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EFFECT OF MISS STITCH ON THE TENSILE STRESS RELAXATIONOF RIB WEFT KNITTED FABRICS

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Abstract: *Stress relaxation is a time-dependent mechanical behavior in textiles. Textile deformations occurred as a result of stress relaxation, induces disturbances in textile function, and further disproportion between performance and application. Stress relaxation can be observed in pressure garments, varicose stockings, pressure bandages, etc.*
The aim of this study is to investigate the effect of miss stitch on the tensile stress relaxation of rib weft knitted fabrics. For this purpose, Rib fabrics with six different knit patterns differing in the number of miss stitches on successive rows were produced from 450/5 denier textured polyester yarn. The stress relaxation of the fabrics was measured in the course and wale directions under 20% strain for 30 minutes.
The results revealed in all fabric structures, the stress created in the fabric decreases with time and that the amount of measured stress in both directions depends on the textile structure, as well as an increase in the number of miss stitches in the fabric structure leads to an increase in the initial stress, residual stress and stress relaxation of the fabric in the course and wale directions. Also, the values of the measured stress in the wale direction were higher than in the course direction.

Key words: *Stress relaxation, Weft knitted, Miss stitch, Pressure garment, viscoelastic materials*

1. INTRODUCTION

Viscoelastic materials are materials whose relationship between stress and strain depends on time. The strength and stiffness of the materials are usually obtained by stress and strain diagrams, which are obtained by applying a constant rate of strain to part of the material. When a viscoelastic material is subjected to a constant strain, the resulting stress decreases over time, which is called the stress relaxation [1]. The applied strain rate, loading velocity, and temperature are the factors that influence the material stress relaxation [2]. Fabrics that have a viscoelastic response to applied load are of particular importance. These fabrics are used for applications such as compression garment, pressure bandages, varicose stockings and more. They are used for clinical treatment, maintaining pressure on the wound area and within a specific range as instructed by physicians or therapists. The reduction of pressure in these fabrics affects their efficiency [3]. The efficacy of compression therapy using compression bandages depends on the amount of compression applied and the pressure maintained during the treatment period. For this purpose, Kumar et al. in 2012 attempted to predict the pressure profile generated by compression bandages using constitutive equations describing the relaxation behavior of viscoelastic materials. It is observed that this pressure profile is highly correlated with the stress relaxation behavior of the bandage. Also to model the pressure profile, the stress relaxation behavior of compression bandages was studied and modeled using three mechanical models: The Maxwell model, the standard linear solid model and the two-component Maxwell model with a nonlinear spring. It was observed that the models with more component values explained the experimental relaxation curves better [4]. Hashemi et al. in 2015 investigated the effect of the fabric structure, strain amount and strain direction on the stress relaxation of two bar warp-knitted fabrics. The results of this study showed that fabric structure, strain value, and strain direction are important factors affecting the stress and stress relaxation percent of the fabrics [5]. Ardakani et al. in 2016 investigate the effect of the fabric structure, strain percentage, and course density on the stress and stress relaxation of the warp-knitted structures which have longer underlaps in the front bar. The results of this study demonstrated that fabric structure, strain value, and fabric density are important and effective factors in stress and the percentage of stress relaxation in the course and wale directions [6]. Kumar et al. in 2014 examined the impact of pressure bandage materials and structures on the change of bandage pressure over time. The purpose of this research was to explore the influence of different materials and varying structures on the interface pressure profile generated by the bandages overtime during the static state of the limb. According to the results, the reduction of interface pressure for these bandages was higher when wrapped at a higher tension level. Lower reduction of interface pressure was obtained for the sample having higher thread density as compared with lower thread density in the structure, for the same applied tension level during wrapping [7].

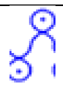
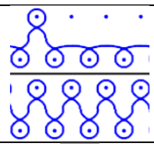
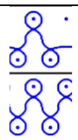
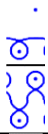
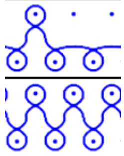
The aim of this research is to investigate the effect of fabric structure on the tensile stress-relaxation of rib weft knitted fabrics.

2. EXPERIMENTAL

To investigate the effect of fabric structure on the stress relaxation of rib weft knitted fabrics, fabrics with six different structures differing in the number of miss (float) stitches on successive rows were produced from 450/5 denier textured polyester yarn. The fabric structures are shown in Table 1. In the fabric code, *k* denots as knit stitch and *m* represents for miss stitch. The first and the two last fabric structures are rib (R), Half Milano (HM) and Full Milano (FM) respectively.

Before tests, the fabrics were relaxed on a flat surface and left to condition for 48h in the laboratory environment. To identify the elastic region for various fabric structures, the tensile test was performed on the fabric samples using an Instron-5566 at a speed of 20 mm/min. Then, the average stress-strain curves of the fabrics were plotted in both course and the wale directions. Thereafter, stress relaxation test was performed utilizing the same instrument and the same speed. The stress relaxation test was conducted in both course and wale directions at 20% strain (common strain in the elastic region of all fabrics) for 30 minutes. From each fabric structure, five samples were tested in each direction and the mean stress relaxation diagrams were plotted over time.

