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EFFECT OF WEAVE STRUCTURE ON COMFORT PROPERTIES OF MICROFIBER POLYESTER WOVEN FABRICS

A.A. Dawoud
Eng. Lecturer – Spinning, weaving & knitting Dept., Faculty of Applied Arts, Helwan University, Egypt

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ABSTRACT

Comfort is an important criterion by which customers judge their clothes via the interaction between the body and the textile. The primary role of clothing is to form a barrier that protects the body against unsuitable physical environments. In the present work, microfiber polyester woven fabrics of different weave structure (plain1/1, twill 2/2 and crepe weave) and different number of fibers in yarn cross section (144-288) were the objects of the investigation. Comfort related properties of polyester microfiber fabrics such as air permeability, water vapour permeability; water absorption, thermal resistance, and ultraviolet protection factor UPF are important factors that affect the comfort of textiles. Statistical analysis of test data demonstrated that the weave structure of fabrics under investigation significantly influence the comfort properties.

INTRODUCTION

One of the most important developments in synthetic fiber industry is the production of extremely fine fibers which are named as microfibers. Until today, there is no exact definition for microfibers, but generally microfiber is defined as a fiber (including staple fibers and filaments) of linear density approximately 1 dtex or less, and above 0.3 dtex. Even finer fibers are produced, of 0.3 dtex or less, but these are commonly referred to as super-microfibers (Table 1) 1 dtex polyester fiber has a fiber diameter of approximately 10 µm [1]–[3].

Table 1. Relationship between fiber linear density and fiber classification

Fiber count, dtex/f	Fiber classification
> 7.0	coarse
7.0-2.4	medium fine
2.4-1.0	fine
1.0-0.3	micro
< 0.3	super-microfibers including nanofibers when their cross-sectional dimensions are within a range of nm, that is of <0.1dtex or <1µm

Microfibers are being increasingly used throughout the world for various end uses due to their fineness, light weight, durability, drapeability, wrinkling resistance, breathability, more comfortable to wear, high performance characteristics, and their unique ability to be engineered for a specific requirement [1], [4].
Moreover, Microfibers are super-absorbent, absorbing over 7 times their weight in water and dries in one-third of the time of ordinary fibers [2].

Tightly woven fabrics produced from microfibers yarns have a very compact structure due to small pore dimensions between the fibers inside the yarns and between yarns themselves. Even if tightly woven, microfiber yarns have a low weight per unit area and are not stiff. Polyester microfibers can be used to create fashionable women's outerwear fabrics with a new hand and smooth drape [5]. Microfibers are used in a variety of fabrics, but most commonly in dress and blouse weight garments. Suit jackets and bottom weights are becoming available [6].

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As the color and appearance of microfibers resembles silk, these fabrics can be used for blouses, dresses, tailored suits, hosiery and evening wear. Fabrics produced with microfiber yarns are consequently softer and drape better than those made with normal fiber yarns [1], [3].
Moreover, very dense fabrics produced from microfibers extend the specific fabric or fiber surface area and at the same time develop more pores to transport vapour out by their superior capillary action. The higher pore density also provides better thermo regulation. Accordingly, Finer fibrils will provide higher specific area, better vapour transmission, softer handle, higher fabric density, better cover and lower flexing resistance [7]. Comfort properties of polyester microfiber fabric are more in terms of wicking when compared with natural and conventional fabrics (non- micro fiber fabrics [8]. As microfiber wicks moisture away from the body, it keeps the wearer cool and dry. As such, it has come to occupy an important position in the category of moisture management fabrics [4].

Human perception of clothing comfort is an interaction between physical, physiological and psychological factors with the surrounding environment when wearing a garment [9]. The thermal balance of a human being is one of the most important functions of clothing, (ref 8) The human body continuously generates heat by its metabolic processes. The body's heat losses are through radiation, convection, conduction, evapouration and through respiration [10]. Clothing creates a barrier between the skin surface and surroundings. This barrier influences not only the heat exchange by convection and radiation, but also the heat exchange by the evapouration of excreted sweat [11]. *In addition,* It reduces sensible heat transfer, while in most cases; it permits evapourated moisture to escape.

