INFLUENCE OF MECHANICAL STRESS ON EVAPORATION RESISTANCE OF KNITTED FABRICS

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Abstract

In this research, the evaporation resistance *Ret* [m^2Pa/W] of knitted fabrics made from different core elastic ratios have been investigated; these fabrics have been extended to different levels and the evaporation resistance have been measured under these variations of extensions. It was found, that the evaporation resistance for the knitted fabric from elastic core yarn under the study decreased with the increase of the extension in the course direction.

Introduction

Moisture transport through textiles is one of the factors that influence the thermo Physiological comfort of the human being. The moisture can be transferred through a textile material in the form of vapors and liquids. The analysis of the scientific literature shows a high and constant interest in the problem of reliable determination of vapor permeability and the evaporation resistance properties of the textile materials [1 – 5].

The task of clothing is, beside fashionable embodiment and expression, the protection against harmful environmental stresses including the climatic conditions. On this account, well being, health and productivity of humans largely depend on clothing. Humans usually wear clothing all day long - even in bed we are surrounded by textiles; therefore it is often characterized as a "second skin". Except in tropical latitudes, a person needs a constant protection to avoid simply freezing [6], so we can tell that the thermal properties are among the most important features of textiles [7-8].

The human body converts the energy provided by food into work and heat, depending mainly on the level of activity.

The main part of the moisture transfer occurs through the skin, since the skin is usually largely covered with clothing, and the moisture release of the human body is strongly influenced by the heat and moisture transfer through clothing [9, 10].

1 Test methodology and materials used for measuring evaporation resistance [m2Pa/W]

The Permetest instrument enables the determination of the relative WVP [%] and evaporation resistance Ret [m^2Pa/W] of dry and wet fabrics within 3 -5 minutes- (*Fig. 1*).

Fig. 1 Permetest used for measuring the evaporation resistance

The measuring head of this small Skin Model is covered by a resistant semi-permeable foil which lets the liquid water transport from the measuring system into the sample. The cooling heat flow caused by water evaporation from the thin porous layer is quickly recorded by a special computer evaluated sensing system. In terms of heat transfer, this instrument presents the model of real human skin. Given by a new concept of measurement, which enables distinguishing small changes of water amount absorbed in the fabric during the unsteady state of diffusion and to record e.g. the heat of sorption, a very good measurement reproducibility was achieved, with CV often under 3%. The instrument provides all kinds of measurements similar to the ISO Standard 11092 and the results are evaluated by the identical procedure as required in this standard. The correlation coefficient of measurements related to the ISO Standard SKINMODEL exceeds 0.9. The results are treated statistically, displayed and recorded for next use [11].
When the results of measurement should be expressed in terms of the water vapor resistance Ret [m2Pa/W] according to the ISO 11092 Standard, then the following relationship is applied:

$$Ret = (pwsat - pwo)\,(1/qo - 1/qs) = C(100 - \varphi)(1/qo - 1/qs) \quad (1)$$

Here, *qs* and *qo* mean heat loses of the moist measuring head in Free State and covered by a sample. The values of water vapor partial pressures *pwsat* and *pwo* in Pascals in this equation represent the water vapor saturate partial pressure valid for the temperature of the air in the measuring laboratory to 22-25C^0, and the partial water vapor pressure in the laboratory air. The constant *C* will be determined by the calibration procedure. For this purpose, a special hydrophobic polypropylene reference fabric is used with the instrument.
Besides the water vapor resistance, the relative water vapor permeability of the textile sample *pwv* can also be determined by the instrument. This practical parameter is given by the relation:

$$pwv\ [\%] = 100\ qs/qo \quad (2)$$

1.1 Test samples

The transport of heat and moisture through fabrics is one of the major concerns in the design of functional clothing such as sports wear. In the clothing research field, researchers usually assess the transport of heat and moisture through fabrics by using a sweating hot plate [12-15], but here the permetest was used to evaluate the evaporation resistance for the elastic fabrics which have been manufactured to achieve some requirements that other fabrics cannot achieve. The use of elastic yarn has resulted in fabrics that fit better on the body like a second skin and have good shape retention without any deformation throughout the life of the garment.

In this work three elastic knitted Rib 1x1 constructed fabrics with different Lycra ratios were used to measure the evaporation resistance [m2Pa/W] under different extensions as mentioned later. The elastic core yarn was used to produce this knitted fabric, Lycra was used as the core and the outer layer (sheath) was cotton. In terms of the core: sheath ratios for the three different types were: 8% Lycra: 92% cotton, 6% Lycra: 94% cotton and 4% Lycra: 96% cotton, and the count of the yarn for producing this fabric was 19.6 Tex for all the three different fabrics. A special frame was manufactured to obtain the different extensions for the used fabric (*Fig. 2*).

The different ratios of extension were applied in the course direction, 10%, 20%, 30%, 40% and 50% from the original length; at each extension of the fabric, the evaporation resistance was measured, three different tests were held for each extension and the mean value was calculated.

