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ON-LINE MEASUREMENT OF FABRIC MECHANICAL PROPERTIES FOR PROCESS CONTROL

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Refereed Journal Articles:

1. Adanur, S., and Qi, J., "Property Analysis of Denim Fabrics Made on Air-Jet Weaving Machine, Part 2: Effects of Tension on Fabric Properties", Textile Research Journal, Vol. 78(1), Jan. 2008, pp. 10-20.
2. Adanur, S., and Qi, J., "Property Analysis of Denim Fabrics Made on Air-Jet Weaving Machine, Part 1: Experimental System and Tension Measurements", Textile Research Journal, Vol. 78(1), Jan. 2008, pp. 3-9.

Abstract

Dynamic filling yarn tensions were measured on a Tsudakoma ZA203 air-jet loom using different count cotton yarns. Fabric samples were woven under different filling tension levels and then tested for fabric weight, thickness, permeability, dimensional stability, abrasion resistance, drapeability, tear strength, breaking load, elongation, stiffness and fabric wrinkle recovery. An attempt was made to correlate the filling tension and the fabric properties. After weaving, each fabric was divided into two sections. One section was washed and dried, and the other was left in the greige state in order to compare the results. All fabric testing was according to ASTM and AATCC standards. Before testing, the samples were conditioned under standard conditions (25°C, 65% RH).

Goal:

To develop principles of on-line measurement of fabric properties to improve product quality.

Technical Background:

Mechanical properties of fabrics are altered either by design or as a side effect in most textile processes. The ability to monitor or control fabric properties in real time is contingent upon the availability of a system to measure these properties on-line and in real time. This is becoming increasingly important with higher levels of automation. The envisaged system will contribute toward manufacturing quality fabrics at lower costs, by minimizing the need for expensive routine laboratory tests of fabrics.

The four principal fabric properties of interest to this research are tensile, bending, compression and surface character. Tension is an important factor which affects the productivity and quality of the fabric. Too high or too low yarn tension will cause defaults in the fabric. Therefore, on line tension control is desirable. Several kinds of yarn tension measurements in weaving systems are reviewed. A coordination meeting was held in Auburn in July 96. A computerized yarn tension measurement system and digital camera equipment were purchased.

During fabric formation, filling and warp tension is one of the leading parameters. Yarn tension is defined as the force acting in the direction of the longitudinal axis of a yarn. It is the quotient of tensile force and the yarn cross section derived from fineness and density of the material. It depends on various material properties, machine type, and yarn stress. High productivity and quality of fabric can be obtained only if the material properties are harmoniously matched with optimal yarn tension. Yarn tension can be divided into two types: static and dynamic. Static yarn tension which is characterized by slow change toward lower figures. Dynamic yarn tension which consists of two components - a basic yarn tension whose magnitude slowly changes, and a superimposed, fluctuating yarn tension with very quick changes. These fluctuations may be of a systematic or random character. Dynamic yarn tension occurs in the various textile manufacturing processes, principally because a yarn or group of yarns can only be moved from a supply position to a delivery position under the influence of a force. A minimum force is required for this movement, which is the basic yarn tension.

During the textile processes yarn tensions may deviate from the optimal values for some reasons. The deviations of yarn tension are possible in either direction, i.e. it may increase or decrease. But an increase is the more significant case and is observed more frequently than a reduction of the force acting on the yarn. If the yarn tension drops too much below the optimum, it may result in faults in the fabric, e.g. loops in the pick. Further drop may cause loom stoppage, e.g. shut down of a loom by the warp stop-motion. An increased yarn tension may result in the deformation of the fabric. Excessive yarn tension leads to many faults in the fabric. If the yarn tension continues to increase, weak yarn may break and a yarn break means stoppage of the machine. If a loom incorporates no monitoring elements for yarn breaks, or if these do not function, faults will appear in the fabric such as holes and runs. If the yarn tension in the process exceeds certain limits and is stressed for extended periods in this state, the yarn will lose its capability to recover. It is so called overextension of the yarn. It results in the permanent change of the material's internal structure. The change alters some of yarn's properties, so that it will react differently to mechanical or thermal influences. In practice yarns whose internal structure has been altered by excessive tension lead to faults as taut yarns, variant coloration, stripiness, etc. Therefore, it is very important to avoid yarn breaks throughout the entire fabric process, and to provide the optimal tension in every subphase.