When a textile product is valued, comfort is considered as a fundamental property. Comfort is a result of the complicated effect of textile properties which basically depends on the chemical structure and physical characteristics of its constituent fibers, fiber content, physical properties of its constituent yarns [12], weight, moisture absorption, heat transmission, air permeability and skin perception . *Accordingly,* comfort is considered to be a multidimensional and complex phenomenon [9].

Comfort properties of fabrics play a crucial role in cold, wind and warm environment. It also protects against the other environmental factors such as UV or IR radiation, chemicals, etc. Textiles are excellent materials for UVR protection and most UV can be blocked by common clothing [13].
The UVR protection of a fabric depends on fiber content, weave, fabric color, finishing processes, the presence of additives, and laundering [14]. Fabric construction, which determines the porosity and type of weave, is the most important factor affecting UV protection. The tighter the weave, the lesser the UVR transmitted. Moreover, UVR is also affected by on the moisture absorption capabilities of thefibers/fabrics. Generally, fabrics provide less UVR protection when wet [9], [15].

EXPERIMENTAL WORK

In the present work 4 samples of microfiber PET woven fabrics were produced by three different weaves structures (plain 1/1– twill 2/2– woven crepe). Polyester warp yarns were the same for all samples (70/1 denier, 36 warps/cm). Similarly, the same weft yarns were used for all samples (150/1 denier, 33 picks/cm). Moreover, for plain weave two different number of fibers in yarn cross section were used (144 and 288). Table 2 lists the constructional parameters of fabrics under study.

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Air permeability, Water absorption and ultraviolet protection factor UPF were determined according to (ASTM D737, AATCC test method 79, ASTM D6603) respectively Thermal resistance and relative , Water vapour permeability were measured on (Permetest skin model Instrument - ISO11092),. The results were evaluated statistically according to one-way variance analysis (ANOVA) in order to evaluate the significance of comfort related properties of produced fabrics.

Table 2. Constructional parameters of fabrics under study

sample no.	weave structure	Fiber type	No. of fibers/ cross section	Warp (density/ cm)	Warp count (denier)	weft (density/ cm)	Weft count (denier)

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1	Plain1/1	PET micro fiber	144	36	70/1	33	150/1
2	Twill 2/2						
3	Crepe						
4	Plain1/1		288				

RESULTS AND DISCUSSION

In this experimental study, comfort related properties of polyester microfiber fabrics such as air permeability, water absorption, thermal resistance, water vapour permeability, and ultraviolet protection factor UPF, were discussed. The results are represented graphically and discussed below.

Table 3. Test results of produced fabrics

No.	sample type	Air permeability (L/m^2s)	Water absorption (sec)	Thermal resistance (m^2K/W)	Relative water vapour permeability (%)	UPF
1	Plain1/1 (144)	73.2	15.57	3.1	77.1	+50
2	Twill 2/2 (144)	127	10.29	2.8	77.6	+50
3	Crepe (144)	257	4.68	2.4	79.5	+40
4	plain1/1 (288)	57	7.39	3.7	79.7	+50

3.1 air permeability

Results presented in Table 3 and Figure 1 show that crepe weave shows higher air permeability value than twill 2/2 and plain 1/1. The difference observed was due to difference in their characteristic covering properties. Crepe weave has a looser structure when compared to other structures because. This may be attributed to the shorter float length of plain and twill weaves which hinders the air flow and hence the lower air permeability values of the more compact structures when compared to the float length of crepe fabrics .[16]. Table 4 shows that the effect of weave structure on air permeability is significant.

When comparing the air permeability results of plain 144 fibers/cross section and that of 288 fibers/ cross section it becomes clear that the air permeability of the 288 fibers/cross section is less than that the former sample. This can be attributed to the compact nature of the 288 fibers yarn that stems from the higher number of fibers that are packed in the same space of that of the 144 fibers sample which in turn hinders the free passage of air through the fabric and hence the lower air permeability result.

