of wales per cm

d = diameter of the yarn, cm

The tightness factor, like the cover factor in the weaving industry, denotes the relative tightness or looseness of the plain weft knitted structure. The cover factor is defined as the ratio of the yarn's area covered in one loop to the area filled by that loop (Spencer 2001). The following formula was used to calculate the cover factor (Gravas & Langenhove 2006).

$$\text{C.F.} = \frac{\sqrt{\text{Tex}}}{l} \tag{4}$$

Where, l = loop length in mm; Tex = the yarn linear density

The proportions of the fabric are determined by the loop shape, which is determined by the yarn used and the treatment that the cloth has received. The loop form factor of single jersey knitted fabrics is calculated by averaging the wales and courses per unit length. It is calculated by dividing the number of courses per centimeter by the number of wales per centimeter.

Loop shape factor (k) = CPcm/WPcm (5)

2.2.1 Moisture Transmission Properties

Drop test

The drop test is carried out as per AATCC 198. The sample is placed on top of a beaker, leaving the center unsupported. A measured drop of water is put 1 cm from the fabric's surface. The time is kept until the water drop has entirely absorbed. The stated value is the average of the measurements.

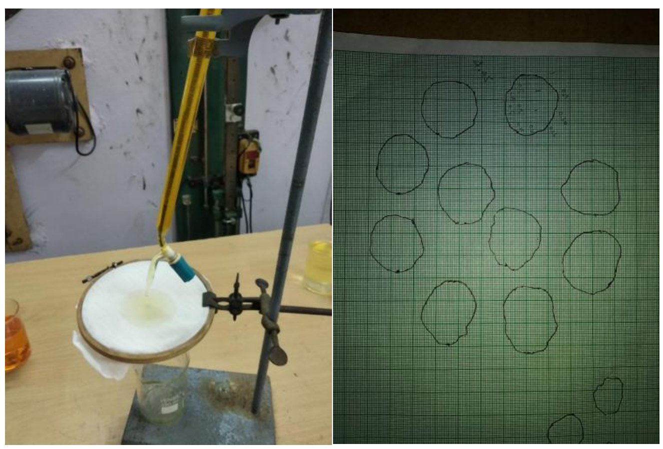

Figure 1 - Drop Test

Vertical and Horizontal Wicking Test

It is measured by the AATCC 197 test protocol. To test the fabric's wicking properties, a strip of 20X2 cm test fabric was suspended vertically with its bottom end (2 cm) immersed in a reservoir of distilled water. Capillary action was used to measure the vertical movement of water every minute for up to 20 minutes. Wicking experiments were performed with ten samples for each wale and course direction independently

Saturation Method

The fabric samples, each 20 cm in diameter, were put on an embroidery frame (AATCC 198). Every 3 seconds, 1ml of water was poured onto the sample from a standard height of 6mm using a burette. The sample constantly absorbed a drop of water that fell on the fabric. The extra water droplets flowed down through the fabric when the sample could no longer absorb any more water. This is referred to as the saturation point. The time it took to attain saturation was recorded, and the area spread was assessed using a graph sheet similar to the previous test. Spray testing is performed using AATCC Test Method 79. The waterfalls on the specimen, which are suspended on a 6-inch diameter embroidery hoop at a 45-degree angle. To conduct the test, 250 ml of 70oF water is steadily poured into the funnel. The American Association of Textile Chemists and Colorists recommends using a photographic chart to compare the actual fabric appearance.

