INFLUENCE OF NATURAL CELLULOSIC FIBERS AND REGENERATED CELLULOSIC FIBERS ON PHYSIOLOGICAL COMFORT OF KNITTED FABRIC

تأثير الألياف السليلوزية الطبيعية والألياف التحويلية السليلوزية على الراحة الحرارية لأقمشة التريكو

By

Alaa Arafa Badr[1], Moustafa Elokeily[1] and Ramsis Farag[2]
[1]Textile Engineering Dept., Faculty of Engineering, Alexandria University
[2] Textile Engineering Dept., Faculty of Engineering, Mansoura University
Alaa300_2000@hotmail.com

الخلاصة:

تلعب خاصية الراحة دورا هاما فى إختيار الملابس، حيث أنها تعتبر خاصية أساسية عند تقييم المنتجات النسيجية، ويمكن التعبير عن الراحة الفيسيولوجية بالتوازن الحراري وإنتقال الرطوبة. والشرط الأساسي عند إرتداء أى ملبس هو أن يساعد على إخراج رطوبة الجسم الى الجو الخارجى. إن التحكم فى إنتقال الحرارة والرطوبة خلال المواد النسيجية يعتمد أساسا على خصائص الخيط و القماش وكذلك على التركيب الهندسى للخيط والقماش. والهدف من هذه الدراسة هو إيجاد حل وسط بين سمات القماش التي تحدد راحة الملبس والتكلفة الاقتصادية (بسبب إرتفاع سعر القطن المصري وقلة الكميات المتوفرة منة في السوق)، وحيث يستند الحل المقترح على إستخدام أنواع أخرى من ألياف القطن والألياف السليلوزية التحويلية. لذلك فإنة تم إختيار القطن اليوناني وألياف المودال السليلوزية التحويلية لهذه الدراسة، إلى جانب القطن/المودال المخلوط. وأيضا تم عمل مقارنة تحليلية لخصائص الراحة الحرارية (مثل التوصيل الحراري، وامتصاص الحرارة ، والمقاومة الحرارية ونفاذية بخار الماء) لأقمشة مصنعة من أقطان بأنواع مختلفة، ومن نسب خلطات مختلفة من القطن والمودال. تم إنتاج جميع الأقمشة المستخدمة بمعامل إحكام متوسط. أيضا تم إستخدام تركيبين نسجيين مختلفين من أقمشة التريكو " 1×1 ريب و إنترلوك". جميع القياسات تم تنفيذها على القماش المجهز بإستخدام جهاز ALAMBETA وطريقة الكوب "ASTM E 96". وقد أظهرت النتائج أن أقمشة التريكو المصنعة من القطن المصري صنف جيزة 86 ومن خلطات قطن مصرى مع شعيرات المودال لها قيم أعلى للتوصيل الحراري ، وامتصاص الحرارة ، ونفاذية بخار الماء و قيم أقل لمقاومة الحرارة عن تلك الأقمشة المصنوعة من ألياف القطن اليوناني. ولوحظ أيضا تأثير تركيب القماش على الخواص الحرارية لجميع أنواع الأقمشة المنتجة من الأقطان المختلفة ومن الأقطان المختلفة المخلوطة بشعيرات المودال.

Abstract

Personal comfort plays a very important role for the choice of apparels. It is considered as a fundamental property when a textile product is valued. The physiological fabric-skin comfort may be expressed by thermal balance and moisture transmission. The basic prerequisite of fabric worn next to skin is that it should help in the moisture release to the atmosphere. Heat, air, and moisture transport through a textile material is controlled mainly by both the fabric and yarn structural properties and the geometry of fabric.

The objective of this study is to find a suitable compromise between the fabric attributes which determine clothing comfort conditions and the economical situation, which recently appeared in the very high price of Egyptian cotton, in addition to the small quantities available in the market. So the solution is based on using other kinds of cotton fibers and regenerated cellulosic fibers. Greek cotton and Modal regenerated cellulosic fibers are selected for this research study, besides cotton/Modal blend. A comparative analysis of thermal comfort properties (such as thermal conductivity, thermal absorption, thermal resistance and water vapor permeability) of fabrics made of different cotton types and different blend ratios of cotton/Modal yarns was presented in this research. All fabrics have a medium tightness level. Two kinds of knitted structures were selected, 1 x 1 rib and interlock structures. The

Accepted March 31, 2012

measurements were carried out on finished knitted fabrics with the use of the ALAMBETA device and cup method, ASTM E 96. The fabrics knitted from Egyptian cotton (Giza 86) fibers and from their blends with Modal fibers showed higher values of thermal conductivity, thermal absorption, relative water vapor permeability and lower values of thermal resistance than fabrics made of Greek cotton fibers. The influence of fabric structure on thermal properties was observed for all tested fabrics.

Key words: Thermal comfort, thermal conductivity, thermal absorption, thermal resistance, Greek cotton, Egyptian cotton, Modal blend ratio, knitted fabrics, moisture transport.

