

NEW WRINKLING MEASUREMENT METHOD OVER TIME BASED ON IMAGE PROCESSING

Lanceron C¹, Soulat D¹, Campagne C¹, Ferreira M¹

¹ ENSAIT, GEMTEX – Laboratoire de Génie et Matériaux Textiles, F-59000 Lille, France

charles.lanceron@ensait.fr

ABSTRACT

Wrinkling is often considered to be an undesirable visual feature on a garment. To answer the need for a realistic wrinkling measurement method over time, a new method based on image processing was designed. Wrinkled fabrics are scanned over time in a step-by-step manner over two hours. Every wrinkled fabric scan is compared to the flat sample scan using a profile line technique. The resulting curves are analyzed by the mean of a successful regression model. To illustrate the benefits of the proposed method, the influence of the weave pattern on wrinkling is presented.

Key Words: cotton, wrinkling, measurement, over time

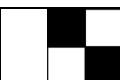
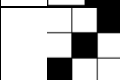
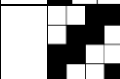
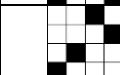
1. INTRODUCTION

Cotton is one of the most desirable fibers because of its aesthetic and comfort properties. However, it is a fiber that is very prone to wrinkling. This effect has a negative impact on its aesthetics and lead to tedious ironing. For these reasons there is an increasing demand for wrinkle-free cotton fabrics. To develop those fabrics there is need for an objective, reliable and realistic wrinkling measurement method. Because of the wash and wear capability of a wrinkle-free fabric, there is a need to assess the wrinkling behavior over time when the fabrics dries after washing. To a lesser extent there is also a need to assess the behavior of wrinkles created during actual wear over time. The most common methods are the wrinkle recovery angle (WRA) method ISO 2313 [1] and the appearance method ISO 7768 [2]. The WRA method consists in folding and compressing a small sample on itself, creating an angle that characterizes wrinkling. In the appearance method, wrinkles are produced by washing samples and evaluated by comparing them with 6 standard replicas. None of the two methods was made to study the wrinkling behavior over time, but some authors tried to use the WRA method to do so. By successfully automating the WRA method, Wang et al. displayed WRA curves over a 0-5min range where most of the curves seem to attain a threshold before 5min [3]. Compared to our observations and the observations of Wilkinson and Stanley [4], wrinkles on a garment take several hours to stabilize their shape. The problem in using the WRA to study a behavior over time is that the samples are too small to reflect the real behavior of a wrinkle on a garment. Indeed the complex structure as well as the anisotropic behavior of a cotton fabric has a peculiar effect: different mechanical behaviors are observed for the same fabric for different sample sizes. This effect was observed in many previous works [5-7]: changing the scale of the sample changes the recovery time scale. Considering this analysis, a need was found to develop a wrinkling measurement method that can assess the behavior of a large fabric sample over time. The proposed method relies on image profile lines processing techniques, inspired by the work if Zaouali et al. [8]. Many authors successfully used image processing and analysis to characterize wrinkling, but they were more focused on characterizing realistic wrinkle shapes, rather than the behavior over time, like Liu et al. [9]. To illustrate the proposed measurement method, the influence of the weaving pattern on the wrinkling behavior over time is studied.

2. MATERIALS

To illustrate the proposed method and study the influence of the weave pattern on wrinkling behavior over time, 4 fabrics are proposed. They were woven with a shirting yarn twisted in 100% cotton with a 136/2 count in Nm (m/g). For all 4 fabrics, the warp yarn density is 40 yarns/cm and the weft yarn density is 30 yarns/cm. The weave patterns and area weights of the 4 fabrics are presented in Table 1.

Table 1. Fabrics characteristics

	Weave pattern		Area weight (g/m ²)
Fabric 1	Plain weave		115.8
Fabric 2	Twill 2/1		110.4
Fabric 3	Twill 2/2		110.8
Fabric 4	Satin 4		111.2

The fabrics have the same characteristics except for their weave pattern which has an influence on the measured area weight. Indeed the warp and weft shrinkage depend on the weave pattern and change the area weight values.

3. METHOD

The method developed in this paper consists in creating wrinkles that can be measured over time on a large sample, scan the wrinkled fabrics over time in a step-by-step manner, compare the wrinkled image and the corresponding flat image by using a profile line technique, and use a regression model to extract wrinkling parameters.