3. RESULTS & DISCUSSIONS

The control and scoured fabric were tested for moisture management properties

Table1. Geometrical properties of fabrics

S. No	Weave Type	Composition	Course per cm	Wales per cm	Loop shape factor (R)	Stitch density (loops/Sq.cm)	Fabric Mass (g/m²)	EMC (%)
1	S/J	50:50 P/M	15	21	0.71	326.4	160	11.3
2	S/J	50:50 P /C	13	17	0.76	218.2	165	6.7
3	S/J	50:50 P/ V	12	17	0.71	204.6	115	11.4

Note: P/M- Polyester/Modal, P/C- Polyester/Cotton, P/V- Polyester/Viscose

Table 5.1 displays the geometrical parameters of fabrics. It is discovered that the stitch density is high for P/M and low for P/V, with P/C offering moderate stitch density due to the variation in loops in both directions. The 50:50 P/V sample has a lower thickness, whereas the 50:50 P/C sample has a larger thickness. This could be due to a greater number of fibers in the cross-section, which results in a higher arial density than the other specimens. Furthermore, EMC percent of 50:50 P/V is discovered to be larger than other textiles; this is because EMC percent is always inversely proportional to fabric thickness. When the fabrics were placed under varied weights, the 50:50 P/V fabric compressed significantly more than the other two materials.

Table 2. Effect of knit parameters on comfort properties

S. No	Composition	Course/ cm	Wale/ cm	Linear Density (Tex)	Yarn Diameter (cm)	loop length (cm)	Tightn ess factor (K)	Air permeability (cm³/cm²/sec)	Porosity (%)
1	50:50 P/M	15	21	21	0.017	2.6	17.6	950.7	94.3
2	50:50 P /C	13	17	22	0.018	2.6	18.1	610.8	91.8
3	50:50 P/ V	12	17	17	0.013	3.0	14.0	758.6	92.4

The air permeability of polyester/modal fabric is significantly higher than that of other blends. Coarser count yarns are employed in polyester/model fabric production (Table 2). Coarser yarns have a larger yarn diameter, which affects the inter yarn gaps between the yarns during the knitting process. Aside from that, the modal fiber is distinguished by its superior breathability. Furthermore, the polyester/modal specimen has the maximum loop density, which may increase the fabric's microporous character. As a result, the polyester/modal knit fabric is far more comfortable than the other test samples.

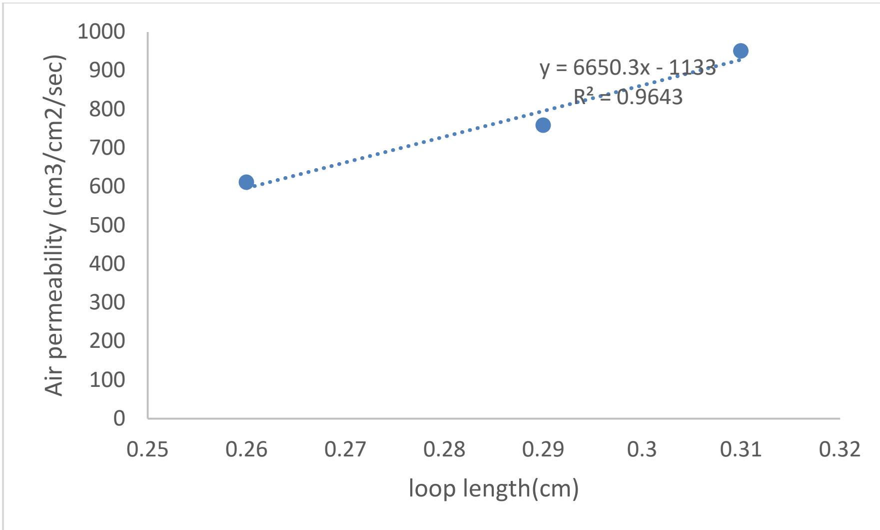

Chart 1. Effect of loop length on air permeability

Table 3 Effect of Scouring on Moisture Management Properties Vertical Wicking Height