1- Introduction:

The demands from fabrics have changed with developments in textile technology and the rise of people's living standards. Now the requirement is not only physical and dimensional properties, but also thermal comfort properties [1-2]. During heavy activities, the body produces lots of heat energy and the body temperature increases. To reduce the high temperature, the body perspires a lot of moisture and vapor form. While this perspiration is transmitted to atmosphere, the body temperature is reduced and then the body feels cool. So the garments should allow the perspiration to pass through, otherwise it will result in discomfort [3]. Therefore, it becomes essential to benefit from the special properties of fibers for high levels of body comfort by using fiber blends, as Oglakcioglu [2] concluded. Therefore, the main target of this paper is to combine the good comfort properties of cotton fibers and the hygroscopic and smoothness properties of Modal fibers to knit fabrics with superior comfort properties.

Cotton remains without a doubt the main natural fiber. Due to good handle and hygienic properties, it can be worn next-to-skin. Moreover, it has good water vapor and air transport, so it is favored for summer garments [2].

It was found that the Modal fiber are harmonic with the cotton fibers after blending with each others in the spinning process and this adds advantages to cotton like processing propensity The reason of this trend is referred to the extra fiber length and fineness of the Modal fibers [4].

Comfort, which is defined as a pleasant state of psychological and physical harmony between a human-being and environment, became the most important feature along with the development of textile technology [5]. Clothing comfort includes three main considerations: psychological, sensorial and thermo-physiological comfort. The thermo-physiological comfort which is the subject of this research, involves both thermoregulation and also moisture management [6]. It is known that fiber type, yarn properties, fabric structure, finishing treatments and clothing conditions are the main factors affecting thermo-physiological comfort.

The effect of different materials and fabric constructions on the comfort behavior of knitted and woven fabrics was investigated by various researchers [7-12]. Vigneswaran investigated that thermal insulation increases while the fabric density decreases [13]. Skenderi stated that the heat and water vapor resistance increase with the increase of fabric thickness and air captured inside the fabric itself [14]. Marsh also showed that fabric thickness, enclosed still air and external air movement are the main factors that affect the heat transfer through fabric [15]. Pac et al [16] found that, the contact interfacial area between skin and fabric is small for rough fabrics and more air is entrapped on a hairier fabric surface. As a result, these fabrics provide a warmer feeling. The structural roughness and warm–cool feelings of the fabrics change according to fiber type, yarn and fabric structure.

The thermal resistance of the textured polyester fabrics are higher than the fabrics produced with non-textured polyester filaments, because of the increased inter-fiber pore dimensions and the consequent thickness. By texturing, the thermal absorptivity values decrease and the contact feeling becomes warmer and this is related to the decrease of contact area between the textured yarns and skin [17].

The spinning method had a significant effect on thermal comfort properties. The fabrics knitted from ring yarns had warmer feeling at first touch and provided more thermal insulation but less water vapor permeability than the fabrics knitted from OE yarns [2]. Ozdil explored thermal properties of 1 x 1 rib fabrics knitted by using different yarn twist level. When the yarn twist is increased, thermal conductivity also increase and these fabrics give cooler feeling. Thermal conductivity, thermal absorptivity and water vapour permeability values of the fabrics knitted with combed yarns are higher from others knitted fabrics produced from carded yarns [3]. Thermal properties of single jersey, 1×1 rib and interlock knitted fabrics were evaluated by Oglakcioglu and Marmarali [1]. They found that single jersey fabrics have really lower thermal conductivity values and as well as higher relative water vapour permeability, which leads to a warmer feeling at first touch due to lower thermal absorptivity values [1].

2- Theoretical Model

The objective of introducing a theoretical model is mainly to illustrate the mathematical relationship between thermal transmission parameters and fabric geometrical parameters (yarn parameters and fabric construction parameters).

Figure 1 represents a diagrammatic configuration for the single jersey fabric as a model used for the confirmation of the experimental investigation. The model illustrates that the jersey fabric is a bi-component structure composed of fiber material in the form of yarn and air component entrapped between yarns. So, heat is flow in parallel through fiber material and air gaps. Knowing that from all the previous work in heat conductivity and heat insulation that the air is a bad thermal conductor or it has the greater thermal insulation with respect to any material including textile fiber material.

Taking an area of a 1 cm^2 of the fabric,

Then Total area $A_t = A_m + A_a$ ---------- (1)

Where:

t = Total model of investigation

m = Material component

a = Air component

A_t = Area covered by the model

A_m = Area covered by fiber material (yarn)

A_a = Area covered by fiber air (entrapped air) (air pocket)

Area covered by material (yarn) = number of stitches per cm^2 (unit area) "S_d" = c * w

Where:

c = Courses per cm

w = Wales per cm

Area covered by one stitch = ℓ * d

Where:

ℓ = stitch length in cm (from point A to B)

d = yarn diameter in cm

Then S_d * area covered by one stitch = A_m

$A_m = S_d * \ell * d = c * w * \ell * d$

$A_t = A_m + A_a = 1$ ---------------------- (2)

Substituting in equation (2) gives

A_a = Area pocket area = 1- (c * w * ℓ * d) ---------- (3)

But, $d\,(mm) = 4.44 * \sqrt{\frac{Tex}{\rho_f}} * 10^{-3}$

(Grossberg equation [18])

Where:

Tex = Yarn count in tex system

ρ_f = Fiber material density g/cm^3

From equation (3) becomes:

$A_a = 1 - (c * w * \ell * d) = 1 - (4.44 * 10^{-3} * c * w * \ell * \sqrt{\frac{Tex}{\rho_f}})$ -------- (4)

