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Effects of sewing thread filament fineness on moisture management properties of seams

M Maanvizhi[1], C Prakash[2,a] & V Ramesh Babu[3]

[1]VIT Fashion Institute of Technology, Vellore Institute of Technology, Chennai 600 127, India

[2]Department of Handloom and Textile Technology, Indian Institute of Handloom Technology, Nadia 741 402, India

[3]Department of Textile Technology, Kumaraguru College of Technology, Coimbatore 641 049, India

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To study the impact of micro-denier filament on seam comfort properties, five different micro-denier polyester filament threads with different fibre fineness (from medium-fine to micro fibres) have been studied. Sewing threads of 150 deniers are made of textured micro-denier polyester filaments with five different filament numbers, viz 3.94 dpf, 3.1 dpf, 1.38 dpf, 1.04 dpf, and 0.52 dpf; calculated based on the number of filament within the specified fibre diameter. The stitch density 10 stitches/inch is used. It is concluded that wetting time, absorption rate, and spreading speed have improved when the filament fineness is varied from 3.94 dpf to 1.38 dpf and dropped from 1.38 dpf to 0.52 dpf. The seam constructed with 1.38 dpf shows the optimum level of moisture management capacity. OMMC values are also indicating the same results. Increasing filament fineness brings about an increase in air permeability and moisture vapour transmission from the seam made with 3.94 dpf to the seam made with 0.52 dpf, attributable to enhance the availability of free air in the seam structure.

Keywords: Comfort, Moisture management, Micro-denier polyester, Sewing thread, Seam properties, Stitch density

1 Introduction

Thermo-physiological comfort encompasses the heat and moisture transfer of the textile material[1-3]. The existence of moisture can modify the surface characteristics of the fabrics and it is capable of changing the fabric's surface properties[4]. Therefore, evaluating the fabric comfort properties under wet conditions is required. The pressure generated on the human skin, because of the compression from tight garments and its frequent friction along with moisture during intense activities, leads to skin-tissue breakdown and causes discomfort to the wearer[5]. Thus moisture management and thermal comfort properties on the seam line are to be analysed for designing and construction high compressive sportswear tight fit garments made of elastic with additional compression from protective materials.

The seam quality evaluation is depending on seam appearance, comfort, wearability, and mechanical interaction with the wearer[6]. Srinivasan[7] stated that the seam has a minimum of two layers of fabrics that are joined by sewing thread. The seam’s thickness, bulkiness, and tightness affect the thermal comfort properties of the garment. Das *et al.*[8] found that an increase in fibre liner density leads to greater thermal resistance and lower thermal conductivity & absorptivity, thus giving a warm feel to the wearer. Havenith *et al.*[9] found that the fabric layers and seam bulkiness are significantly affecting the garment's thermal properties. Seam consists of multi-layer which is limiting the heat and moisture transfer in and around the seams, thereby affecting the thermal properties of clothing[10]. The garment must support the wearer in the areas where a large amount of sweat is produced, for which the fabric should be included with ultra-breathable and possess great qualities of moisture management properties, less weight, and fast-drying properties[11]. Varshney *et al.*[12] found that the fabric made of micro-fibre polyester shows better comfort properties than the made of staple polyester fibre. Heat enters more quickly because of the finer diameter of the micro-fibres and it gives the cooler feel to the skin.

