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Effect of Microfiber Yarn's Linear Densities on Blanket's Water Vapour Transmission Ratio

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Abstract

Microfibers are considered a great development and expansion in the field of synthetic fibers production. These fibers have many special properties which improved many textile products. The main objective of this research is studying the effect of different linear densities of polyester microfiber yarns that are (1600/1527, 1200/1152, 2000/1920 denier) on weight, and water vapour transmission ratio of blankets. Polyester microfiber yarns have the same fiber linear density which is 1.04 denier; however, there is a considerable difference in the number of fibers in yarn's cross section. Warp yarn's count, the linear density of weft and warp yarns, design and other production variables are constant where the effect of microfiber weft yarn's count difference is determined by water vapour transmission of blankets which many researches didn't subject it and focused on thermal insulation, softness, weight etc. Water vapour transmission through fabrics depends on capillary action in terms of size and density of capillaries tubes which depends on fiber type, fiber density, yarn type, yarn count, yarn structure and fabric formation system. Due to using different linear densities of microfiber yarns and number of fibers per cross section of polyester microfiber yarns, cover factor is calculated as one of the most important factors. The results showed that there is a strong direct relationship between total cover factor and water vapour transmission. Also, there is a strong inverse relationship between total cover factor and weight.

Keywords: Cover factor; Microfibers; Water vapour transmission

Introduction

One of the most important developments in synthetic fibers industry is absolutely producing extremely fine fibers which are named as microfibers. Microfibers were developed because of improved in engineering techniques and because of the need for lightweight, soft water proof fabrics [1]. A microfilament can be defined as a filament finer than 1 dtex or 1 denier [2]. Micro denier fibers have excellent flexibility, improved regularity, higher elongation, better softness, drape, dimensional stability and wicking, thus ensuring better mechanical and comfort properties [3]. Woven fabrics produced from microfilament yarns are superior to conventional filament fabrics in rain clothes, tents, parachutes, sails, wind-proof clothes, sleeping bags, filters, sportswear, ladies apparel, synthetic leather, cleaning fabrics, automotive application, furniture and upholstery fabrics [4-6].

Comfort is a pleasant state of psychological, physiological and physical harmony between the human being and the environment. The processes involved in human comfort are physical, thermo physiological, neuron-physiological and psychological [7]. Water vapour can pass through textile layers by the following mechanisms:

- Diffusion of the water vapour through the layers.
- Absorption, transmission and desorption of the water vapour by the fibers.
- Adsorption and migration of the water vapour along the fiber surface.
- Transmission of water vapour by forced convection [7-9].
- Capillary transport of condensed water through the structural capillaries of textiles used [8].
- Mechanical interactions in the form of pressure, friction and dynamic irregular contact [9].

Evaporation of sweat becomes an important avenue of body heat loss and fabrics must allow water vapor to escape in time to maintain the relative humidity between the skin and the first layer of clothing at about 50% [10]. If resistance to water vapor diffusion is high, the water vapor transfer is impeded and the discomfort sensation of dampness and clamminess may arise [10,11]. Water vapour can diffuse through a textile structure in two ways, simple diffusion through the air spaces between the fibers and yarns and along the fiber itself. Moisture vapour transfer though textile material by absorption desorption method is mainly influenced by moisture regain of the material and humidity (%) of the atmosphere. In forced convection process, moisture transfer takes place while air is flowing through the fabric layer and taking moisture vapour along with it. The mechanism in which moisture is transported in textiles is similar to the wicking of a liquid in capillaries. Capillary action is determined by two fundamental properties; its diameter; and surface energy of it inside face. Moisture vapour transmission relies on the existence of a temperature/pressure gradient between inside and outside of the garment. Once body moisture reaches the inner face of the garment, it must pass through the fabric and then evaporate on the surface. If it can't pass through the fabric, or if the rate of transmission is slower than the arrival of extra vapour, then the vapour condenses on the inside face [12]. There are several factors, which affect moisture transport of a fabric. The most important are:

- Fiber type
- Cloth construction or weave.

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- Weight or thickness of the material and
- Chemical treatment

Materials and Methods

Three samples were produced by using three different linear densities of polyester microfiber yarns (1600/1527, 1200/1152, 2000/1920 denier) respectively as wefts with acrylic (2.1 Nm).

All finishing and raising processes were carried out for all produced samples under the same conditions. Total cover factor is calculated for all blankets samples as an important research variable as shown in Table 1. Cover factor indicates the extent to which the area of a fabric is covered by one set of threads. For any fabric, there are two cover factors: the warp cover factor and the weft cover factor. The cloth cover factor is obtained by adding the weft cover factor to the warp cover factor.