Time (Min)	50:50 P/M				50:50P/C				50:50 P/V			
	Control		Scoured		Control		Scoured		Control		Scoured	
	Course	Wale	Course	Wale	Course	Wale	Course	Wale	Course	Wale	Course	Wale
1	5.6	6.5	7.6	7.2	2.0	2.5	3.0	3.2	5.0	5.0	5.0	5.5
2	6.7	7.8	9.0	8.5	2.5	3.0	4.0	5.0	5.5	6.2	5.9	6.3
3	7.8	9.0	10.0	9.4	3.0	4.2	4.5	5.9	6.0	6.7	6.1	6.6
4	8.5	9.7	10.2	9.8	3.2	4.5	5.0	6.7	6.3	7.0	6.7	7.2
5	9.2	10.5	11.2	10.5	3.2	4.9	5.5	7.0	6.5	7.1	7.2	7.9
6	9.7	10.9	11.6	11.0	3.3	5.0	5.9	7.5	7.1	7.3	8.0	8.0
7	10.4	11.5	12.0	11.4	3.5	5.1	6.2	8.0	7.4	7.5	8.1	8.2
8	10.6	11.8	12.6	12.0	3.5	5.5	6.5	8.6	7.5	7.7	8.1	8.4
9	11.0	12.1	12.9	12.6	3.7	5.8	6.8	8.9	7.6	8.0	8.2	8.6
10	11.4	12.6	13.0	12.9	3.8	6.4	7.0	9.0	7.8	8.2	8.3	8.8
11	11.6	12.8	13.5	13.1	4.2	6.3	7.4	9.4	8.1	8.4	8.4	9.0
12	11.9	13.0	13.8	13.5	4.3	6.5	7.6	9.7	8.2	8.5	8.5	9.2
13	12.2	13.4	14.0	13.9	4.3	6.7	7.9	10.1	8.4	8.7	8.6	9.4
14	12.7	13.6	14.2	14.2	4.6	6.8	8.1	10.3	8.6	9.0	8.7	9.6
15	13.0	13.8	14.6	14.6	4.6	7.0	8.4	11.0	9.0	9.3	9.0	9.8
16	13.2	14.0	14.9	14.8	5.4	7.4	8.7	11.2	9.1	9.6	9.2	10.0

17	13.5	14.2	15.0	15.3	5.5	7.6	9.0	11.5	9.2	10.0	9.6	10.1
18	13.7	14.5	15.3	15.6	5.6	7.8	9.1	11.7	9.3	10.3	10.0	10.5
19	14.0	14.7	15.6	16.1	5.6	8.1	9.4	12.3	9.5	10.4	10.3	10.9
20	14.1	15.0	15.8	16.3	5.6	8.3	9.5	12.6	9.6	10.5	10.5	11.3

Table 4. Effect of scouring on moisture management properties

Control fabric								Scoured fabric					
		Horizontal Wicking (cm)			Drop Test			Horizontal Wicking (cm)			Drop Test		
S.no	Fabric type	Area Covered to reach saturation (cm²)	Time to reach saturation (Sec)	Sinking time (Sec)	Area covered in cm²	Time to disappear (Sec)	Spray test (Rating)	Area Covered to reach saturation (cm²)	Time to reach saturation (Sec)	Sinking time (Sec)	area covered in cm²	Time to disappear (Sec)	Spray test (Rating)
1	50:50 P/M	50.7	17.9	10.91	5.1	5.8	0.0	36.9	12.5	12.9	1.6	2.0	0.0
2	50:50 P /C	12.7	13.8	28.01	1.7	44.8	0.0	9.2	10.6	29.7	1.4	33.6	0.0
3	50:50 P/ V	39.7	14.5	2.71	3.6	8.6	0.0	16.6	13.7	5.7	3.0	2.8	0.0

3.1 Vertical Wicking Height

Table 3 shows the vertical wicking height of different fabrics. The Polyester/Model blend knit fabric has better vertical wicking height per unit time than other fabrics in both the course and wale directions. This could be attributable to the textiles' increased stitch density; a higher stitch density reduces the gaps between the threads and increases capillary action; a higher capillary action results in a higher rate of wicking. The modal component has a high degree of polymerization, a microstructure, and is recognized for its hydrophilic character, which absorbs moisture, and its hydrophobic nature, which rids moisture out of the fabric, which is known as the push-pull action, which increases the pace of wicking. The wale direction of the fabric has a higher rate of wicking than the course direction. Polyester/cotton knit fabric has the lowest wicking rate because cotton fibers swell upon absorption, resulting in reduced capillary action.