At a unit time the amount of heat flow Q_t could be divided into 2 components

Q_m = Quantity of heat flow through material component

Q_a = Quantity of heat flow through air pocket component

$Q_t = Q_m + Q_a$

Applying the basic equation of heat flow, then

$$\frac{\lambda_t\, A_t\, \Delta\theta}{h} = \frac{\lambda_m\, A_m\, \Delta\theta}{h} + \frac{\lambda_a\, A_a\, \Delta\theta}{h} \quad \text{----- (5)}$$

Where:

λ = Thermal conductivity ($\lambda_m >> \lambda_a$)

A= Area

$\Delta\theta$ = Temperature difference between the two sides of the fabric

h = Fabric thickness

Substituting from equation (4) in (5) gives:

$$\frac{\lambda_t\, A_t\, \Delta\theta}{h} = \frac{\lambda_m\, \Delta\theta * c * w * \ell * d}{h} + \frac{\lambda_a\, \Delta\theta}{h}\left[1 - (4.44 * 10^{-3} * c * w * \ell * \sqrt{\frac{Tex}{\rho_f}})\right]$$

$$\lambda_t = 4.44 * 10^{-3} * \lambda_m * c * w * \ell * \sqrt{\frac{Tex}{\rho_f}} + \lambda_a\left[1 - (4.44 * 10^{-3} * c * w * \ell * \sqrt{\frac{Tex}{\rho_f}})\right] \quad \text{----- (6)}$$

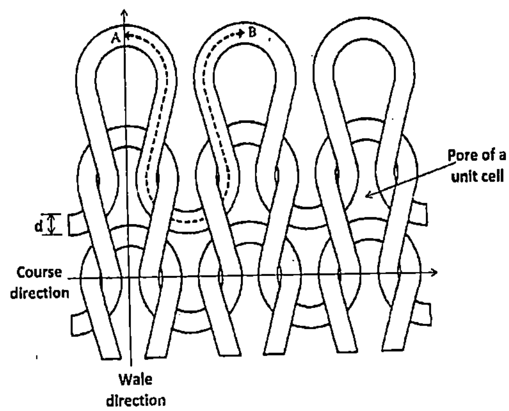


Figure 1 Schematic representation of a plain weft knitted structure

Equation (6) gives the relationship between the heat transfer parameters and fabric geometrical parameters. Moreover, we can deduce the following:

- Air thermal conductivity is less than the conductivity of any material (any fiber). Therefore, as air pocket increases thermal conductivity decreases and thermal insulation increases. This equation gives that conclusion clearly.
-As Air pocket increases both air permeability and water vapor permeability increases
- As material component increases, water absorption increases.

3- Material and Methods:

3-1 Material:

In this study, 24/1, 50/50% Modal/Egyptian cotton Giza 86, 50/50% Modal/Greek cotton, 100% Egyptian cotton Giza 86 and 100 % Greek cotton yarns were applied to knit 1 x1 rib and interlock knitted fabrics. The yarn properties were shown in table 1. Additionally, the Egyptian cotton Giza 86 and Greek cottons properties used in this research are given in table 2. For Modal fibers properties, the fiber length is 38 to 40 mm and the fineness is 1.29 dtex.

3-2 Fabric Manufacture:

The rib samples were knitted on rib knitting machine with 18 gauge Mayer & Cie, 18-inch diameter, 37 feeders and with total number of needles equal to 1080*2. While for the interlock samples, the machine specification was: 20 gauge Mayer & Cie, interlock circular knitting machine with 32 feeders, 16-inch diameter and total number of needles equal to 1008*2.

The loop length was kept constant to produce a medium tightness knitted fabrics. Also, the yarn input tension for all machine feeders and for all samples was adjusted at a constant value equal to 5 CN.

All fabric samples were dyed with a medium color shade inside the overflow dyeing machine and then finished through squeezing and tensionless drying machines respectively and at last all the fabrics were ironed and put in a suitable form by using calendar machine.

3-3 Methodology:

The information about the experiments studied in this research is revealed in table 3. In addition, table 4 clears the design of experiment used in the regression analysis for getting the effect of the studied parameters knowing that: C = Cotton fibers, M = Modal fibers and C/M = Blend cotton/Modal

3-4 Fabric Testing:

After leaving the finished samples 72 hours in standard conditions (Relative humidity = 65 $\pm$ 2%, Temperature = 20 $\pm$ 2 c°), the thermal properties were measured.

Alambeta instrument was used directly to measure thermal conductivity, thermal resistance, thermal absorptivity and fabric thickness values based on the principle of hot and cold plates [19] as shown in figure 2. In this apparatus, the fabric sample is put between a hot and cold plate. The amount of heat flow from the hot plate to the cold plate throughout the fabric is measured by heat flux sensors.

Water vapor permeability was measured using ASTM E 96 - "Standard Test method for Water Vapor Transmission of materials" - cup method [20], as cleared in figure 3. Upright cup is filled with distilled water. The circular sample is put firmly covering the cup. The cup prepared for testing is located in the controlled environment. Under action of a difference of concentration (pressure), water vapor inside of a cup and from the outside makes vapor diffusion through a textile from a cup in an environment. I.e. Vapor transport is passed out from inside of cup to environment (outside of cup).