3.1 Wrinkling method

The fabrics are cut to 15x8cm samples with a 45° orientation relatively to the warp and weft directions. In this way, the wrinkles are created on both warp and weft directions at the same time. Before the beginning of the wrinkling process, the samples are carefully ironed and conditioned for 48 hours under standard and stable conditions of temperature (20°C) and relative humidity (65%) as recommended by the NF EN 20139 standard. The same conditions are conserved throughout the measurements.

The samples are wrinkled using the device described on figure 1 a): from left to right, the lower part, the upper part, a weight, and clamps. The first step of the wrinkling process consists in positioning the sample along its length on the lower blue part of the device. The sample is centered and maintained in this position using clamps weighting 39g each. The sample is then wrinkled on b) by applying the upper blue part, which is complementary to the lower blue part, and a 500g weight is put on top for 5 min. After the wrinkling the sample is released by removing the clamps first, then the weight, then the upper blue part. Using a peak geometry to create wrinkles allows a wrinkle creation on both face and back sides of the

sample. Since the sample were cut with a 45° orientation, a sample is wrinkled along 4 directions at once: wrap face, warp back, weft face and weft back.

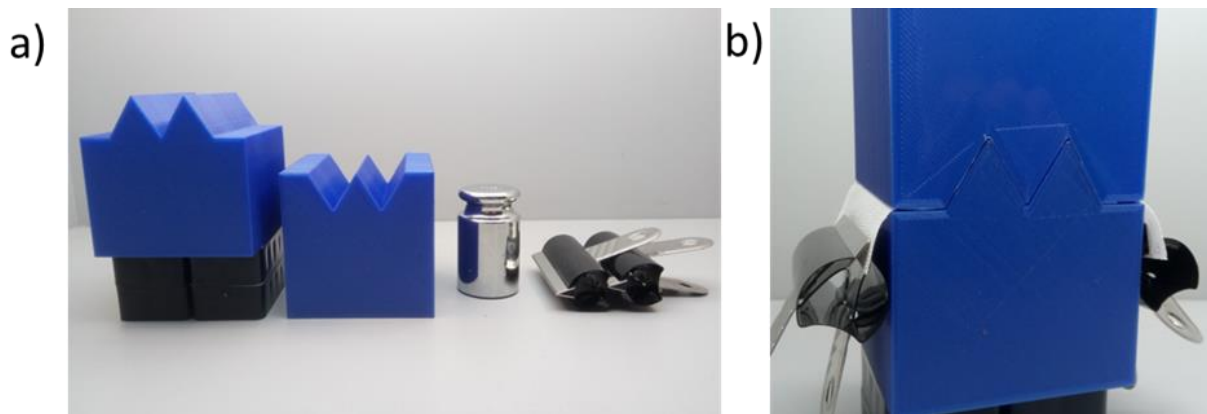


Figure 1. Wrinkling device

After a sample is wrinkled by the method previously described, it is manually removed from the device and placed in a Canon 9000F Mark II scanner.

3.2 Image acquisition and analysis

The scanner is set with a 200ppi (pixels per inch) precision and isolated from outside light during picture acquisition. Before wrinkling, the sample is scanned flat to have the non-wrinkled image of the sample which will be used later in the analysis. A first acquisition is done immediately after the placement of the fabric in the scanner and a second scan is taken 15 sec later. In total 12 scans are performed at regular times, the last one at 7200 s (2 hours). Once the images have been gathered, they are analyzed by comparing the wrinkled images with the flat image before wrinkling.

A threshold is computed by calculated the mean gray value of the flat image minus the standard deviation of the gray values. The wrinkle profile is created by calculating the mean line gray values after performing a Gaussian filter. On figure 2 the wrinkles profiles as well as the threshold are shown at $t=0s$ and $t=7200s$ for fabric 3: a clear decrease in wrinkle degree can be observed.