Micro-denier filaments are considered a significant factor in influencing clothing comfort[3]. Comparatively finer microfibres provide better moisture transport and control moisture effectively in the microclimate, especially when there is an enormous sweat generation takes place. This is due to the higher moisture absorption potential of the micro-fibre surface and the good capillary liquid transport effect during

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

perspiration. Finer filaments are packed tightly together and macro pores (space between the fibres) are aiding the wicking process and breathability of the material. Moisture management should be achieved on the seam line to avoid skin injuries due to continuous rubbing of seams during intense activities[14]. This can be achieved by effective raw material selection, which is essential in engineering a seam for improving the comfort properties. Sewing thread is the most integral part of a seam. It is necessary to have a soft and smooth seam to avoid injuries caused by skin-fabric friction during the high-level athletic activities specifically for tight fit garments with high compression made from elastic and additional compressions from protective equipment. This study aims to analyze the influence of micro-denier polyester sewing thread on moisture management properties of seams. It is observed that the sewing thread fineness improves the moisture management capacity of seamed fabric. In this study, the "top surface" refers to the inner side of the seam that is next to the skin side and the "bottom surface" refers to the outer side of the seam.

2 Materials and Methods

2.1 Materials

Commercially available 100% polyester single jersey knitted fabric of 150 GSM is used for making seams. Seams were prepared using standard sewing thread of micro-denier polyester. Optimized stitch density, identified as 10 stitches/inch in previous research, which is on the comfort properties of seams at various stitch densities. It is used in this investigation to study the effect of sewing thread's filament fineness on comfort characteristics of seams.

2.1.1 Seam Constructions

In order to investigate the effect of sewing thread's filament fineness on the comfort characteristics, 100% polyester continuous filament seam with 2-3 TPI and 150 deniers, comprising 34, 48, 108, 144, and 288 filaments considering individual filament size calculated as 3.94 dpf, 3.1 dpf, 1.38 dpf, 1.04 dpf, and 0.52 dpf respectively was used. For making seams, Juki five-thread flack lock and four-thread overlock industrial sewing machines were used for constructing flatlock and overlock stitches respectively.

2.1.2 Seam and Stitch Class

Figure 1 shows the seam class LSa-1 and SSa-2 as per ASTM D6193-11. LSa-1 seam is a lapped seam formed by overlapping two or more layers of fabric joined by two rows of stitches. SSa-2 is a superimposed seam formed by superimposing two layers of fabrics and joined by two rows of stitches.

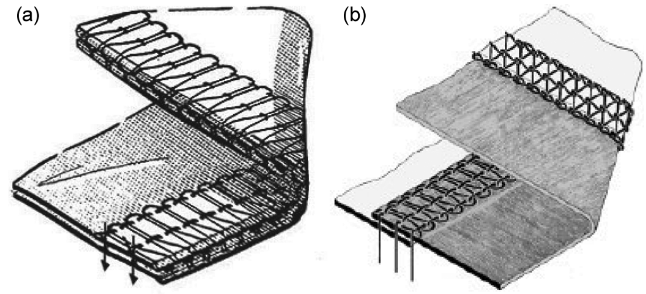


Fig. 1 — Seams (a) superimposed seam 2 (SSa-2) – 514 and (b) lapped Seam 1 (LSa-1) – 605

One of the class 500 stitches used for the construction of sportswear is the overlock stitch class (Class 514). It is structured by two needle threads and two looper threads. The excess fabric edges will be trimmed off for an even seam. The lapped seam is the second most commonly used seam in sportswear, especially in the areas like neck finishing, crotch line, and the waistband construction of highly active sports garments. Stitch class of flat-seaming stitch (class 605) is used for the construction of lapped seams using a flat lock machine which needs a top and a bottom looping thread. All the seams were constructed as per the ASTM D6193-11 standard. Increasing the number of seams within the sample increases the impact of seams on the overall test results. Thus, several seams were incorporated within the sample size, the gap between seams was maintained as 1 inch and the seam allowance was maintained as exactly 6 mm for all the constructed seams. Lapped seam 1 (LS_b-2) and Superimposed seam (SSa-2) and the stitching class Stitch class 605 and 514 are mentioned as per the standard ASTM 6193 and ISO 4915

2.2 Methods

2.2.1 Thickness and Air Permeability Measurements

The seam and the fabric thickness were measured by using a fabric thickness gauge.