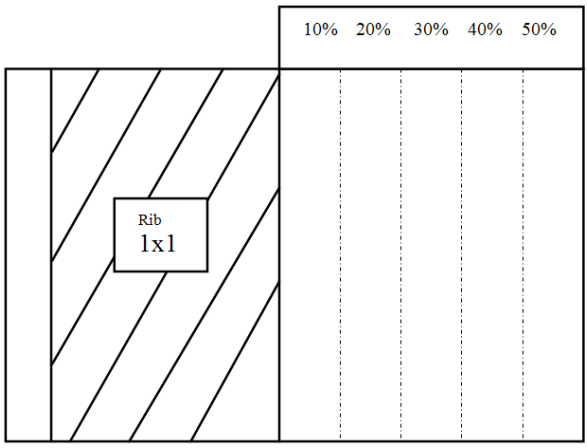

Fig. 2 Symbolic drawing of the extension frame made for applying mechanical tension

2 Effect of mechanical stress on the evaporation resistance [m2Pa/W]

Elastic core yarns have become established in many new application areas. They are used in sports wear, leisure garments and children's wear, in high quality outer wear, in functional clothes and in technical products. Core yarn can be either elastic or rigid filament which is covered with natural or synthetic fibers. It is an ingenious idea as elastic or rigid material can be produced without sacrificing the texture or quality of traditional fibers. This is probably why its use in the textile sector is becoming more and more popular.

In this work the evaporation resistance of a Rib 1x1 knitted elastic fabric was measured with applying different degrees of extension from 10% to 50% and the water evaporation

resistance [Ret] was measured at each extension. *Tab. 1* shows the variation in the evaporation resistance at each level of extension for the different samples.

Tab. 1 Ret [m2Pa/W] values at different extensions

Ext. %	*Ret* [m^2Pa/W] Lycra 4%	*Ret* [m^2Pa/W] Lycra 6%	*Ret* [m^2Pa/W] Lycra 8%
0%	4.18	4.53	4.83
10%	3.81	4.18	4.46
20%	3.67	3.82	4.19
30%	3.25	3.46	3.56
40%	3.19	3.38	3.47
50%	3.12	3.27	3.38

The results show that applying different extensions to the Rib 1x1 elastic knitted fabric has an obvious effect on the evaporation resistence. As we can see from *Fig. 3*, the evaporation resistance for the measured fabrics decreases by the increase of the extension for all the different samples with the different Lycra ratios: 4%,6%,8%. *Tab. 2* shows the *Ret* change percentage. We can say that the evaporative resistance [m^2Pa/W] in the Lycra 4% decreased by 25.35% when applying 50% extension from the relaxed position, while decreased by 27.8% in Lycra 6% and by 30% in Lycra 8% at the same extension percentage.

Tab. 2 Ret [m^2Pa/W] decrease percentage by different mechanical tension applied

Change% of *Ret*[m2Pa/W]			
Extension %	*Ret* [m^2Pa/W] Lycra 4%	*Ret* [m^2Pa/W] Lycra 6%	*Ret* [m^2Pa/W] Lycra 8%
0%	0	0	0
10%	8.85	7.72	7.66
20%	12.2	15.67	13.25
30%	22.24	23.62	26.29
40%	23.68	25.38	28.15
50%	25.35	27.81	30.02

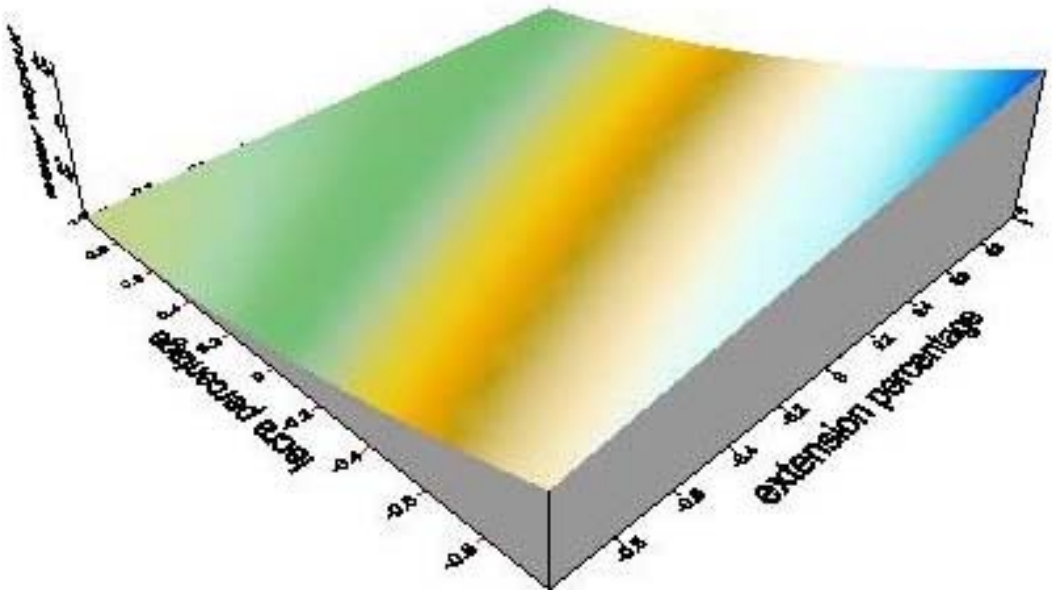

Fig. 3 Interaction effect of different extensions and Lycra percentage on Ret [m2Pa/W]