In looms the yarn tension must be considered separately for warp and weft. In the weft system, particularly in shuttleless systems, extremely rapid changes occur in the yarn tension, which may lead to very high tension peaks. The warp tension has relatively slow changes. It follows periodic changes due to the shaft movement and the reed beat-up. The importance of the tension in the warp yarns during weaving is well recognized. Warp tension requirement will vary depending on fabric structure and density. The tension fluctuation is the result of shedding, beat-up, take-up, and let-off motions. Among these, the shedding and the beat-up processes cause considerable tension loads, and the effect of shedding is of the longest duration compared with the others. Fluctuation of warp tension causes the yarns to be stretched, then loosened cyclically, such repeated action damages the quality of the warp yarn. On the other hand, under the ever changing tension, the warp will move back and forth through the reed, heddle eyes, and drop wires many times within one deformation cycle. Therefore, finding ways to improve warp tension is important in weaving. In weaving plain fabric, warp tension due to shedding is usually compensated by an oscillating whip roll. Different kinds of cams have different influence of the whip roll motion on the process of weaving on certain looms. The cam design has little effect on fabric construction for weight, thickness, and thread count, but the warp tension in various operating periods changes with different cams. The effect of changing warp tension on fabric tearing strength is highly significant. Tension fluctuation during weaving process causes the heddle to deflect in the direction of yarn movement. Greater deflection of the heddles with certain cam could have reduced yarn abrasion and thus compensated for the differences in warp tension fluctuation to some extent.

Yarn tension measurement device includes a sensor (often called measuring head) to determine the measurement magnitude, also the amplifier, tensiometer, computer, and output units for indication, recording, and storage of the measurement values. Yarn tension measurements can be with analog or digital methods.

Measurement or estimation of bending behavior of textile fabrics under static conditions can be carried out by using pure bending testers (Kawabata's) or by examining shapes of loops (Peirce's "Heart" or "Pear") or beams (FAST: Cantilever). None of these methods can be used readily under dynamic conditions. However, types of loops can be generated and their instantaneous shapes can be examined under dynamic conditions. These shapes are determined primarily by the bending rigidity of the fabric in addition to few other known parameters. The relationship between the loop-shape and these parameters can be derived theoretically. So, in principle, once the loop-shape is determined the theoretical relationship can be used to determine/estimate the bending rigidity of the fabric.

Results:

1. Fabric Weight

Samples were weighed using ASTM D-3776 specifications. The fabric weight increased with an increase in filling tension which resulted in the formation of heavier fabric. When the average filling tension increased further, the filling yarn was stretched which resulted in decrease of the fabric weight (Figure 1).

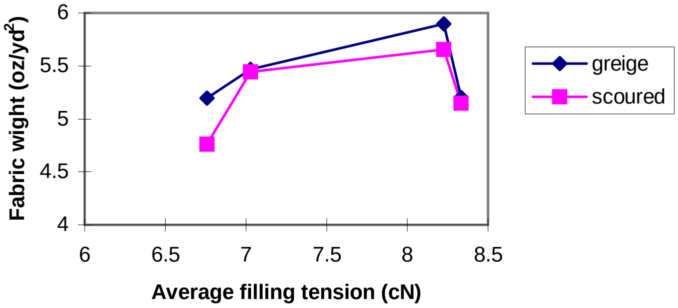

FIGURE 1. Fabric weight vs average tension

2. Fabric Thickness

The samples were measured according to ASTM D1777 - 96 specifications. With the increase of filling tension, the yarn becomes straightened and stretched. The higher the average filling tension, the thinner the fabric (Figure 2).

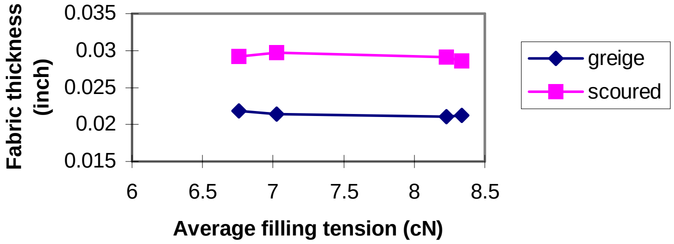

FIGURE 2. Fabric thickness vs average filling tension

3. Fabric Air Permeability

With increasing filling tension, fabric becomes thinner and the openings between yarns get larger. The air permeability is generally increased (Figure 3).