Textest FX 3300 air permeability tester was used to examine the air permeability of the seams (ASTM D737 - 18). Open seams were kept in the experiment as shown in Fig. 2, since the fabric layering of the seams is an important consideration.

2.2.2 Moisture Vapour Transmission

The tests were carried out in accordance with ASTM E 96, which specifies the assessment

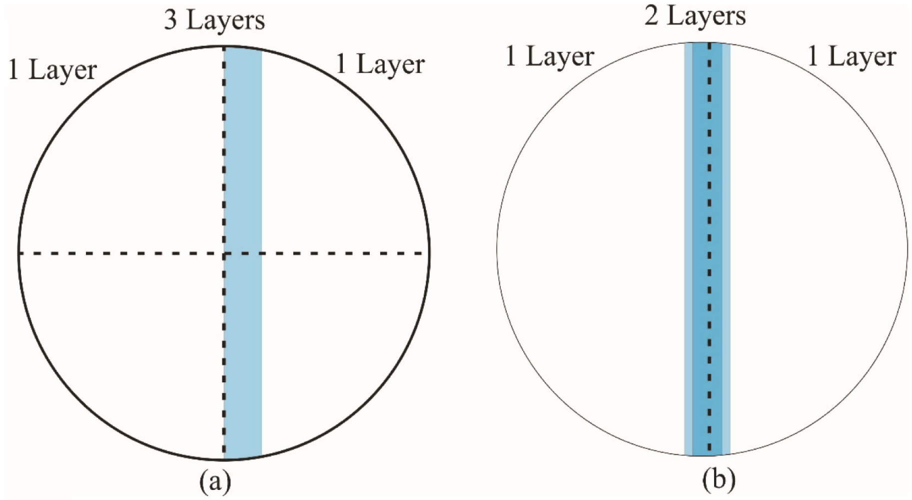


Fig. 2 — Schematic representations of fabric layering seams in experimental setup (a) layering of superimposed seam in experimental setup and (b) layering of lapped seam in experimental setup

of moisture vapour transmission (MVT) of materials through which moisture may move. Two separate approaches, namely the Desiccant method and the Water method were used to assess the rate of moisture vapour transmission through the fabric sample.

2.2.2.1 Lowering of Water Level

Water was poured into a cup to a height of 6 cm. The cup height was measured every five millimetres, and fabric samples were placed on top of the cups. After 48 h, the level of water in the cup was measured to see if there has been any changes.

2.2.2.2 Lowering the Weight of Water

The cup weight was determined after 48 h, and the fabric samples were removed from the cups. The amount of water in the cup was weighed, and the weight loss was calculated.

2.2.3 Vertical Wicking

The fabric samples were cut into 10 × 1 inch strips, seam lines were introduced along the lengthwise centreline of the strip and immersed vertically in a distilled water container with the lower end dipped up to 2 cm of fabric sample for determining the vertical wicking behaviour of seamed and unseamed fabric. In every 5 min, the water travelled upward on a strip of fabric, for each sample was inspected. This test was carried out as per BS 3424 standard.

2.2.4 Moisture Management Properties

The SDL Atlas MMT was used to examine the fabric samples' moisture management capabilities

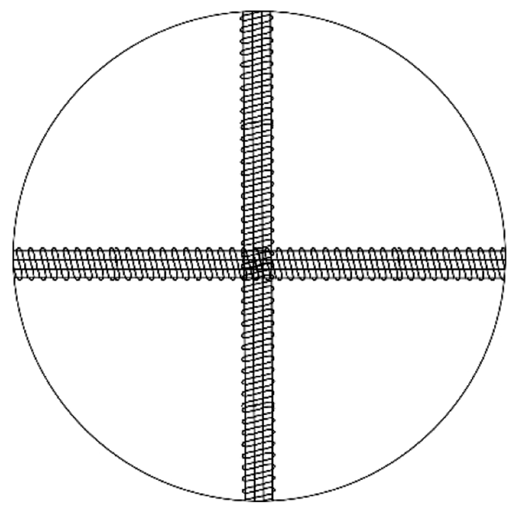


Fig. 3 — Schematic of moisture management testing sample

(AATCC TM 195). The absorption rate, wetting duration, and one-way transport index on the seam line, as well as the maximum wetted radius and spreading speed on and around the seam, were all tested to assess the moisture management properties of the seamed fabric.

