ON-LINE MEASUREMENT OF FABRIC MECHANICAL PROPERTIES FOR PROCESS CONTROL

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On-line Measurement of Fabric Mechanical Properties for Process Control

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Goal

To develop principles of on-line measurement of fabric mechanical and physical properties to improve product quality and reduce waste.

Abstract

We conducted dynamic warp and filling tension measurements on a Tsudakoma ZA203 air-jet loom using different count cotton yarns, to make the correlations of yarn characteristics - count, twist multiplier and hairiness to filling tension and to measure filling yarn friction coefficient. Yarn tension data will be used to establish relationships between fabric properties and tension. A generalized fabric bending model has been developed. A vision system is under development to monitor fabric defects on line.

1. Yarn Tension Measurements

Experiments were carried out on a Tsudakoma ZA203 air-jet loom. The loom uses multiple nozzles and profiled reed. A cutter is mounted on the entry side of the loom frame and it cuts the filling yarn at the moment of beat up. During experiments, the air pressure was controlled at 80 psi. A 3/1 left-handed twill fabric with leno salvage was woven. The warp yarns were 16Ne 65/35 polyester/cotton. 100% cotton yarns with different yarn counts and twist multipliers were used as filling yarns.

The dynamic yarn tensions were recorded and evaluated by using Denkendorf Yarn Tension Tester (DEFAT). A 500 cN measuring head based on the three point deflection principle was used in continuous contact with the yarn during weaving to monitor dynamic yarn tension. For filling tension measurement, it was placed at the minimum possible distance just before the main nozzle, as shown in Figure 1. We took releasing solenoid pin of the drum feeder as the triggering moment to record certain part of the tension signal. The air jet loom was operated at a speed of 540 picks/min. The entire tension cycle for a weft took about 111 ms with a sampling rate of 8 kHz and 888 tension data per pick cycle were recorded for 35 cycles throughout the experiment to evaluate the average filling tension traces. For measuring warp yarn tension, the measuring head was placed in the warp sheet slightly forward of the back roller on the loom. One yarn from the center heddle shafts is fed into the measuring head to produce a trace. A microswitch was triggered at beat-up action to begin the warp tension sampling.

A typical weft tension trace for one pick and the average of 35 picks is shown in Figure 2. In the figure, the beginning of the cycle corresponds to releasing the filling by the solenoid pin of the drum feeder. After the yarn is released, the yarn tension increases due to the force effect of the air stream of the main nozzle upon the yarn surface and due to the formation of a yarn balloon between the drum feeder and the thread guide in front of the solenoid pin. When one wind of the stored weft yarn wound on the drum feeder runs out, the interruption of filling movement causes the tension to rise resulting a tension peak. But it drops again as the filling yarn continues to be fed from the drum. When one pick length is exhausted, the maximum tension peak occurs as the yarn hooked by solenoid pin. The position of the maximum tension peak slightly varies according to different filling yarn (Figure 4). After solenoid pin is turned off, the tension starts to rise as the filling becomes straight in the shed. When the actual pick length is consumed, the entry of the filling yarn tip falls into the suction nozzle which causes a tension peak. When the cutter begins to cut the yarn, the tension on the yarn has a sudden drop.

Figure 3 shows the single end warp tension trace. Warp tension curve is the result of shedding, beat up, let off and take up actions. It also depends on fabric structure. Weaving motions cause warp yarn move back and forth through reed, heddle eyes and drop wires which stretch and loosen warp yarn within weaving cycles. As the warp tension sampling was triggered at beat up moment, the magnitude of the beat up peak at time 0 becomes significant. Then the tension sharply decreases as the fell of the cloth returns to its normal position. As the shed opening continues, it results in a further increase in warp tension. Before the harnesses reach their extreme top and bottom positions, a maximum warp tension occurs. After that, the warp tension decreased as the shed was closing. Another tension peak is due to the four - pick shedding. The tension cycle repeats every four picks because of the 3/1 twill weave.

Results and Conclusions

The effects of different yarn parameters on filling tension were investigated. The tensions of several 100% cotton filling yarns with different yarn count, twist multiplier and hairiness under same air pressure are compared in Figure 4.

The characteristics tested filling yarn as shown in the following table:

Table 1. The tested filling yarn parameters

Yarn Count (Ne)	Twist Multiplier	Hairiness (count/100 m)	CV of Unevenness (%)
14.25/1 OE	4.01	2526	15.29
17/1 OE	4.14	1686	22.06
20/2 RS	4.53	3884	9.89
20/1 OE	4.72	2558	15.66
23/1 OE	3.99	2068	17.40

Yarn Count

Yarn with high linear density has longer insertion times. Finer yarn has considerably higher average velocity compared to coarse yarn. The effect of linear density increases as the difference between densities gets larger. Basically the higher the yarn count, the higher the average filling tension per cycle.

Hairiness

The bulkier OE yarn has more hairiness which increases the yarn surface area resulting in an increased filling tension. The higher hairiness of OE yarn has higher initial acceleration.

