Theoretical Analysis and Prediction of Overfeed Sewing Shrinkage of Wool-type Fabrics

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Abstract: Overfeed is referred to two pieces of fabrics of different lengths being joined together with a thread by sewing processing. In overfeed sewing, the differences in mechanical properties of fabrics are vital factors contributing to the shrinkage of the finished fabric. Based on theory of material mechanics, the relationship model between overfeed sewing shrinkage and mechanical properties including bending modulus of the long fabric, stretch coefficient of the short fabric and the overfeeding quantity was established in this paper, and experiments were carried out to verify the relationship model. The obtained results indicated a good linear correlation between the calculated values of the model and the actual tested values. This model can provide a new method for predicting overfeed sewing shrinkage of wool-type fabric.

Keywords: Wool-type fabric, overfeed sewing shrinkage, bending modulus, stretch coefficient, FAST instrument

1. Introduction

It is a common operation in garment sewing process, where the two pieces of fabrics are joined together to make a three dimensional shape, as shown in Figure 1. As shown in Figure 2, fabric A is obviously longer than fabric B, so while sewing, A is overfed and B is elongated. When the spot 1 and 2 in fabric A and B coincide to make the seam, fabric A needs to be compressed and fabric B needs to be elongated lengthwise. If this strain causes large quantity of deformation, malformed wrinkles will occur.

There have been many researches conducted on overfeed sewing shrinkage (OSS) [1-7]. As demonstrated in Figure 3, one study [1] described that for pure wool flannel 5% of overfeed cannot make shoulder full and round, 11.6% of overfeed can make a good looking one and 18% can result in obvious wrinkles.

Masako Niwa [2] studied the relationship between mechanical properties and sewing wrinkle by means of experiments on new synthetic fabrics, and established two models, which are overfeed sewing and non-overfeed sewing respectively. Her research indicated that the shrinkage of overfeed sewing is larger than that of non-overfeed sewing. She also made regression analysis on the relationship between sewing shrinkage and sewing wrinkling ratings, and arrived at a correlation coefficient of 0.847. She set up a predictive equation with mechanical properties measured in KES instrument for sewing wrinkling of different garment materials.

Investigating into various quality problems of light wool-type fabrics, Keite Tasaki [3] studied the relation between fabric mechanical properties and sewing quality from the fabric producer's view. He found the extent of sewing wrinkling is related to bending rigidity and tensile property of fabrics. Especially, the bending rigidity manifested a negative correlation with sewing wrinkling. He created a linear discrimination formula for predicting the fabric sewing quality.

In fact, previous studies were conducted mainly on experimental methods. The theoretical relation between sewing shrinkage and mechanical properties of fabrics still remains unclear. In overfeed sewing there are two factors contributing to fabric shrinking, which are the mechanical properties and the sewing technologies including tension, performance and pressure imposed by the sewing thread. There have been some researches on the improvement of sewing technology [8-9]. Now this paper will carry out theoretical analysis and predict the relation between the OSS and mechanical properties of the fabrics from the aspect of textile design.

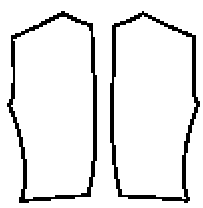

Figure 1 Indication of the shape stitched clothing pieces.

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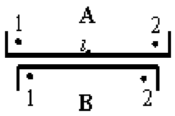

Figure 2 Schematic diagram of two fabrics.

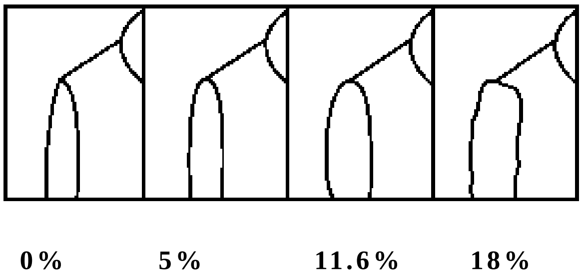

Figure 3 Appearance of the stitching under various overfeed quantities.

2. Theory

2.1 Theoretical model

As shown in Figure 2, the length l_e from spot 1 to spot 2 in fabric A is longer than its counterpart l_c in fabric B, thus fabric B is to be elongated when it is stitched with fabric A in sewing process.

Fabric A is to be bent and shrunk in length due to the pressure imposed by fabric B on its ends, while fabric B is held by horizontal tension. Ignoring the effect produced by sewing threads and the friction force between two fabrics, when the pressure in length caused by fabric B on A and the resistance generated by fabric A counteractively come in balance, at this moment, suppose the pressure in length on A at its ends is *p* (N/m), as shown in Figure 4, fabric A reaches the least horizontal length l_0 as shown in Figure 5. A Cartesian coordinate system is set up with the origin at the left endpoint of fabric A and its x-axis according to the fabric's length direction. The x-coordinate designates position of the cross-section and the y-coordinate designates deflection of this cross-section. Figure 6 shows the mathematical model for analyzing a thin fabric A's strip behavior. Thus, the differential equation can be derived as follows: [10]

$$EI\frac{d\theta}{ds} = -py + M_e + Rx + \int_0^s w(x - x')ds' \qquad (1)$$

Wherein,

EI: bending modulus of fabric A;
R: bearing force from the long fabric;
w: weight of the fabric;
M_e: external moment

In order to simplify the problem and find the key factors that affect overfeed shrinkage, the weight of fabric A and the external moment can be neglected. Namely, w=0, R=0, M_e=0, and formula(1)changes into:

$$EI\frac{d\theta}{ds} = -Py \qquad (2)$$

The deformation caused by overfeed is small, so

$$\theta \approx tg\theta = \frac{dy}{dx}$$

$$ds \approx dx$$

And formula (2) changes into:

$$EI\frac{d^2y}{dx^2} = -Py \qquad (3)$$

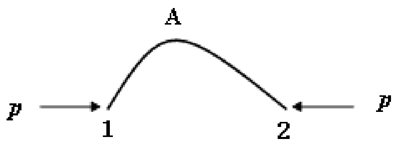

Figure 4 Pressure (p) in length on fabric A caused by fabric B.

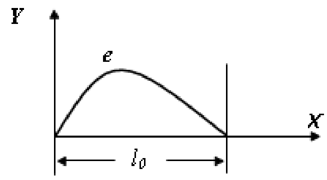

Figure 5 The minimal length of fabric A under pressure.

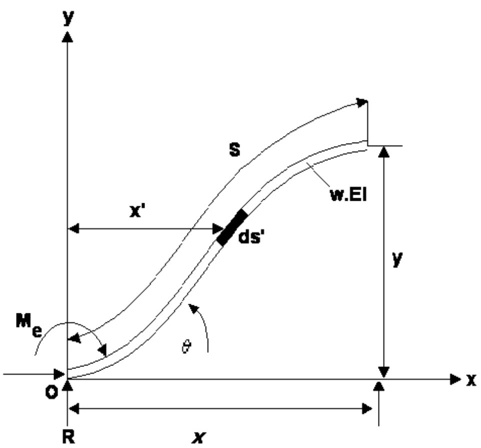

Figure 6 The mathematical model of fabric A.