Seams are inserted exactly at the centre of the sample, as shown in Fig. 3 (superimposed seam with overlock stitch 514 class and lapped seam with flatlock stitch 605 class) in both course and wales directions. All the seamed fabrics were tested for examining the influence of sewing thread fineness on seam moisture management properties. By placing a seamed fabric specimen in the exact centre of two horizontal electrical sensors (upper and lower), each having seven concentric pins, the liquid moisture management properties of the seamed fabrics were

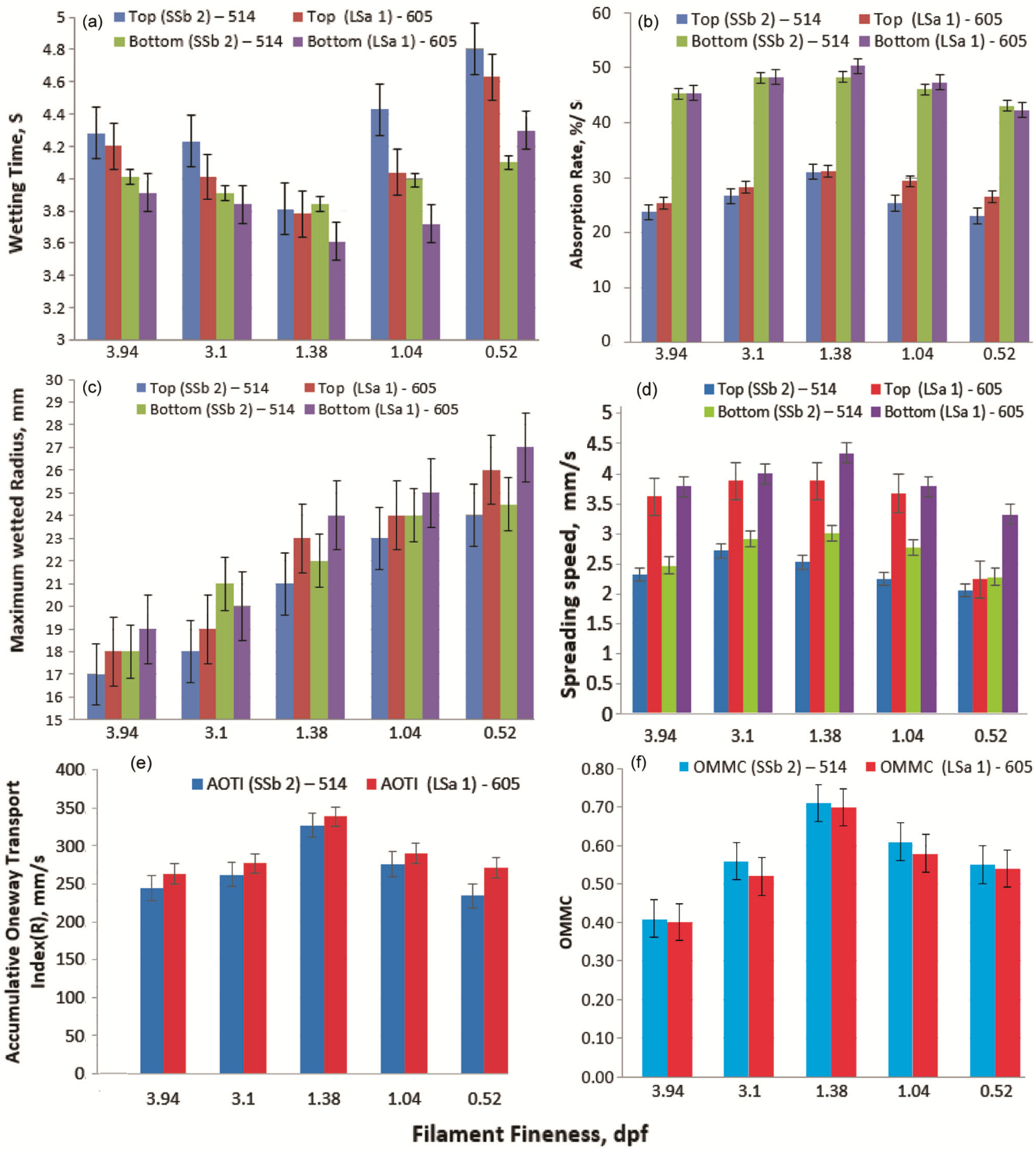


Fig. 4 — Impact of sewing thread filament fineness and seam type on (a) wetting time, (b) absorption rate, (c) maximum wetted radius, (d) spreading speed, (e) accumulative one way transport index(AOTI), and (f) overall moisture management capability(OMMC)

tested, similar to unseamed fabric samples. Prefixed amounts of liquid were dropped onto the centre of the seam line. From the centre of the seam line, the test solution started to spread in three directions. When the liquid was spread over the seamed fabric surface, the electrical conductivity of the test solution was measured and recorded. The results of the liquid moisture management properties of the seamed fabric were graded by a prefixed scale.

3 Results and Discussion

3.1 Impact of Filament Fineness and Seam Type on Wetting Time

From Fig. 4(a), it is observed that the seam constructed with 1.38 dpf sized sewing thread shows less wetting time. As the filament size decreases (1.04 dpf and 0.52 dpf) or increases (3.94 dpf and 3.1 dpf), the time taken to wet the seam increases. This may be due to the fact that the interspace between the fibre becomes too large or too small and hence this slows down the water entry, thereby taking more time to wet the seamed fabric. Among all the seams, the seam constructed with 1.38 dpf may be having the optimum inter-fibre space, and this causes the fastest water entry into the