3.2 Traverse wicking, drop test and spray test

The transverse wicking properties of the fabric are more important than longitudinal wicking because perspiration transfer from the skin involves the lateral direction of the fabrics; therefore, the area covered by one drop of water method and saturation methods are used to evaluate the transverse wicking behavior of materials. The area covered to obtain saturation in saturation/horizontal wicking is shown to be high for polyester/modal mixes and lower for polyester/cotton blends (Table 4). Furthermore, the time to saturation is longer for polyester/modal knit fabric than for other samples. The fabric construction and knit parameters can be a reason for this issue. Wicking and water absorbency cannot be separated and occur simultaneously as soon as the fabric comes into touch with water, especially when the cloth is contacting water horizontally. As a result, excellent wicking was discovered in the polyester/modal blend, as well as a higher rate of absorbency for the modal component; improved capillary causes the fabric to hold the water droplet and transfer it in the lateral direction against gravitational forces, spreading the water to a larger area before saturation. The benefit of these analyses is that because transverse wicking is multi-directional, the directional influence is eliminated. When the time required to obtain saturation increases, so does the area spread. The scouring procedure improves the time to saturation, and the area covered to obtain saturation is found to be less than in the control cloth, a similar pattern reported in other materials. The drop test findings are favorable for the polyester/modal mix, which is followed by the other control materials. It provides excellent coverage before the droplet vanishes. It is assumed that when the microporous structure blends, the loop length decreases, and the water spreading area increase. It has a 30% larger spreading area than the other fabrics chosen. The polyester/cotton fabric has a slower spreading time than other examples because when a water droplet is absorbed by the cotton; it swells laterally, increasing pressure on the capillary. This may decrease water transport, resulting in a small spread area. The scouring process minimizes the spreading area and time to saturation in both transverse wicking and chemical processing of samples, which increases the absorbency rate and hence reduces the spreading area. Spray test ratings of controlled and scouring specimens are '0'. The impact forces of the water spray, as well as the fabric's rapid absorption and transmitting properties, maybe cause total wetness on the face and back of the cloth.

4. CONCLUSION

The primary goal of the research is to investigate the impact of knit characteristics and scouring on comfort and moisture management capabilities. The air permeability, vertical, transverse wicking drop test, spray test, and sinking, scouring process of the chosen fabrics are all analyzed. The air permeability of polyester/modal knit specimens are found to be the best, followed by others. In both the course and wale directions, the vertical wicking height of polyester/modal specimens is significantly higher than that of other selected specimens. P/M had a larger spreading area in the saturation and drop tests, and the spray test results were the same for all textiles, indicating that the samples were thoroughly wet. As a result, it is concluded that the polyester/modal blend knit fabric provides superior comfort and moisture management capabilities both during and after scouring.

REFERENCES

[1]. Das, B., Das, A., Kothari, V.K., Fanguiero, R. and De Araujo, M., 2008. Effect of fiber diameter and cross-sectional shape on moisture transmission through fabrics. Fibers and Polymers, 9(2), pp.225-231.

[2]. Onofrei, E., Rocha, A.M. and Catarino, A., 2011. The influence of knitted fabrics' structure on the thermal and moisture management properties. Journal of Engineered Fibers and Fabrics, 6(4)

[3]. Ho, C.P., Fan, J., Newton, E. and Au, R., 2011. Improving thermal comfort in apparel. In Improving comfort in clothing (pp. 165-181). Woodhead Publishing.