Table 1. Yarn Properties

	100% Cotton Giza 86	50/50% Modal / Cotton Giza 86	100% Cotton Greek	50/50% Modal / Greek Cotton
Count (Ne)	23.9	23.7	23.9	23.8
Twist (Turns/inch)	18	18	18.2	17.8
Irregularity (CV %)	11.7	11	12.8	11.1
Thin places (-50%)	1	0	3	1
Thick places (+50%)	14	7	30	10
Neps	27	36	91	49
RKM (Kg_f*Nm)	21	24	18.5	20
Elongation %	5.7	8.4	5.3	7.3
Hairiness (H)	7.5	6.8	8.1	7.2

Table 2. Fiber Main Characteristics

	Len	Unif. %	Str.	Elong. %	MIC	Mat.%	Rd	+b	Neps/gm
Egyptian cotton Giza 86	32.8	90	40	5.8	4.3	89	73	9	66
Greek cotton	28	83	28	6.4	3.6	75	63	7	248

Table 3. Experiments Studied in this Research

Sample Number	Cotton type or fiber Type	Fabric Structure	Cotton/Modal Blend Ratio
1	Egyptian	Interlock	100 % C
2	Egyptian	Interlock	50/50 C/M
3	Greek	Interlock	100 % C
4	Greek	Interlock	50/50 C/M
5	Egyptian	Rib	100 % C
6	Egyptian	Rib	50/50 C/M
7	Greek	Rib	100 % C
8	Greek	Rib	50/50 C/M

Table 4. Design of Experiment

Sample Number	Cotton type or fiber Type	Fabric Structure	Cotton/Modal Blend Ratio (cotton %)
1	1	1	1
2	1	1	-1
3	-1	1	1
4	-1	1	-1
5	1	-1	1
6	1	-1	-1
7	-1	-1	1
8	-1	-1	-1

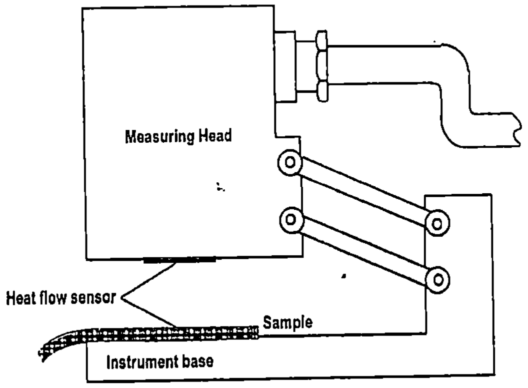


Figure 2 Alambeta instrument [19]

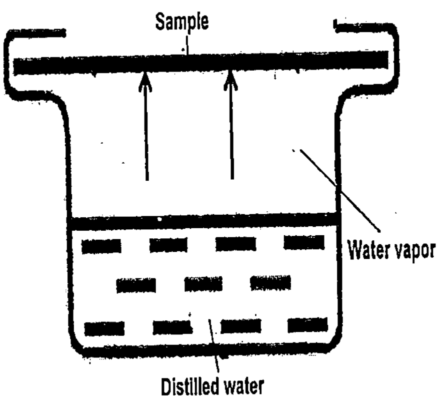


Figure 3 Scheme for measuring water vapor permeability by "cup method" (ASTM E96)

4- Results and Discussion

Evaluation of the test results was based on the use of regression analysis to determine the effect of the factors under study (cotton type, yarn blend ratio and fabric structure) on the thermal comfort. Table 5 shows the regression equations for every studied thermal parameter on the different thermal fabrics properties. To deduce whether the parameters were significant or not, p values were examined. Where, if "p" value of a parameter is more than 0.05 ($p > .05$), the parameter will not be important and should be ignored. Knowing that: CT= cotton type, S = fabric structure, B = Modal blend ratio, EG = Egyptian and GR = Greek.

From the regression analysis, all the studied parameters have a significant effect on all thermal fabric properties due to its lower p-values.

Table 5 – The regression analysis between studied parameters and thermal comfort properties

Thermal Property	Regression equation
Thermal conductivity "λ"	$\lambda = 0.0432+0.0015CT+0.0035S-0.0035B$
Thermal absorptivity "b"	$b = 140.39+1.99CT+15.04S-4.36B$
Thermal resistivity "r"	$r = 0.01761-0.00097CT+0.00052S+0.00241B$
Water Vapour Permeability "WVP"	$WVP = 1706.9+35.62CT-222.12S-65.62B$
Air Permeability "a"	$a = 143.62+9.62CT-61.12S-21.87B$