yarn. From the Fig. 5, fibre space between the filaments is very high for the filament size of 3.94 dpf, resulting in less water entry. When comparing seam types, the Lapped seam 1 (LSa-1) - 605 shows less wetting time than the Superimposed seam (SSa-2) – 514. The reason may be, lapped seam is less bulky than the superimposed seam and also because of the differences in stitch pattern for both seams. Therefore, it is inferred that sewing thread filament fineness and the seam type is significantly affecting the seam wetting time[13].

3.2 Impact of Filament Fineness and Seam Type on Rate of Absorption

The quantity of moisture absorbed (%) for a period of 20s is expressed as the absorption rate. The absorption rates of the top and bottom surfaces of the seamed fabrics with different sewing thread fineness are given in Fig. 4(b). The liquid moisture absorption rate is increased when the filament fineness increases to a certain limit. For seam constructed with 1.38 dpf, the absorption rate is increased, but in the seams with 3.94 dpf, 3.1 dpf, 1.04 dpf, and 0.52 dpf, the moisture absorption rate is decreased. This is due to the inter-fibre space between the filaments in the sewing thread. When inter-fibre space is decreased due to an increased number of filaments the liquid moisture absorption rate is decreased. The inter-fibre space is seen in Fig. 5. As seen in Fig. 4(b), the absorption rates of the seamed fabrics are greatly affected by sewing thread filament fineness. From Table 1, it is observed that the seam thickness is less for lapped seams due to which absorption rate is also higher for lapped seams. It is stated[1] that the absorption rate increases with a decrease in fabric thickness. In general, the absorption rate is higher for the bottom surface than for the top surfaces. This shows that the maximum amount of liquid distribution is on the bottom surface than on the top surface. Figure 4(b) shows the same which means seamed fabric also behaves the same.