Warp Cover Factor=Warp yarn density per inch ÷ √warp linear density (Ne)

Weft Cover Factor=Weft yarn density per inch ÷ √weft linear density (Ne)

Total Fabric Cover Factor=Warp Cover Factor + Weft Cover Factor

Fabric weight, water vapour transmission were determined according to (ASTM D3776/D3776M – 79a, ISO 11092:2014) respectively [13,14]. The results were analyzed statistically according to studying the relationship between total cover factor and selected properties by using simple linear regression and correlation coefficient.

Results and Discussions

Test results of blankets samples

The results in Table 1 showed the total cover factor values of blankets samples, results of weight, and water vapour Transmission tests. All blankets production variables are constant in all produced samples except yarn count of polyester microfiber used as wefts and number of fibers per polyester microfiber yarn cross section.

Weight test results

From Table 1 and Figures 1-4 shows that the weight values decreases as the total cover factor increases. That means sample which was produced using polyester microfiber yarn with linear density 2000/1920 denier gave the highest value in total cover factor and lowest weight.

MVTR Test results

From Table 1, Figures 2 and 5 it is visible that the water vapour permeability values increases as the total cover factor increases. That means sample which was produced using polyester microfiber yarn with linear density 2000/1920 denier gave the highest value in total cover factor and water vapour permeability because of an increasing in number of capillaries tubes or spaces between fibers with themselves that allow water vapour to pass easily as shown in Figure 3.

This is calculated mathematically as follows:

The number of capillary tubes/cm=number of fibers per yarn cross section×polyester microfiber wefts density/cm,

The number of capillary tubes/cm in Sample No. 1=1920 × 7=13440 capillary tubes,

(where as wefts/cm=14, were arranged 1 face polyester microfiber weft: 1 back acrylic weft),

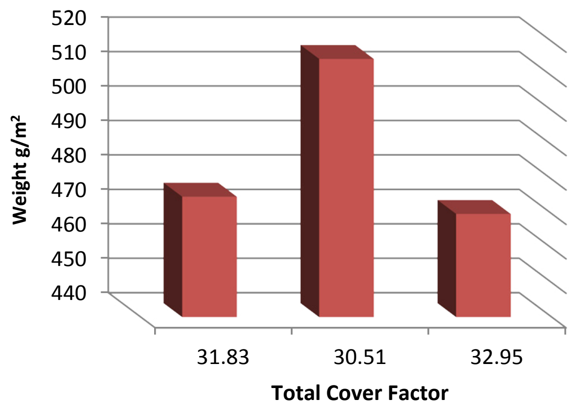

Figure 1: Relationship between total cover factor and weight.

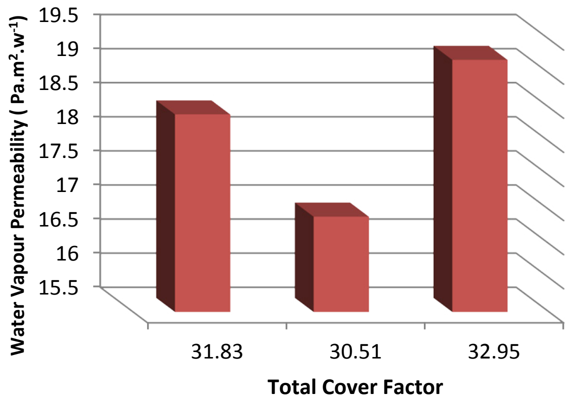

Figure 2: Relationship between total cover factor and water vapour permeability

Sample No.	Weft yarn specifications			Cover factor			Weight (g/m²)	Blanket weight	Water vapour transmission (Pa.m².w⁻¹)
	Material	Liner Density	Density/cm	Weft	Warp	Total			
1	Polyester Microfiber	1600 Den/1527F	7	9.77	6.037	31.83	475	2491	18.4
	Acrylic	2.1 Nm	7	16.01					
2	Polyester Microfiber	1200 Den /1152F	7	8.47	6.037	30.51	515	2298	16.9
	Acrylic	2.1 Nm	7	16.01					
3	Polyester Microfiber	2000 Den /1920F	7	10.9	6.037	32.95	470	2273	19.2
	Acrylic	2.1 Nm	7	16.01					

Table 1: Tests results of blankets samples.