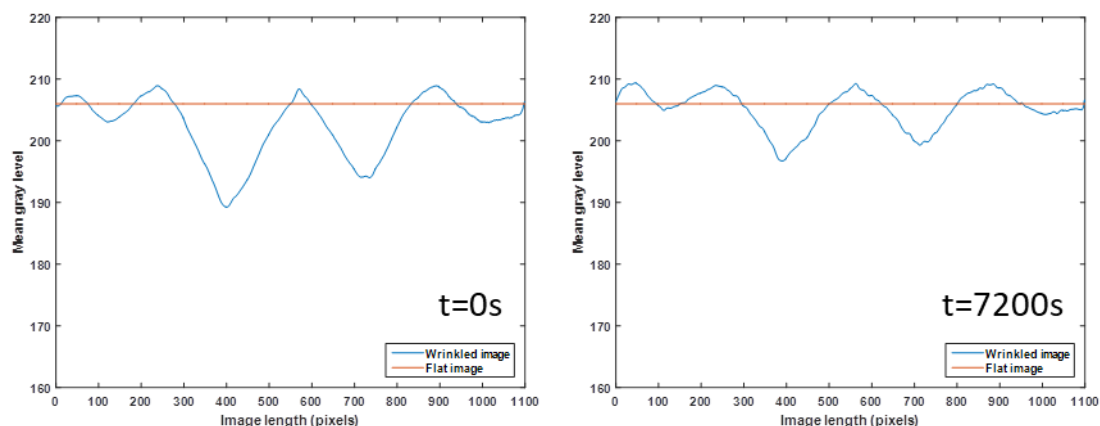


Figure 2. Wrinkles profiles at 0s and 7200s for fabric 3

The parameter used to characterize wrinkling is called Q_w and represents the number of gray values in the wrinkle profile that have a value inferior to the threshold value.

Q_w is expressed in equation (1).

$$Q_w = \frac{N_w}{n} ; 0 \leq Q_w \leq 1 \quad (1)$$

Where N_w is the number of values below the threshold, and n the total number of values in the wrinkle profile. Q_w is calculated in this manner at each time, resulting in a curve as shown on figure 3 for fabric 3.

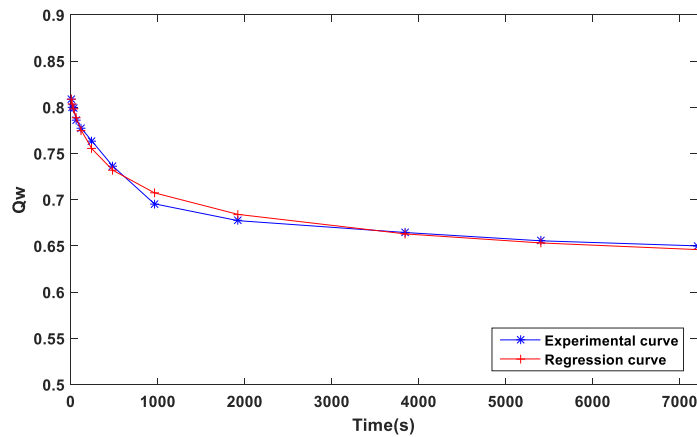


Figure 3. Experimental and regression curves for fabric 3

The experimental curve is fitted with a regression model inspired from the work of Wilkinson and Stanley [4], detailed in equation (2).

$$Q_w(t) = Q_\infty - \frac{S}{\log(t+k)} \quad (2)$$

Where Q_∞ is the theoretical Q_w value for an infinite time or permanent set, S the curvature, and k the value of the left vertical asymptote. The regression proves to be very effective with coefficients of determination at 0.99 for Fabric1, 0.97 for Fabric2, 0.99 for Fabric3 and 0.99 for Fabric4.

4. RESULTS AND DISCUSSION

The experimental Q_w curves are shown on figure 4 for each fabric.

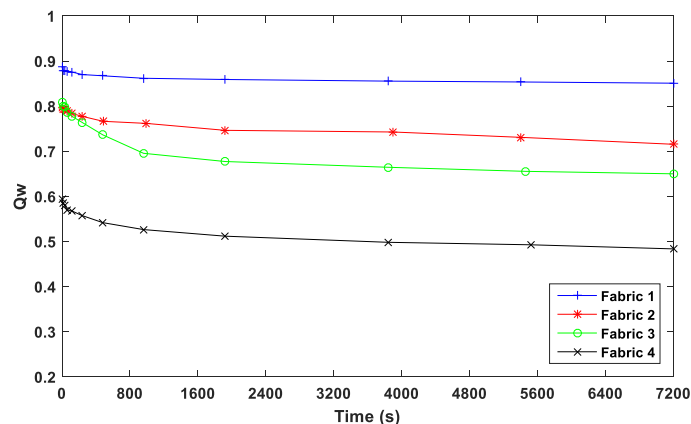


Figure 4. Q_w curves for each fabric

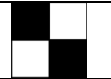
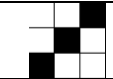
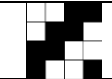
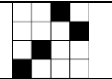
A lower Q_w value means a lower wrinkle degree. Clearly, if a weave pattern has to be chosen to develop a wrinkle-free fabric, it would be fabric4 which has the lower Q_w values at any time.