3.3 Impact of Filament Fineness and Seam Type on Maximum Wetted Radius

The effect of sewing thread filament fineness and seam type on the seam maximum wetted radius is shown in Fig. 4(c). The result shows that the maximum wetted radius has increased on the seam line from 3.94 dpf sewing thread to 0.52 dpf sewing thread. Finer filaments store more water droplets due to higher surface tension and help to transfer it to a lateral direction against gravitational force. Sampath and Senthilkumar[14] stated that finer filaments hold more water than coarser filaments. Sewing thread fibre fineness is seen in the SEM analysis of the seam line in Fig. 5. The lapped seam shows a higher wetted radius than the superimposed seam. The thinner the fabric sample, the higher is the area of water spread. The fabric structure is significantly affecting the water area absorbed by the fabric. Sewing thread fibre fineness is seen in the SEM analysis of the seam line in Fig. 5. The lapped seam shows a higher wetted radius than the superimposed seam. The thinner the fabric sample, the higher is the area of water spread. The fabric structure is significantly affecting the water area absorbed by the fabric. The same findings are reported by Patil *et al.*[14]

3.4 Impact of Filament Fineness and Seam Type on Spreading Speed

The effect of sewing thread filament fineness and the seam types on spreading speed is given in Fig. 4(d). It is observed that the accumulative spreading speed from the centre to reach the maximum wetted radius is increased when the sewing thread filament fineness is changed from 3.94 dpf to 1.38 dpf. The liquid spreading speed is decreased from sewing thread changing from 1.38 dpf to 0.52 dpf. This is due to the fact that, when sewing thread has finer filaments in cross-section the inter-fibre space is decreased and thus water droplet takes more time to enter. The arrangement of fibre with higher number of finer filaments is visualised in Fig. 5. When comparing the lapped seam with stitch type 605, the spreading speed for the superimposed seam with stitch type 514 is lower. This may be due to the differences in fabric layers and the stitch pattern on the seam line.

3.5 Impact of Filament Fineness and Seam Type on AOTI and OMMC

Accumulative one-way transport index (AOTI) is the index to specify the ability of the material to pass the liquid from the top layer to the bottom layer. Figure 4(e) shows the comparative view of AOTI of the lapped seam and superimposed seam constructed with various sewing thread fineness. It is noted that the AOTI is significantly affected by the sewing thread