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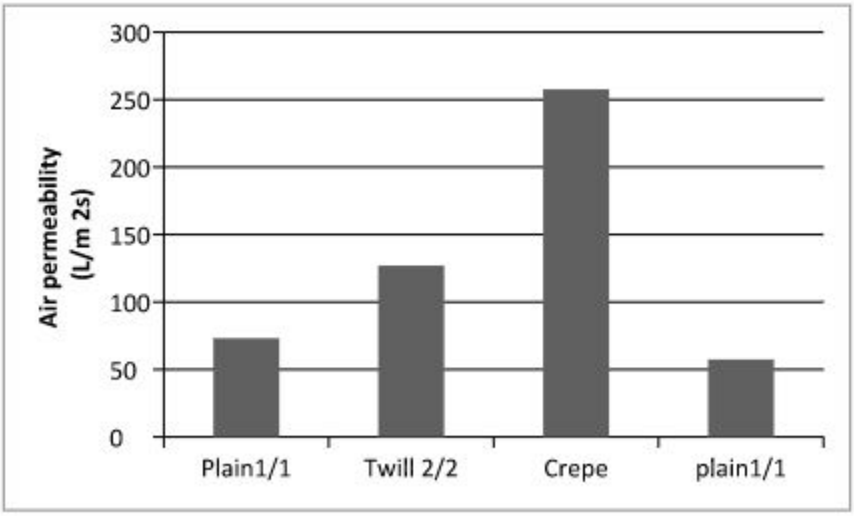

Figure 1 Effect of weave structure on air permeability

Table 4 ANOVA chart for weave structure and air permeability test

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	53996.17	2	26998.08	2423.285	1.89E-09	5.143253
Within Groups	66.84667	6	11.14111			
Total	54063.02	8				

3.2 water absorption

For this test a drop of water is allowed to fall from a fixed height onto the taut surface of a test specimen. The time required for the specular reflection of the water drop to disappear is measured and recorded as water absorbency time. Water absorbency results of different weaves plain1/1, twill 2/2, and crepe weaves are shown in Figure 2 and Table 3. By reviewing the results it is obvious that crepe weave fabric samples have significantly higher water absorbency in comparison with the other structures Table 5 . Accordingly, Crepe weave takes less time (sec) to absorb the water drop. This may be attributed to the loose and more open structure of crepe fabrics when compared to the other structures which offer more space for water to be trapped in and hence the better absorption time.

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On the other hand, with respect to plain weave It is seen that 288 fibers/cross-section had a higher water absorbency than 144 fibers/cross section fabric. This is due to the more surface area available for water absorption present in the 288 fibers/cross-section yarn variant.

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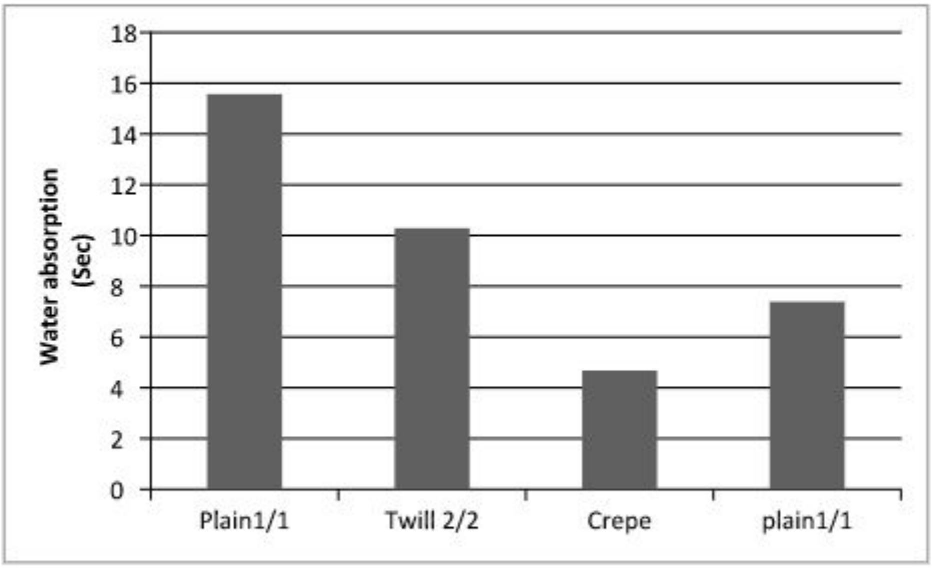