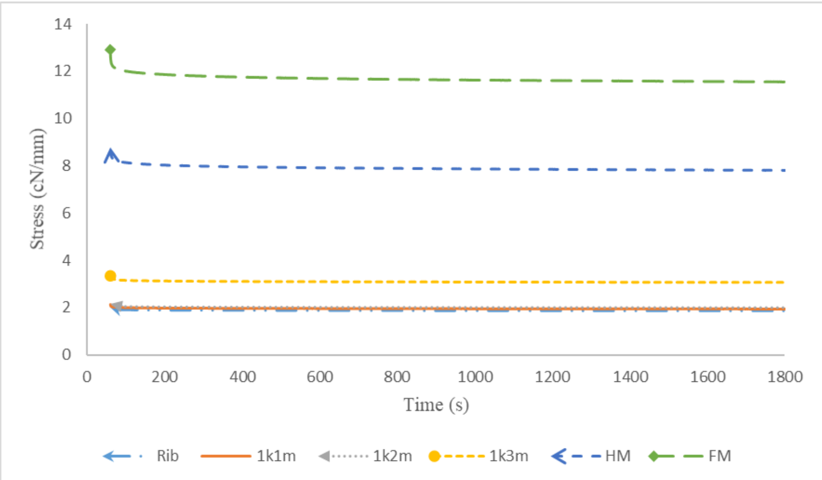
Table 1: *Fabrics structures*

Fabric code	Running notation	Fabric code	Running notation
R		1K3M	
1K1M		HM	
1K2M		FM	

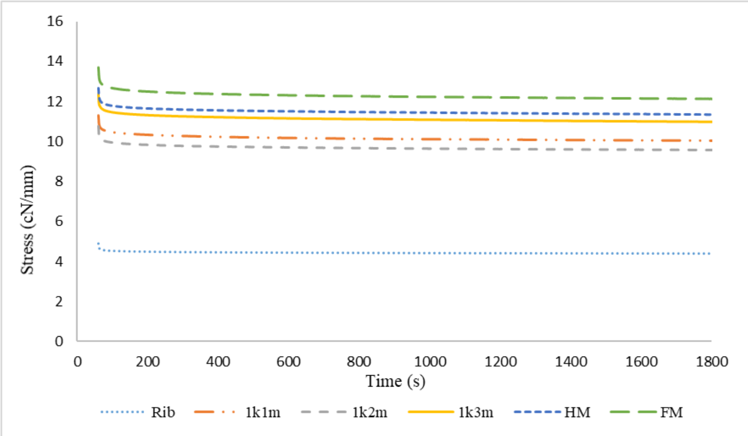
3. RESULT AND DISCUSSION

3.1. Stress decay of the fabrics in the course and wale directions

The plots of average stress decay for different fabric structures in the course and wale directions are illustrated in Fig. 1. As can be seen, in all fabric structures and both directions, the stress created in the fabric decreases with time. Moreover, the fabric structure has significant effect on the fabric stress at any given moment, including the initial stress and residual stress. Full Milano structure (FM) demonstrates the highest initial and residual stresses, whilst rib structure (R) exhibits the lowest initial and residual stresses.



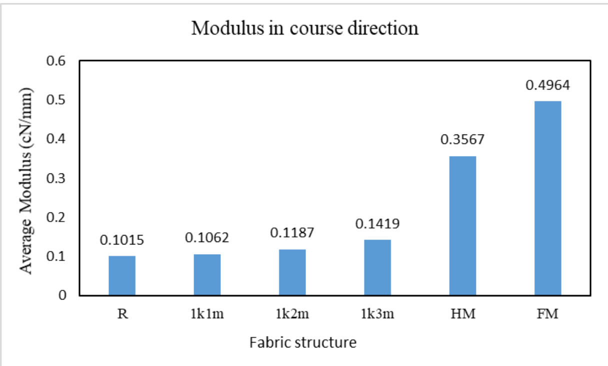
(a)



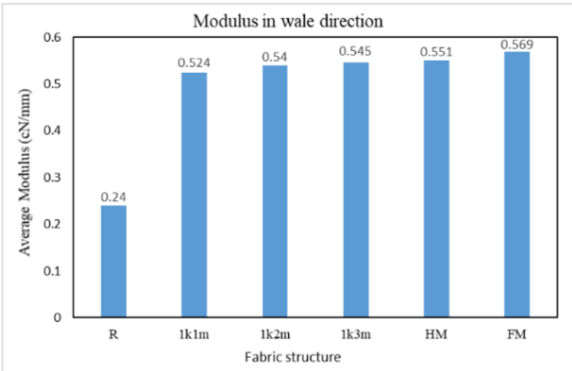
(b)

Fig. 1*: Effect of fabric structure on the stress decay in the (a) course direction b) wale direction*

The difference in stress values can be attributed to the difference in elastic modulus of the fabrics. The elastic modulus of each fabric structure in the course and wale directions is shown in Figure 2. Due to the same strain applied to fabrics with different structures, according to Hooke's law, the stress created in fabrics will be proportional to their elastic modulus. In the other word, the higher the elastic modulus of the fabric, the greater the initial stress. Therefore, as shown in Fig.2, by inecreasing the elastic modulus of the fabric from rib to FM, the fabric stress at any moment including the initial stress and the residual stress increases. Besides, as can be seen, the stress decay graphes of rib, 1k1m and 1k2m in the course direction are close to each other due to the slight difference between the elastic modulus of these fabrics in the course direction. The same trend is observed in case of HM, 1k3m, 1k2m and 1k1m in the wale direction, due to the same reason.