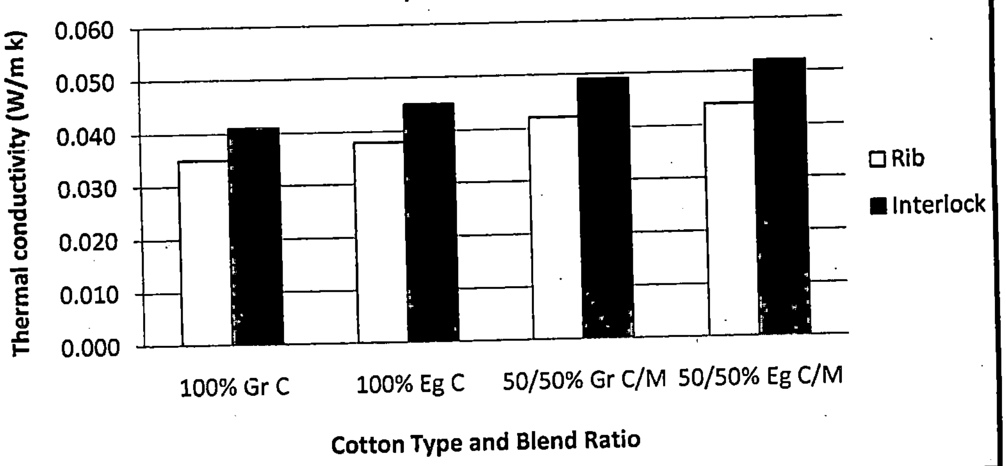
4-1 Thermal Conductivity

Thermal conductivity (λ) is an intensive property of a material that indicates its ability to conduct heat. Thermal conductivity can be thought as an amount of conducted heat transmitted through a fabric thickness "h" in a direction normal to its surface area due to temperature difference. For textile materials, still air in the fabric structure is the main factor for conductivity value, as still air has the least thermal conductivity value compared to all fibers [1, 2, 11, and 13].

Comparing the values of thermal conductivity in relation to the cotton type used, it can be observed that fabrics made of Egyptian cotton Giza 86 have higher thermal conductivity than those made of Greek cotton as shown in the regression equation contained in table 5 and also as observed in figure 4. This could be explained with the properties of the fibers and yarns for the Egyptian and Greek cottons. The less yarn hairiness degree of the Egyptian yarn could be the reason of that trend. As mentioned by Pac and his colleagues [16], the hairs encapsulate air between the emergent fibers and the fabric surface and the trapped air has a lower thermal conductivity than the fibers, also the packing of fibers in cotton Giza 86 has a higher density reducing air gaps inside the yarn. As a result, air carries a low quantity of energy by conduction, and consequently with the increase of hairiness, thermal conductivity decreases too. In addition to the hairiness, the longer fiber length of the Egyptian cotton accompanied with high yarn uniformity also gives a less insulation property. Moreover, from the same figure and from the regression equations included in table 5, as the amount of Modal fiber increased inside the yarn, the thermal conductivity increased. This could be referred to the hairiness level of the cotton yarns, which are more than Modal/cotton blended yarns.

In addition, according to the same figure and regression equation, interlock structure has more thermal conductivity than 1 x1 rib structure. This condition can be explained by the amount of entrapped air in the fabric structure. The amount of fiber in the unit area increases and the amount of air layer decreases as the weight increases. As is known, thermal conductivity values of fibers are higher than the thermal conductivity of entrapped air [1]. So heavier fabrics that contain less still air (like interlock), have higher thermal conductivity values.

Figure 4 Thermal conductivity values for different cotton types and cotton/Modal blend ratios



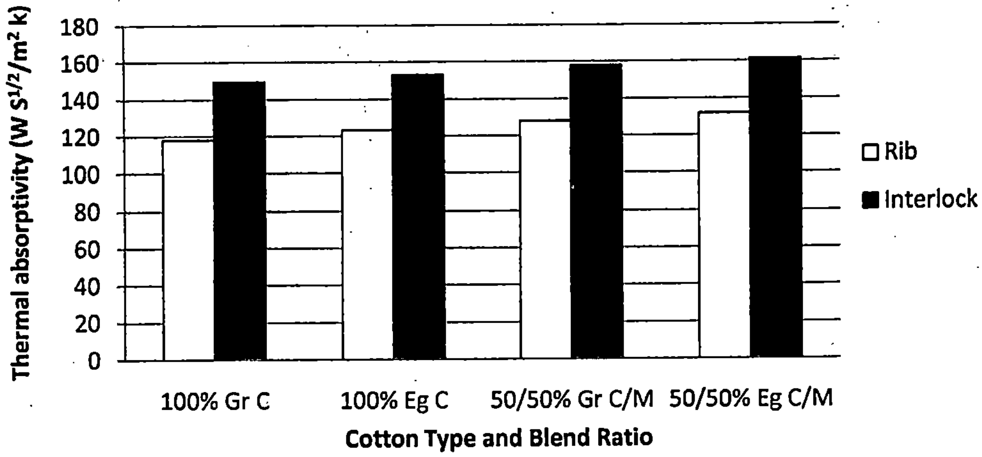
4-2 Thermal Absorptivity

Thermal absorptivity determines the contact temperature of two materials. Thermal absorptivity is the objective measurement of the warm-cool feeling of fabrics. A warm-cool feeling is the first sensation. When a human touches a garment that has a different temperature than the skin, heat exchange occurs between the hand and the fabric. If the thermal absorptivity of clothing is high, it gives a cooler feeling at first contact [11, 16].

Fabrics produced from of Egyptian cotton Giza 86 have higher Thermal absorptivity than those made of Greek cotton (Figure 5). Therefore, these fabrics gave a cooler feeling, which is ideal for summer clothes. This case could be explained by more hairiness of Greek cotton fabric as explained before.

Additionally, from the regression equation in table 5 and from the same figure, thermal absorptivity values of the fabrics knitted from 50/50% cotton/Modal yarns were higher than the fabrics from 100% cotton yarns, because of less yarn hairiness. Cotton yarns have more hairiness than Modal yarns, so the hairs encapsulate air between the emergent fibers and the fabric surface. Therefore, when the skin comes into contact with the fabric, a thin air layer is at the contact interface. Thus, the heat transfer is reduced and the fabric feels warmer to the initial touch. Furthermore, interlock structure has more thermal absorptivity than 1 x1 rib structure and this gave the coolest feeling at the beginning of skin contact. This trend is explained by the construction of the fabric surface. The surface area between the fabric and skin is bigger for smooth fabric surfaces and these structures cause a cooler feeling [16].