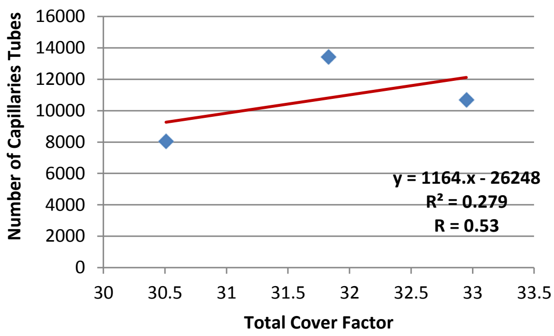

Figure 3: Simple linear regression between Capillaries tubes and Total cover factor.

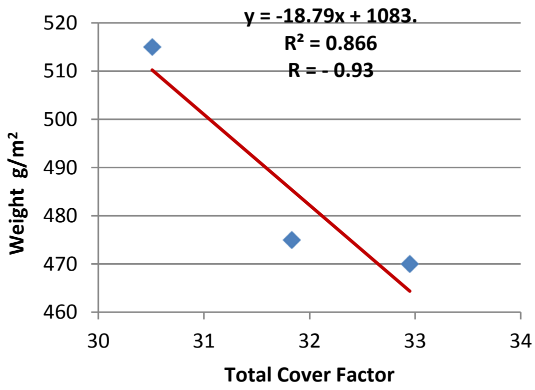

Figure 4: Simple linear regression total cover factor and weight.

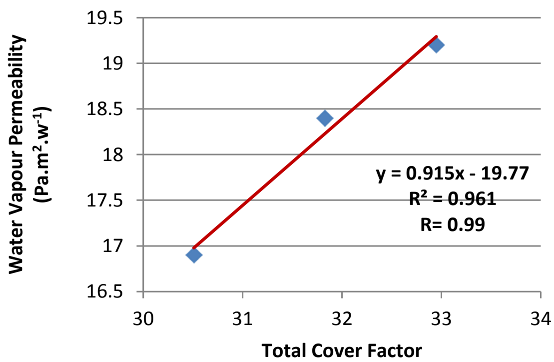

Figure 5: Simple Linear Regression between total cover factor and water vapour permeability.

The number of capillary tubes/cm in Sample No. 2=1152 × 7=8064 capillary tubes,

The number of capillary tubes/cm in Sample No. 3=1527 × 7=10689 capillary tubes,

Number of capillaries tubes in samples and total cover factor.

Data analysis

- By calculation of the weight of blankets, it can be see that the lightest blanket is samples no.3 which weighs 2273 gm, followed by sample no.1 and sample no.2 which weigh 2298 and 2491 gm respectively.
- There is a strong inverse relationship between total cover factor and weight by studying the correlation coefficient that is (R=-0.93) as shown in Figure 4. It's explained that an increasing in microfibers lead to increasing in cover factor and therefore decreasing fabric weight.
- There is a moderate relationship between total cover factor and number of capillaries tubes in each sample by studying the correlation coefficient that is (R=0.53) as shown in Figure 3. It's explained that an increasing cover factor leads to increasing in capillaries tubes of microfibers and consequently increasing water vapour transmission.
- The highest water vapour permeability of sample no.3 which was produced by using polyester microfiber yarns 2000/1920 denier as wefts with acrylic because of increasing in number of capillaries tubes that allowed water vapour to pass easily through the yarn and the fabric. So, there is a strong direct relationship between total cover factor and water vapour permeability by studying the correlation coefficient that is (R=0.99) as shown in Figures 4 and 5.

Conclusions

- It can be concluded that total cover factor is an important factor affecting on functional performance of blankets and comfort characteristics by reducing weight, improving water vapour permeability and thermal insulation properties.
- Using microfiber yarns significantly contributed to reducing weight of blankets and this is indicated by the calculation of the weight of each produced blanket where it was concluded that sample no.3 has the lightest in comparison with other samples.
- Sample no.3 which has the highest cover factor has recorded the best results in weight, and water vapour permeability tests results.
- There is a strong inverse relationship between total cover factor and weight that means an increasing in cover factor leads to decreasing in blanket's weight.
- There is a direct moderate relationship between the number of capillaries tubes in each sample and total cover factor that means an increasing in total cover factor leads to an increasing in microfiber yarns and increasing in number of capillaries tubes which allow water vapour to pass effectively.
- There is a strong direct relationship between total cover factor and water vapour permeability that means an increasing in cover factor leads to increasing in water vapour transmission.

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