Figure 2 Effect of weave structure on water absorption

Table 5 ANOVA chart for weave structure and water absorption test

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	177.8326	2	88.91631	203.3096	3.07E-06	5.143253
Within Groups	2.624067	6	0.437344	-	-	-
Total	180.4567	8	-			

3.3 Thermal Resistance

The insulation value of a fabric is measured by its thermal resistance which refers to its ability to resist the heat flow through it.

Influence of weave structure on thermal properties of fabric is listed in Table 3 where the plain 1/1 weave showed the highest thermal resistance. On the contrary, twill 2/2 weave and crepe weave showed the lowest thermal resistance. This is because of interlacing points in weave structure, as plain 1/1 weave has the maximum yarn interlacing points between warp and weft. The compact nature leads to the formation of more air gaps when compared to crepe samples. And as air has low thermal transmittance, the plain samples show better thermal resistance values compared to crepe samples. On the contrary, twill 2/2 and crepe weaves showed the lowest thermal resistance due to its relatively less number of yarn interlacing points between warp and weft compared to plain weave, and thus these weave structures lead to the formation of less air gaps. ANOVA results in Table 6 show that the effect of fabric structure on thermal resistance is statistically significant for fabrics under study.

Thermal resistance of fabrics produced from 288 fibers/cross section was higher than that produced from 144 fibers/cross section. This may be attributed to the fact that yarns with finer filaments have a high number of micro pores between the filaments as more air is held in the intra fiber and inter yarn pores. As a consequence, fabrics which have more pores in the structure, where more air is held, have higher thermal resistance.

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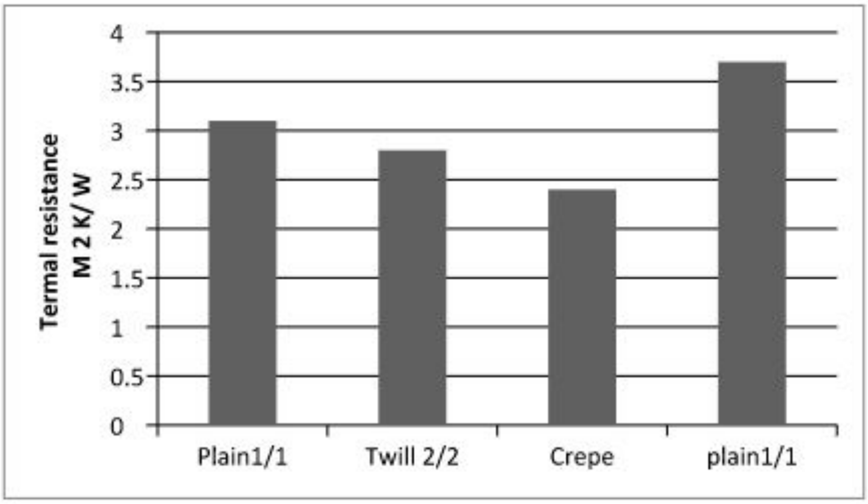

Figure 3 Effect of weave structure on thermal resistance

Table 6 ANOVA chart for weave structure and vapour permeability test

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.486667	2	0.243333	10.95	0.009946	5.143253
Within Groups	0.133333	6	0.022222			
Total	0.62	8				

3.4 water vapour permeability

Results presented in Table 3 and Figure 4 show that water vapour permeability values are affected by the weave structure. Moreover, Differences observed among the relative water vapour permeability values of the fabrics produced having different weave structures were statistically significant Table 7. From the aforementioned Table and figure it is clear that crepe fabrics scored the highest water permeability value. On the other end of the spectrum, plain fabrics scored the lowest value for water vapour permeability. The improved water vapour permeability of crepe fabrics may be attributed the loose structure for that type of fabrics which results from low interlacing points and long float length. On the contrary, twill and plain structures are characterized by tight structure due to the high number of interlacing points and shorter float lengh when compared to crepe fabrics.