(a)



(b)

Fig. 2*: Elastic modulus of fabrics in the a) course direction b)wale direction*

The difference of elastic modulus of fabrics with different structures is due to the presence of miss stitch and their number in the fabric structure. As can be seen in table 1, the orientation of miss stitches in the fabric structure are straight compared to knit stitches which are zigzag. Moreover, miss stitches reduce fabric length because the higher yarn tension on the held loops causes it to rob yarn from adjacent knitted loops, making them smaller [8]. As a result, the fabric's course density increases. Consequently, by increasing the number of miss stitches in the fabric structure, the fabric strength and modulus increase in the course direction. In the wale direction, due to straight orientation of miss stitches in the fabric structure, the wales approach each other, which leads to increase in the fabric's wale density. Thus, as previously mentioned, the fabric strength and modulus increase in the wale direction as well.

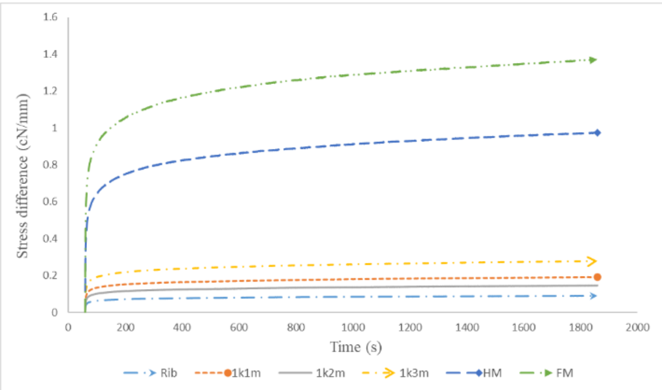
3.2. Stress relaxation of the fabrics in the course and wale directions

The fabrics stress relaxation was calculated at each moment using equation 1, then the stress relaxation diagram was plotted for each fabric structure in the course and wale directions (Fig. 3).

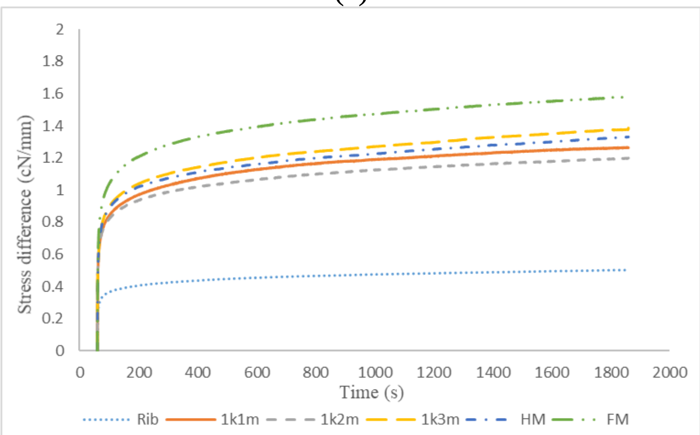
$$\Delta\sigma_t = \sigma_i - \sigma_t \qquad (1)$$

In this equation, σ_i is the initial stress or stress at the beginning of the test, σ_t is the stress at time t and $\Delta\sigma_t$ is the stress relaxation at time t.

Figure 3 reveals that for all fabric structures, stress relaxation of the fabric increases with time, but the rate of stress relaxation decreases gradually. In the other word, the slope of the stress relaxation plot decreases with time. Furthermore, fabric structure has remarkable effect on the stress relaxation. By increasing the number of miss stitches in the fabric structure, the stress relaxation increases in both directions. As mensioned formerly, this is due to the fact that, increasing the number of miss stitches leads to higher initial stress in the fabric structure. Consequently, the fabric release more stresses to reach the relaxed state.



(a)



(b)

***Fig. 3**: Fabric stress relaxation under 20% strain in the (a) course direction b) wale direction*

4. CONCLUSIONS

In order to investigate the tensile stress relaxation of rib weft knitted fabrics, polyester fabrics were manufactured with six different structures. Stress relaxation tests were performed for 30 minutes in both course and wale directions with a 20% strain on each fabric. It can be deduced that in all fabric structures, the stress created in the fabric decreases with time. Moreover, the structure of fabrics has significant effect on the fabric stress and stress relaxation. By increasing the number of miss stitches in the fabric structure, stress at any given moment, including initial stress, residual stress and the stress relaxation increases in both directions. Furthermore, in both directions, Rib and Full Milano structures exhibited the lowest and highest stress relaxation respectively.

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