Figure 5 Thermal absorptivity values for different cotton types and cotton/Modal blend ratios



4-3 Thermal resistivity

Thermal resistance is a measure of the body's ability to prevent heat from passing through it. Thermal resistance is an indication of how well a material insulates. Under a certain condition of climate, if the thermal resistance of clothing is small, the heat energy will gradually reduce with a sense of coolness. It is based on the equation: $R = h / \lambda$ ----- (7)

Where: h = thickness (m), λ = thermal conductivity.

From the regression equation written in table 5, the results showed that the fabrics knitted from Egyptian cotton Giza 86 have less thermal resistance than others knitted from Greek cotton and this is also shown in figure 6. This could be explained with the thermal conductivity and fabric thickness. The fabrics knitted from Egyptian cotton yarns have more thermal conductivity and are less thickness than the fabrics knitted from Greek cotton yarns. Therefore, the fabrics knitted from Egyptian cotton yarns provided less thermal insulation.

Also, as the ratio of Modal fibers increased inside the yarn, the thermal resistance decreased as well (regression equations at table 5 and figure 6). This result is also related to both the thermal conductivity and the fabric thickness. Because as the amount of Modal fiber increased, the thermal conductivity values increased and thickness decreased, so the thermal resistance decreased as mentioned in the last equation. A secondary reason is yarn hairiness. The fabric includes more modal fiber % generated a less level of yarn hairiness and so a less thermal resistance and this fabric sample gave the coolest feeling. As the yarn hairiness increases, the amount of static air that prevents the passage of heat increases, where this fabric is characterized by Modal fiber merits like softness, coolness and visual appeal.

Thermal resistance is a very important parameter from the point of view of thermal insulation, and is proportional to the fabric structure. As can be seen from regression equations in table 5 and from figures 6, thermal resistance value of interlock structure is significantly higher than 1 x1 rib structure. Actually, the general expectation was to see an inverse relationship between thermal conductivity and thermal resistance for the interlock and rib structures. However, the test results revealed this trend is reversed. This contradiction might be clarified by the fabric thickness. If the amount of increase in fabric thickness is more than the amount of increase in thermal conductivity ($R = h / \lambda$), thermal resistance will increase as well. Therefore, the growth of thermal resistance values depending on 1×1 rib and interlock structures is usual [1].

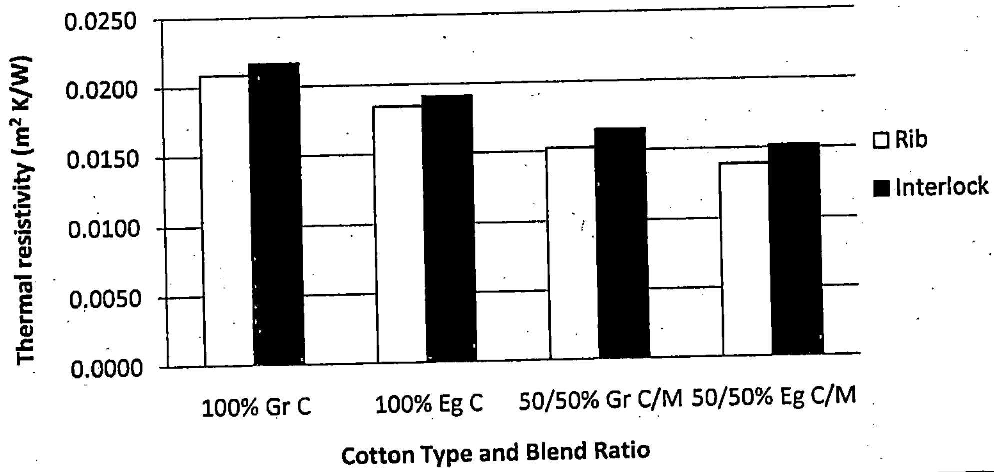


Figure 6 Thermal resistance values for different cotton types and cotton/Modal blend ratios