Applying mathematical treatment the next equation was obtained:

$$z = 3.8 + 0.24x - 0.58y + 0.01x^2 + 0.03y^2 - 0.09xy \quad (3)$$

where z = *Ret* , x = Lycra, y = Extension ratio. *Fig. 3* also shows the interaction between the different Lycra ratios and the different extension applied to the elastic knitted fabric and their effect on the evaporation resistance of these fabrics. It also shows that the evaporation resistance increases with the increase of the Lycra ratio at each of the extension levels as observed from the equation (3). It is obvious from R^2 = 99.5 % that when applying various extensions in the course direction in all of these cases we notice a significant effect on the evaporation resistance *Ret* [m^2Pa/W] of the fabrics made from core yarns with different elastic ratios as previously mentioned.

Concerning the water vapor permeability of these fabrics and using *Fick's* equation, [16]

$$Wd = \frac{1}{Ret \cdot \phi \cdot Tm} \quad (4)$$

the rate of water vapor transfer for a fabric is directly proportional to the partial water vapor Δp. It is a linear relationship to the vapor pressure inversely proportional to the evaporation resistance and ϕT_m which is the latent heat of vaporization of water at the temperature T_m of the measuring unit. We can count the approximate diffusion of water vapor transfer, i.e. when *Ret* [m^2Pa/W] for the 8% Lycra sample in the beginning of the extension (0%) was 4.83 [m^2Pa/W] and by applying the maximum extension (50%), the evaporation resistance was 3.38 [m^2Pa/W]. It was found out that the water vapor permeability increased about 42% which is a significant increase for the water vapor permeability.

Conclusion

In this work it was noticed that the evaporation resistance of Rib 1x1 knitted fabrics made from elastic core yarns was obviously affected by applying different levels of extensions, by increasing the extension for the tested fabrics. It was noticed that the evaporation resistance decreased rapidly at the beginning and at a certain level – here it was about 30% - the evaporation resistance decreased slightly and it was nearly the same, maybe due to the change of the fabric construction and due to the fact that the porous area in the fabric is nearly the same according to the different level of the applied tension. It could be concluded that the tight elastic knitted fabric could lead to more comfortable properties if it was used during practicing a light activity, but when practicing a heavy activity, the comfort of these fabrics will decrease due to the heavy sweat production, and it will also be difficult to get rid of this sweat in that liquid form and in this case the garment will stick to the body causing a lack of comfort. It was also concluded that the evaporation resistance increases with the increase of the elastomer ratio in the fabric. These results could be applied in designing functional, more comfortable garments concerning the different dimensions of the body's different parts where we can apply different elastomer ratios and tightness to achieve the optimal comfortable wear.

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VLIV MECHANICKÉHO ZATĚŽOVÁNÍ NA PRODYŠNOST ÚPLETŮ

V tomto výzkumu byla šetřena prodyšnost Ret [m^2Pa/W] úpletů vyrobených z různě elastických vláken. Tyto látky byly napínány a jejich prodyšnost byla měřena v závislosti na různých napětích. Bylo zjištěno, že se prodyšnost testovaných úpletů z různě elastických vláken snižuje s rostoucím napětím.

DER EINFLUSS VON MECHANISCHEM DRUCK AUF DIE DURCHLÄSSIGKEIT GESTRICKTER TEXTILWAREN

In dieser Forschungsarbeit wurde die Durchlässigkeit Ret [m^2Pa/W] gestrickter Textilprodukte, die aus unterschiedlich elastischen Fasern gemacht sind, untersucht. Dieses Textilprodukt wurde über verschiedene Ebenen gespannt und die Durchlässigkeit bei allen verschiedenen Spannungen gemessen. Dabei stellte sich heraus, dass die Durchlässigkeit der getesteten gestrickten Textilien aus unterschiedlich elastischen Fasern mit dem Anstieg der Spannung in Laufrichtung nachließ.

WPŁYW OBCIĄŻENIA MECHANICZNEGO NA PRZEWIEWNOŚĆ DZIANIN

W prowadzonych badaniach badano przewiewność Ret [m^2Pa/W] dzianin wyprodukowanych z włókien o różnej elastyczności. Tkaniny te były naprężane a ich przewiewność badano przy różnych naprężeniach. Stwierdzono, że przewiewność badanych dzianin z włókiem o różnej elastyczności zmiejsza się wraz z rosnącym naprężeniem.