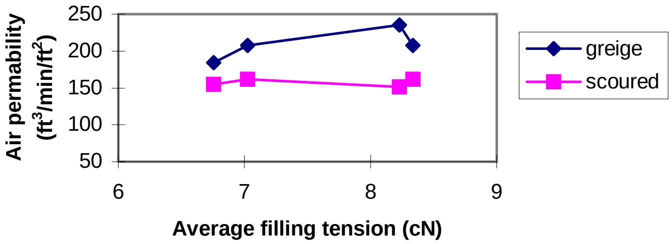

FIGURE 3. Fabric permeability vs average filling tension

4. Fabric Dimensional Stability

Filling tension introduced during weaving is one of the reasons, which makes a fabric shrink after washing. When the stressed fabric is agitated in water, the internal tension may be relieved. The structural readjustment takes place. The dimensional changes of fabric were tested using AATCC test method 135-1992. Filling-way shrinkage was measured after first and fifth washing and drying cycle (Figure 4).

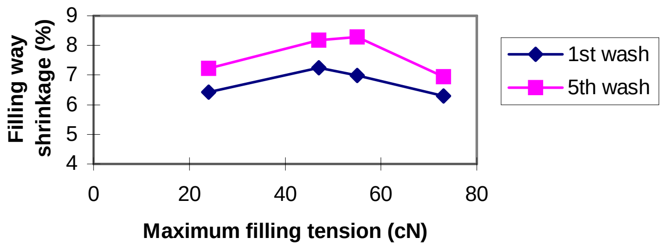

FIGURE 4. Fabric dimensional stability vs maximum filling tension

5. Abrasion Resistance

The abrasion resistance of fabric is the ability to withstand rubbing (frictional force) applied to its surface. Fabrics with high abrasion resistance retain their physical integrity. Fabrics with low abrasion resistance become thin and/or develop holes. They were tested using AATCC test method 93-1989 (accelerator method).

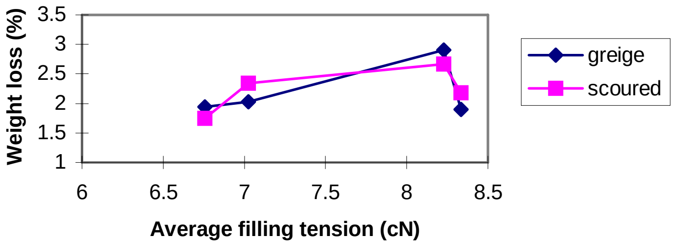

FIGURE 5. Fabric abrasion resistance vs average filling tension

6. Fabric Drapeability

Fabric drapeability is related to fabric weight, stiffness, and shear resistance. The greater the fabric weight, the better the drapeability. The greater the fabric stiffness, the worse the drapeability.

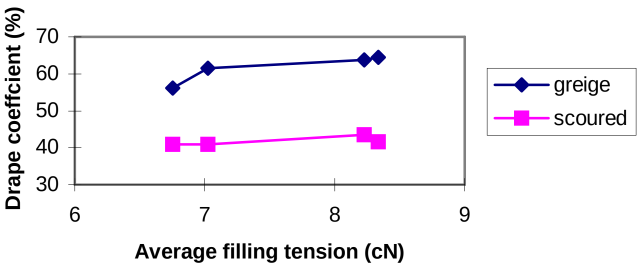

FIGURE 6. Fabric drapeability vs average filling tension

7. Fabric Tear Strength

Fabric tear strength is a reflection of the individual strength of yarns. The fabric filling way tear strength was tested according to ASTM D 1424-83 specification (Figure 7).

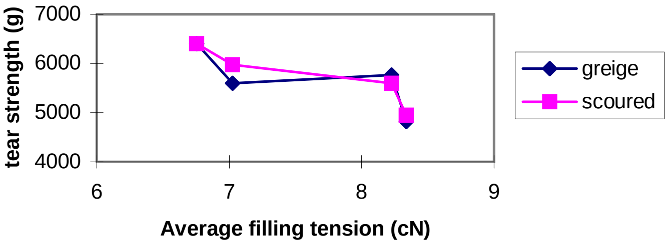

FIGURE 7. Fabric tear strength vs average filling tension

8. Fabric Breaking (Tensile) Strength

Fabric samples were tested in wet and dry condition as specified in ASTM D 5035-90. The filling way breaking load verses average filling tension is shown in Figure 8.