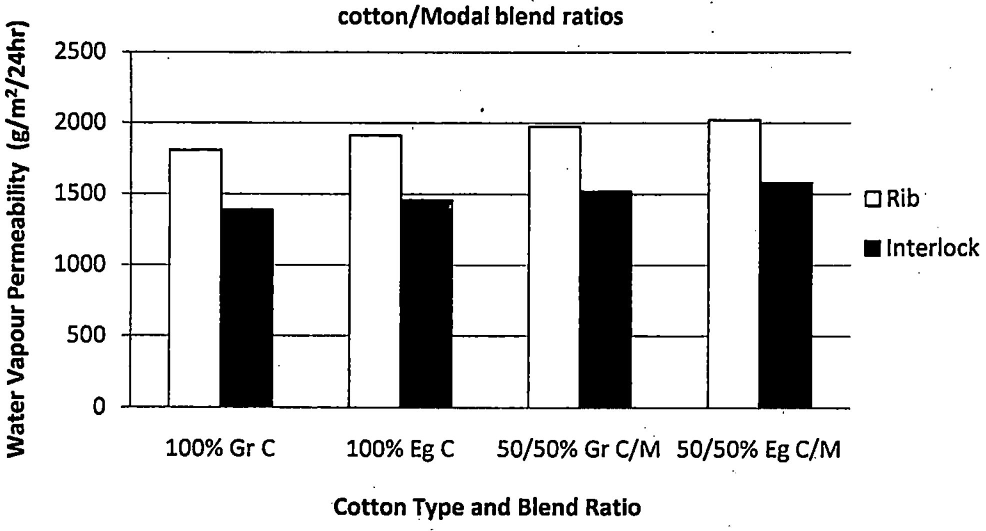
4-4 Water Vapor Permeability

Water vapour permeability is the ability to convey vapour from the body. If the moisture resistance is too high to transmit heat, the accumulated heat in the body cannot be driven away and causes an uncomfortable feeling.

From figure 7, it could be seen that Water vapour permeability of the fabrics produced from Egyptian cotton yarns is higher than others knitted from Greek cotton. The possible reason of this is hairiness of the Greek cotton yarns. The fabric pores are closed with hair in the fabric knitted with hairy yarn and thus water vapour permeability will be low. In case of cotton Giza 86, the yarn has a higher density and smaller diameter, causing more spaces in the knitted structure. According to the results, there is a significant effect of the Modal % inside the yarn on the water vapor permeability. As can be seen from Figure 7, due to the less hairy structure of Modal yarn, water vapor permeability value of its knitted fabric is higher than others fabrics produced from pure cotton yarns.

Moreover, it can be seen from the same figure that relative water vapour permeability value of 1×1 rib fabric is more than interlock fabric sample. The existence of this increase is most probably a consequence of the thinner structure of 1×1 rib fabric. Because the transportation of water vapour through a thin fabric will be easier and due to less resistance to vapor-molecules.

Figure 7 Water vapour permeability values for different cotton types and cotton/Modal blend ratios



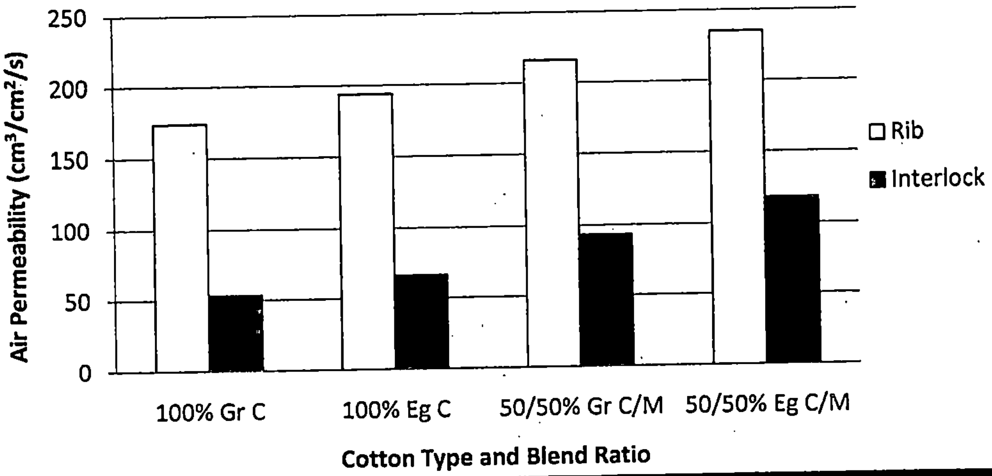
4-5 Air Permeability

Air permeability is a hygienic property of textiles, which controls the flow of gas from the human body to the environment and the flow of fresh air to the body. Air permeability depends on fabric porosity, which means the number of canals in the textile fabric, its cross-section and shape. Thermal properties are basically influenced by air permeability.

The results indicate that Fabrics made of 100% Egyptian cotton yarns have the highest air permeability value than others fabrics knitted from the Greek cotton yarns as noticed in figure 8. This is due to the higher density in the cotton Giza 86 yarn causing larger spaces in the knitted structure.

The increase of Modal percentage affects the air permeability value statistically and there is a difference between 100% Cotton and 50/50 % cotton/Modal samples. It could be seen that the cotton/Modal fabrics gave higher air permeability due to the smooth surface of the Modal fabric and the low hairiness which permits more amount of air to pass through the same area, and also the high packing factor of modal fiber compared with cotton fiber, which agrees with the results obtained in research work [21]. From this point of view, these fabrics are more suitable for summer clothing.

Figure 8 Air permeability values for different cotton types and cotton/Modal blend ratios



5-Conclusion

In the current study, thermal comfort properties of 1 x 1 rib and interlock fabrics made of different cotton types and different blend ratio of cotton/Modal yarns were examined. All fabrics have a medium tightness level.

All the transmission properties: thermal conductivity, thermal resistance, thermal absorptivity and water vapor permeability values are strongly correlated to cotton type, Modal blend ratio and knitted fabric structure. The fabrics knitted from Egyptian cotton Giza 86 yarns have higher thermal conductivity, thermal absorptivity, water vapor permeability and lower , thermal resistance than those made of Greek cotton. The cause of these results is due to the lower yarn hairiness and higher yarn density, which are the main factors affecting thermal properties of fabrics.