From those curves, the goal is to find a relationship between the weave pattern and parameters that characterize the wrinkling behavior over time: S , Q_∞ , and Q_i the initial Q_w value at $t=0s$. To characterise the weave patterns with numerical values, the four weave patterns are characterized by a “floating factor” C_f , described in equation (3), and inspired by the work of Milasius [10].

$$C_f = \frac{R^3}{N_p \cdot \sigma} \quad (3)$$

Where R is the pattern size, N_p the number of yarn evolutions in the pattern, and σ the area weight in g/m^2 . This factor reflects the flexibility of the weave structure; the C_f values for each fabric are presented on table 2.

Table 2. C_f values for each fabric

	Fabric 1	Fabric 2	Fabric 3	Fabric 4
Weave pattern				
C_f	0.03	0.08	0.07	0.14

C_f values are compared with S , Q_∞ and Q_i on figure 5. S is shown in absolute values.

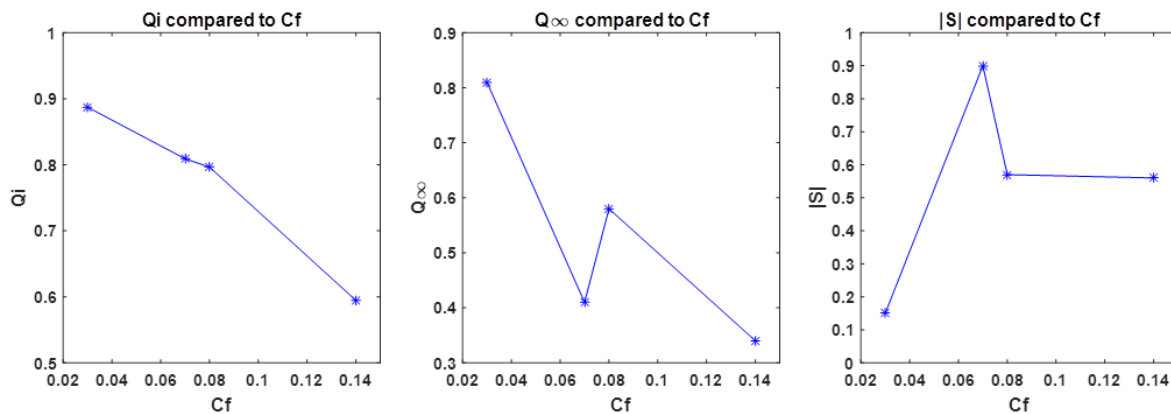


Figure 5. S , Q_∞ and Q_i compared to C_f

No clear trend is found when the parameters extracted from the regression are compared with C_f . However it is quite clear that a higher C_f means a lower Q_w value at $t=0s$, and this trend is only true for short times. The benefit of studying wrinkling over time is highlighted when fabrics 2 and 3 are compared. If they were compared using a WRA measurement, similar results would be found, exactly like measuring Q_w for short times. However, as time goes on, fabric 3 seems to attain a lower wrinkling degree and would be a preferred choice in designing a wrinkle-free fabric.

5. CONCLUSION

A new method that assesses the wrinkling behavior of fabrics over time was presented; it is successful in finding various behaviors for fabrics with very close constructions. Indeed, it proves to be an effective tool in designing a wrinkle-free fabric.

Only 4 fabrics with 4 weave patterns, the most commons in the shirting market, were presented in this paper. Among those fabrics the satin 4 is the preferred choice to limit the wrinkling of a cotton fabric. More weave patterns should however be studied in order to have a more accurate comprehension on the effect of weave pattern on wrinkling. In addition, more work is needed on finding parameters that accurately represent the influence of the weave pattern on a fabric's behavior.

To complete the work, the wrinkling behavior of drying fabrics should be measured. It would give additional insight on how wrinkling evolves in a wash-and-wear perspective.

6. REFERENCES

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