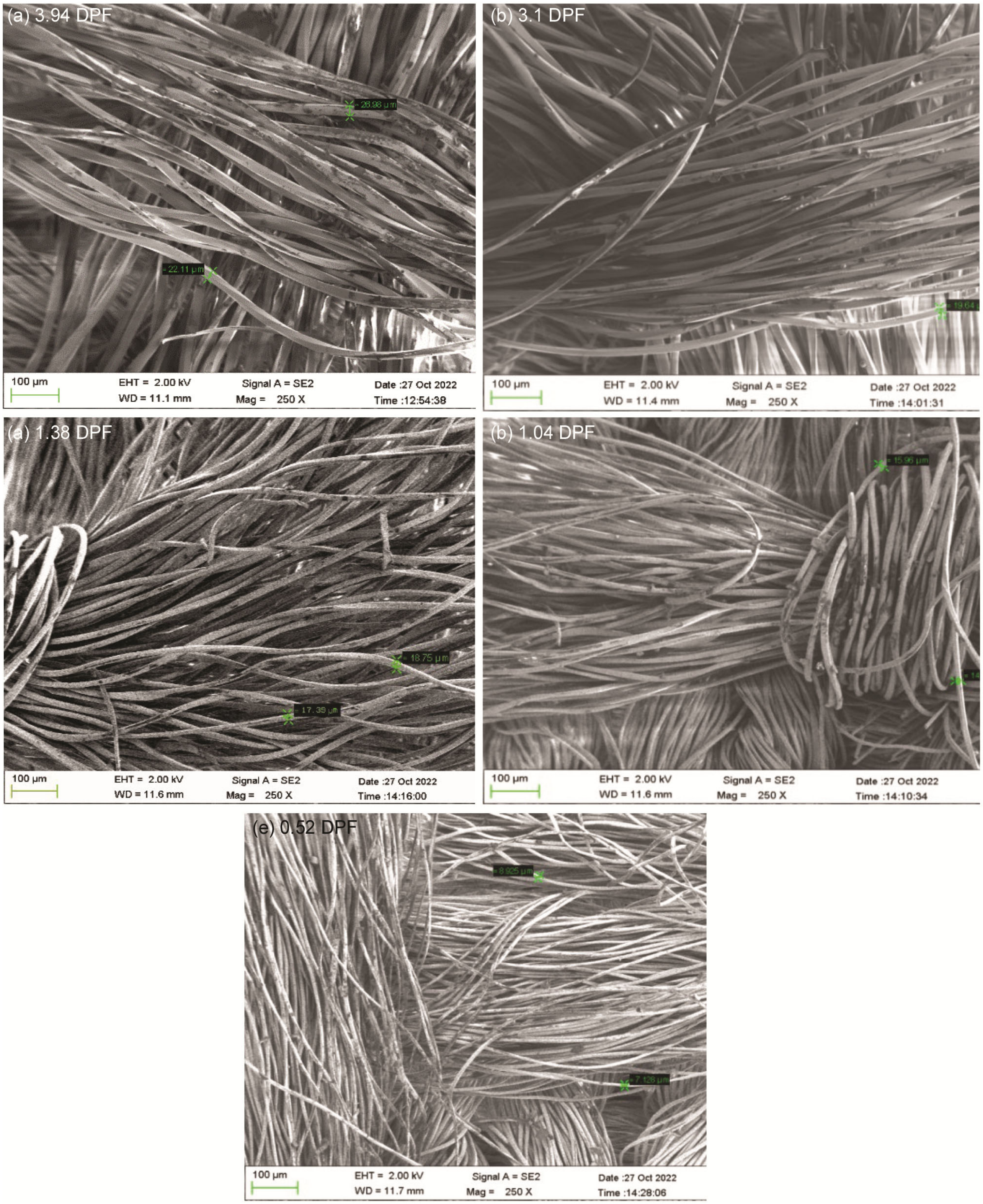
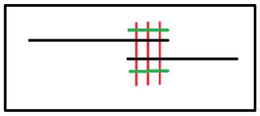
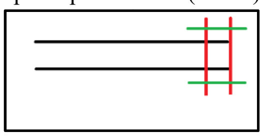


Fig. 5 — SEM images of sewing threads with five different filament fineness values on seam line

Table 1 — Technical parameters of seams (single jersey 100% polyester fabric)
[Weight = 150 gsm, Size = 150 den, TPI = 3 -4]

Seam type	Stitch type	Number of filaments in the sewing thread	Denier per filament, dpf	Number of threads involved	Seam thickness mm
Lapped seam 1 (LS_a-1)	Stitch class 605	34	3.94	5 Threads (3 needle threads, 1 looper thread, 1 covering thread)	1.71
		48	3.1		1.72
		108	1.38		1.70
		144	1.04		1.68
		288	0.52		1.65
Superimposed seam (SSa-2)		34	3.94	4 Threads (2 needle threads, 1 looper thread, and 1 cover thread)	1.81
	Stitch class 514	48	3.1		1.85
		108	1.38		1.88
		144	1.04		1.79
		288	0.52		1.76

filament fineness and the seam selection of seamed fabrics. AOTI is increased with decreased filament fineness.