The increase of Modal blend ratio in the fabric affects thermal comfort properties. As the Modal fiber percentage increases, yarn hairiness, fabric thickness and thermal resistance decreases, whereas thermal conductivity, thermal absorptivity and relative water vapor permeability increases. Within this research work, interlock structure has more thermal conductivity, thermal absorptivity, thermal resistance and lower water vapor permeability than 1 x1 rib structure.

From these results, yarn hairiness has a great effect on fabric thermal transmission where it increases the effective air pocket area between threads which means decreases the material area and influence the fabric overall thermal properties. Therefore, it is recommended to use Egyptian cotton fibers and its blend with Modal fibers for producing summer garments for better moisture management and for saving from hot weather and to get a cooler feeling at first contact.

Because of the different structural properties of the fabric samples selected, the results are suitable only for these particular conditions. The reader should be cautioned that these evaluations are only to give a general opinion.

References:.

[1] Oğlakcioğlu Nida and Marmarali Arzu, "Thermal Comfort Properties of some Knitted Fabrics", Fibers & Textiles in Eastern Europe January / December 2007, Vol. 15, No. 5 - 6, pp. 64-65.

[2] Oglakcioglu Nida, Celik Pinar, Ute Tuba Bedez, Marmarali Arzu and Kadoglu Huseyin, "Thermal Comfort Properties of Angora Rabbit/Cotton Fiber Blended Knitted Fabrics", Textile Research Journal, 2009, Vol. 79 (10): pp. 888-894.

[3] Özdil Nilgün, Marmaralı Arzu and Kretzschmar Serap Dönmez, "Effect of Yarn Properties on Thermal Comfort of Knitted Fabrics", International Journal of Thermal Sciences 46 (2007), pp. 1318-1322.

[4] Farag Ramsis, El Mogahzy Yehia and Badr Alaa Arafa, "Cotton / Synthetic fiber blending – the Theory & the Practice: Cotton/Modal Blending", Beltwide Cotton Conferences, New Orleans, Louisiana, January 9-12, 2007.

[5] E. Önder, N. Sarıer, "Improving Thermal Regulation Functions of Textiles", in: WTC 4th AUTEX Conference, June 22-24, Roubaix, France, 2004.

[6] http://textilepapers.tripod.com/smart.htm (2005).

[7] Y. Shoshani, S. Shaltiel, "Heat Resistance Characteristics of Weft Knit Single Jersey Inlay Fabrics", Knitting Times (1989), pp. 70-72.

[8] Marmarali Arzu, Kadoglu Huseyin, Oglakcioglu Nida, Celik Pinar, "Thermal Comfort Properties of some New Yarns Generation Knitted Fabrics", AUTEX 2009 World Textile Conference, , 2009, 26-28 May, Izmir, Turkey.

[9] Huang Jianhua and Qian Xiaoming, "Comparison of Test Methods for Measuring Water Vapor Permeability of Fabrics", Textile Research Journal, 2008, Vol. 78(4), pp. 342-352.

[10] Serin Mavruza; R. Tugru Ogulata, "Investigation of Air Permeability of Single Jersey Fabrics with Different Relaxation States", The Journal of The Textile Institute, January 2011, Vol. 102, No. 1, pp. 57-64.

[11] I. Frydrych, G. Dziworska, J. Bilska, "Comparative Analysis of the Thermal Insulation Properties of Fabrics Made of Natural and Man-Made Cellulose Fibers", Fibres & Textiles in Eastern Europe (October/December 2002), pp. 40-44.

[12] S. Güne¸so˘glu, B. Meriç, C. Güne¸so˘glu, "Thermal Contact Properties of 2-Yarn Fleece Knitted Fabrics", Fibres and Textiles in Eastern Europe, 2005, No. 2 (50), pp. 46-50.

[13] Vigneswaran C., Chandrasekaran K. and Senthilkumar P., "Effect of Thermal Conductivity Behavior of Jute/Cotton Blended Knitted Fabrics", Journal of Industrial Textiles January 2009, 38: 289.

[14] Skenderi Z., Čubrić Ivana Salopek, Srdjak M., "Water Vapour Resistance of Knitted Fabrics under Different Environmental Conditions", Fibres & Textiles in Eastern Europe 2009, Vol. 17, No. 2 (73), pp. 72-75.

[15] Marsh M. C., A. M., Sc.B., P. A. Inst., "The Thermal Insulating Properties of Fabrics", Communicated by S. G. Barker, British Research Association for the Woolen and Worsted Industries, 1930, April 30.

[16] Pac, M. J., Bueno, M. A., and Renner, M., "Warm-Cool Feeling Relative to Tribological Properties of Fabrics",

Textile Res. J. 71(19), pp. 806-812, (2001).

[17] Özçelik Gonca, Çay Ahmet, Kirtay Erhan, "A Study of the Thermal Properties of Textured Knitted Fabrics", Fibres & Textiles in Eastern Europe, January / March 2007, Vol. 15, No. 1 (60).

[18] Hearle J. W. S., Grossberg, Backer, S., "Structure Mechanics of Fibers, Yarns and Fabrics, 1969.

[19] Lubos Hes, inventor of the Alambeta device.

[20] ASTM E96

[21] Badr A., EL Nahrawy A., "Optimizing the Cotton and Cotton/ Modal Blended Fabric Properties on Single Jersey Machinery", Beltwide Cotton Conference, in New Orleans, Louisiana, 4-7 January, 2010.