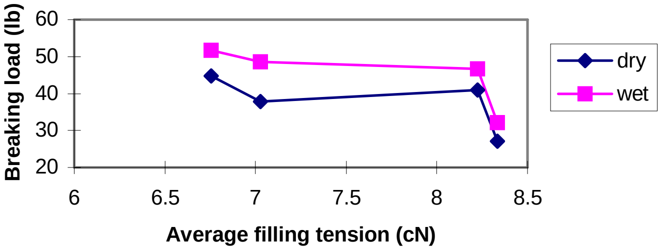

FIGURE 8. Fabric breaking load vs average filling tension

9. Fabric Elongation

Fabric filling way elongation was measured according to ASTM D 5035-90 (Figure 9).

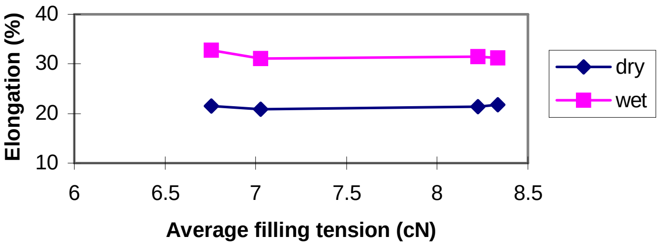

FIGURE 9. Fabric elongation vs average filling tension

10. Fabric Stiffness

Fabric stiffness was tested using ASTM D1388-64 specification. The filling way fabric stiffness verses average filling tension is shown in Figure 10.

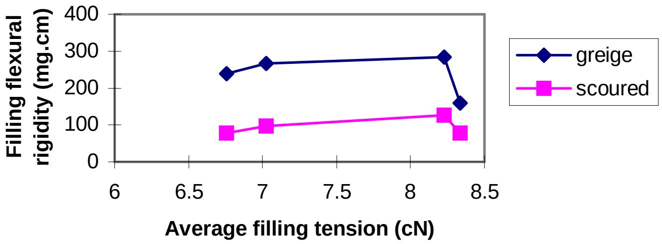

FIGURE 10. Fabric stiffness vs average filling tension

11. Fabric Wrinkle Recovery

The fabric wrinkle recovery was tested according to AATCC test method 66-1990 specification. The fabric filling way wrinkle recovery verses average filling tension is shown in Figure 11.

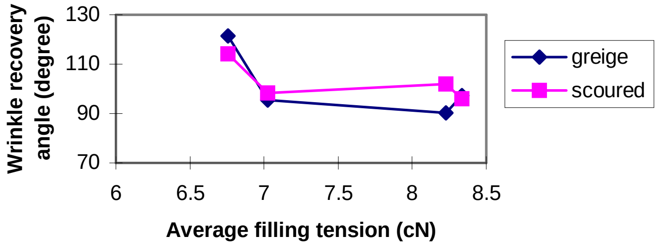

FIGURE 11. Fabric wrinkle recovery vs average filling tension

Summary and Conclusions:

In this study, a yarn tension measurement system was developed. Filling and warp tensions were measured on line on an airjet weaving machine. A 3/1 left-handed twill fabric was woven. Yarn and fabric properties were tested according to ASTM and AATCC standard test methods. On the basis of the test results, the following conclusions can be made:

- the higher the yarn count, the higher the average filling tension per cycle
- the higher the yarn twist multiplier, the lower the filling tension
- hairiness increases filling tension
- higher friction coefficient of yarn results in higher tension
- increasing filling tension increases fabric air permeability
- lower filling tension results in higher abrasion resistance
- the higher the filling tension, the lower the tear and tensile strength
- higher filling tension results in higher filling direction flexural rigidity.

Literature cited

- P. M. Latzke, Yarn tension measurements in the textile industry, Melliand Textilberichte, September 1978, p. 714

- V. Chahal, M. H. Mohamed, Measuring filling yarn tension and its influence on fabrics woven on a projectile weaving machine, Textile Research Journal, May 1986, p. 324

- S. Adanur, M. H. Mohamed, Analysis of yarn tension in air-jet filling insertion, Textile Research Journal, May 1991, p. 259
- B. V. Holcombe, R. E. Griffith & R. Postle, A study of weaving systems by means of dynamic warp and weft tension measurement, Indian Journal of Textile Research, March 1980, p.1
- H. Gu, Reduction of warp tension fluctuation and beat-up strip width in weaving, Textile Research Journal, March 1984, p. 143
- D. C. Snowden, Some aspects of warp tension, Journal of Textile Institute, 1950, p.237.