Overall moisture management capacity (OMMC) of seamed fabric is also given in Fig. 4(f). Both AOTI and OMMC values are optimum for the seam constructed with 1.38 dpf. The reason behind this is that AOTI and OMMC are entirely based on the result of the rate of absorption, spreading speed, wetted radius, and wetting times. It is inferred that the sewing thread filament fineness is significantly affecting the overall moisture management capacity of the seamed fabric. When the results are compared with the standard grade chart of MMT, the grades are improved from “Good” to “Very Good” from the seam constructed with 3.94 dpf to seams constructed with 1.38 dpf for OMMC. Grades are dropped from “Very good” to “Good” from the seams constructed with 1.38 dpf to seams constructed with 0.52 dpf. These results show that the optimum sewing thread filament fineness is 1.38 dpf when the overall moisture management capability of seamed fabric is concerned.

3.6 Statistical Analysis

3.6.1 One-Way ANOVA

One way-way ANOVA test results prove that there are significant differences in seamed fabric moisture management characteristics when the sewing thread filament varies. From the results of the ANOVA analysis, it is proved that the sewing thread filament fineness is significantly influencing the moisture management properties, such as wetting time, absorption rate, maximum wetted radius, spreading speed and AOTI of the seamed fabric. As a follow-up of one-way ANOVA, Tukey HSD is also performed for the data in order to determine the significant difference between the pairs of group mean.

3.6.2 SEM Analysis

Seam lines with five different sewing threads having various filament fineness are analysed using a scanning electron microscope (SEM) to explore the surface structure of the seam line with micro-denier sewing thread. The results are shown in Figs 5(a)-(e).

4 Conclusion

This work is mainly focused on the impact of sewing thread filament fineness on the moisture management capacity of seamed fabric. Sewing thread filament fineness is significantly influencing the moisture management properties of the seamed fabric. It is concluded that wetting time, absorption rate, and spreading speed have improved when the filament fineness is changing from 3.94 dpf to 1.38 dpf and dropped from 1.38 dpf to 0.52 dpf. This shows that the optimum level of the moisture management capacity of seamed fabric is for the seam made with 1.38 dpf. OMMC values are also indicating the same results. It is concluded that the seam type and sewing thread filament fineness are significantly influencing the overall moisture management capability of seamed fabrics.

References

1 Vidhya M, Parveen Banu K, Vasanth Kumar D, Prakash C & Subramaniam V, *Tekstil Konfeksiyon,* 31 (2022) 37.

2 Vidhya M, Parveen Banu K, Vasanth Kumar D, Prakash C & Subramaniam V, *Tekstil Konfeksiyon,* 31 (2021) 295.

3 Mohapatra S, Vidya T, Kumar D V, Rajwin A J, Babu VR, Prakash C, Anas Shah B & Roy R, *Fibres Text East Eur,* 29 (2021) 50.

4 Sampath M B, Prakash C & SenthilKumar M, *Indian J Fibre Text Res,* 45 (2020) 102.

5 Gerhardt L C, Mattle, N, Schrade, GU, Spencer ND & Derler S, *Skin Res Technol,* 14 (2008) 77.

6 Maanvizhi M, Prakash C & Rameshbabu V, *Fibres Text East Eur,* 28 (2020) 72.

7 Srinivasan J*, Engineering Finer and Softer Textile Yarns* (Woodhead Publishing Limited, UK), 2010, 185.

8 Das B, Das A, Kothari V, Fanguiero R & Araujo MD, *J Eng Fiber Fab,* 4 (2009) 20.

9 Havenith G, Heus R & Lotens WA, *Ergonomics,* 33 (1990) 67.

10 Beaudette E & Park H, *Text Res J,* 87 (2017) 1052.

11 Uttam D, *Int J Engg Sci Res*, 2 (2013) 34.

12 Varshney RK, Kothari VK & Dhamija S, *J Text Inst,* 101 (2010) 495.

13 Sampath MB & Senthilkumar M, *J Ind Text,* 39 (2009) 163.

14 Rengasamy R S, Das B R & Patil YB, *J Text Inst*, 100 (2009) 507.