[4]. Nemcokova, R., Glombikova, V. and Komarkova, P., 2015. Study on liquid moisture transport of knitted fabrics by means of MMT, Thermography and Microtomography Systems. Autex Research Journal, 15(4), pp.233-242.

[5]. Kothari, V.K. and Sanyal, P., 2003. Fibres and fabrics for active sportswear. ASIAN TEXTILE JOURNAL-BOMBAY-, 12(3), pp.55-61.)

[6]. Jhanji, Y., Gupta, D. and Kothari, V.K., 2015. Moisture management properties of plated knit structures with varying fiber types. The Journal of The Textile Institute, 106(6), pp.663-673

[7]. Kumar, P., Sinha, S.K. and Ghosh, S., 2015. Moisture management behaviour of modified polyester wool fabrics. Fashion and Textiles, 2(1), pp.1-17

[8]. Sampath, M.B. and Senthilkumar, M., 2009. Effect of moisture management finish on comfort characteristics of microdenier polyester knitted fabrics. Journal of Industrial Textiles, 39(2), pp.163-173

[9]. Ramratan, R. and Choudhary, A.K., 2020. The Influence of Yarn and Knit Structure on Comfort Properties of Sportswear Fabric. Journal of Textile and Apparel, Technology and Management, 11(2).
[10]. Nazir, A., Hussain, T., Ahmad, F. and Faheem, S., 2014. Effect of knitting parameters on moisture management and air permeability of interlock fabrics. AUTEX research Journal, 14(1), pp.39-46.
[11]. Öner, E., Atasağun, H.G., Okur, A., Beden, A.R. and Durur, G., 2013. Evaluation of moisture management properties on knitted fabrics. Journal of the Textile Institute, 104(7), pp.699-707.
[12]. Hsieh, Y.L., 1995. Liquid transport in fabric structures. Textile Research Journal, 65(5), pp.299-307
[13]. Kissa, E., 1996. Wetting and wicking. Textile Research Journal, 66(10), pp.660-668
[14]. Babu, R.V., Ramakrishnan, G., Subramanian, V.S. and Kantha, L., 2012. Analysis of fabrics structure on the character of wicking. Journal of engineered fibers and fabrics, 7(3), pp.28-33.
[15]. Nemcokova, R., Glombikova, V. and Komarkova, P., 2015. Study on liquid moisture transport of knitted fabrics by means of Mmt, Thermography and Microtomography Systems. Autex Research Journal, 15(4), pp.233-242
[16]. Öztürk, M.K., Nergis, B. and Candan, C., 2011. A study of wicking properties of cotton-acrylic yarns and knitted fabrics. Textile Research Journal, 81(3), pp.324-328
[17]. Ghali, K., Jones, B. and Tracy, J., 1994. Experimental techniques for measuring parameters describing wetting and wicking in fabrics. Textile Research Journal, 64(2), pp.106-111
[18]. Wang, N., Zha, A. and Wang, J., 2008. Study on the wicking property of polyester filament yarns. Fibers and Polymers, 9(1), pp.97-100.
[19]. Rajagopalan, D., Aneja, A.P. and Marchal, J.M., 2001. Modeling capillary flow in complex geometries. Textile Research Journal, 71(9), pp.813-821.
[20]. Zhou, L., Feng, X., Du, Y. and Li, Y., 2007. Characterization of liquid moisture transport performance of wool knitted fabrics. Textile Research Journal, 77(12), pp.951-956
[21]. Supuren, G., Oglakcioglu, N., Ozdil, N. and Marmarali, A., 2011. Moisture management and thermal absorptivity properties of double-face knitted fabrics. Textile Research Journal, 81(13), pp.1320-1330
[22]. Jhanji, Y., Gupta, D. and Kothari, V.K., 2017. Moisture management and wicking properties of polyester-cotton plated knits. Indian Journal of Fibre & Textile Research (IJFTR), 42(2), pp.183-188.