Similarly the fabrics produced from 288 fibers/cross-section had higher relative water vapour permeability values than those produced from 144 fibers. It has to be pointed out that water vapour when it comes into contact with the fabric surface it condenses and thus its transport through the fabric will follow the same rules that govern the passage of liquids through fabrics. Accordingly, the 288 fibers/cross section yarn variant contains finer channels between the fibers inside the yarn, and hence the capillary effect will be more than that of the 144 fibers/cross section yarn variant and so will be its water vapour permeability [17].

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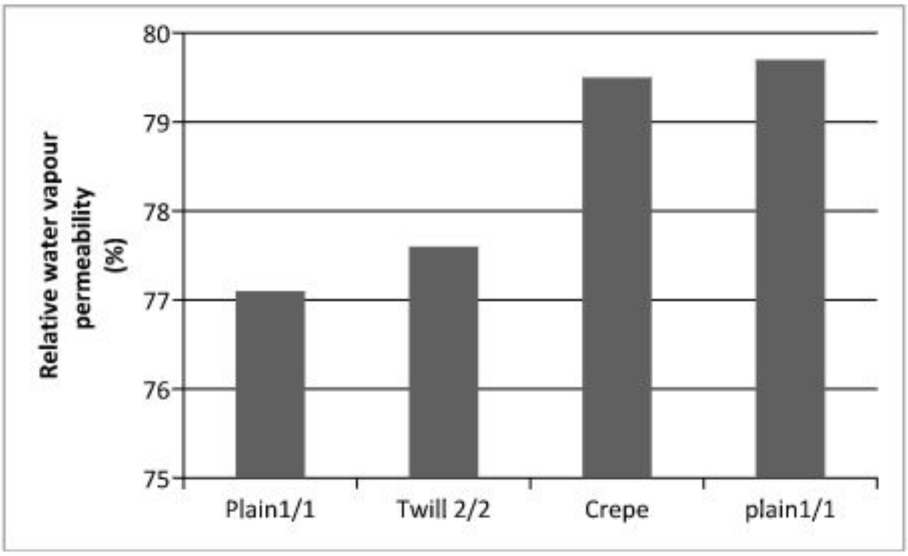

Figure 4 Effect of weave structure on water vapour permeability

Table 7 ANOVA chart for weave structure and water vapour permeability test

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.46	2	2.73	8.029412	0.020124	5.143253
Within Groups	2.04	6	0.34			
Total	7.5	8				

3.5 ultraviolet protection factor UPF

The evaluation of the protection of the woven fabric samples against UV radiation is shown in Table 3. All samples showed excellent UV protection where plain and twill weave structures recorded UPF 50+, and crepe recorded 40+. This can be explained by the higher porosity of crepe weave than other weave structures which permits the ultra violet rays to partially penetrate the fabric.

CONCLUSION

Fabrics produced with polyester are being increasingly used throughout the world for various end uses due to their high performance characteristics and their comfort ability. Several textile properties would influence the comfort of fabric, such as air permeability, thermal resistance, water vapour transmission, water absorbency and ultraviolet protection factor UPF. The research results proved that weave structure has a statistically significant effect on comfort related properties of the fabrics. It can be concluded from the experimental results that crepe weave has the highest air permeability, thermal resistance, water vapour transmission, water absorbency among the selected weaves, and lowest value of ultraviolet protection factor UPF. The fabrics produced from 288 fibers in yarn cross-section presented higher thermal resistance, water vapour transmission and water absorbency values, and lower air permeability values compared to those produced from 144 fibers in yarn cross section.

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