Twist Multiplier

Twist increases the strength of the yarns by creating lateral forces which prevents the fibers in the yarn from slipping over one another. These forces bring the fibers closer which makes the yarn more compact. High twist level increases the insertion time. This is because twist reduces the diameter of the yarn and makes the yarn surface smoother. The propulsive force decreases with a decrease in the diameter. Also, smoother surface reduces the friction between the yarn surface and the air. As a result, basically yarns with low twist have longer velocities and high weft drag.

Coefficient of Friction

The filling yarn coefficient of friction is a dimensionless parameter which is a function of Reynold's number, surface roughness and turbulence level. Higher air velocity causes smaller coefficient of friction. The yarn count, yarn material and hairiness influence the coefficient of friction.

2. Fabric Bending Model

A generalized fabric bending model has been developed based on the nonlinear bending moment-curvature relationship of fabrics (Figure 5). Introduction of this model makes it possible to theoretically investigate the effects of fabric nonlinear bending behavior on the measured bending property values.

The dependence of measured parameters, e.g., bending length, bending rigidity) on the test conditions for Cantilever and Heart loop (Loop 3 and 4 in Figure 2) has been determined theoretically. Calculated results show good agreement with experimental observations reported in the literature. An important discovery from this investigation indicates that the bending length values calculated and measured from loop 3 and loop 4 are virtually not influenced by fabric sample length if the sample length is beyond a certain critical value.

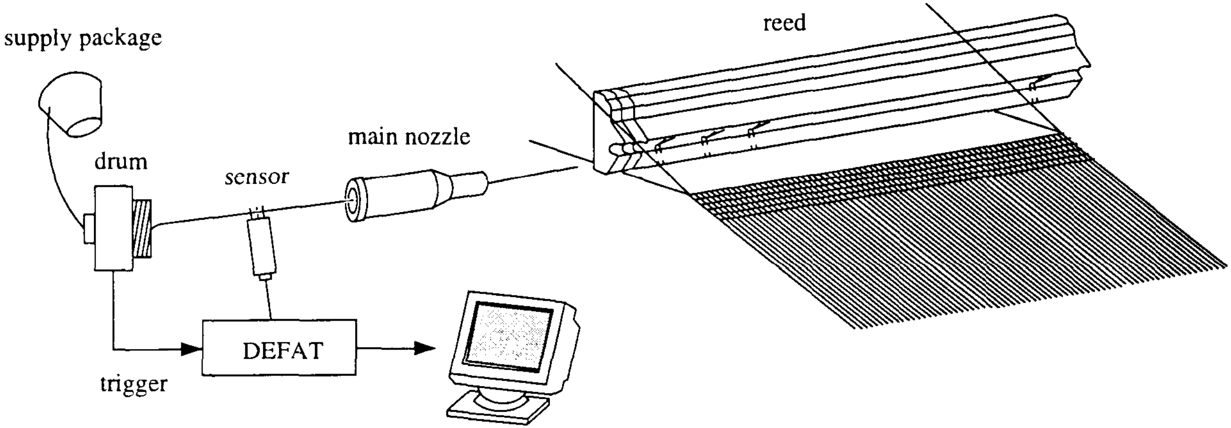

FIGURE 1. Schematic of fillling yam tension measurement.

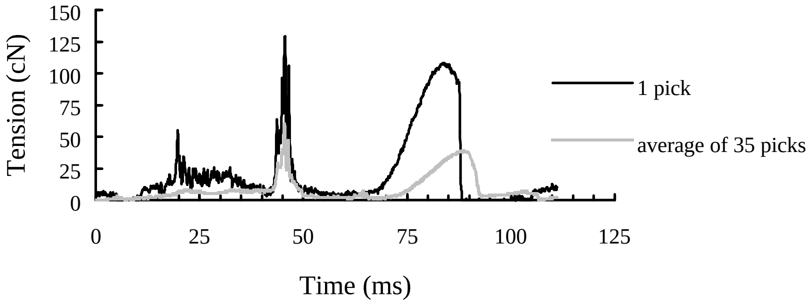

FIGURE 2. Air-Jet loom Filling Tension Trace

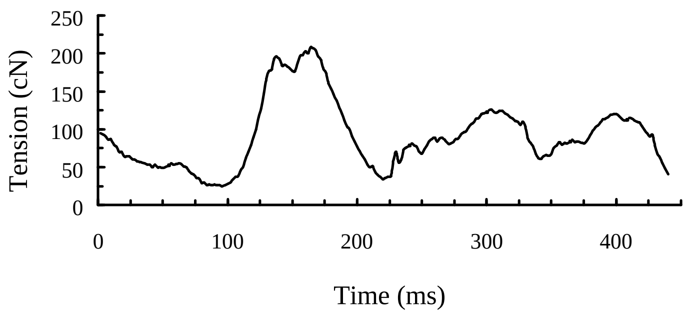

FIGURE 3. Air Jet Loom Warp Tension Trace

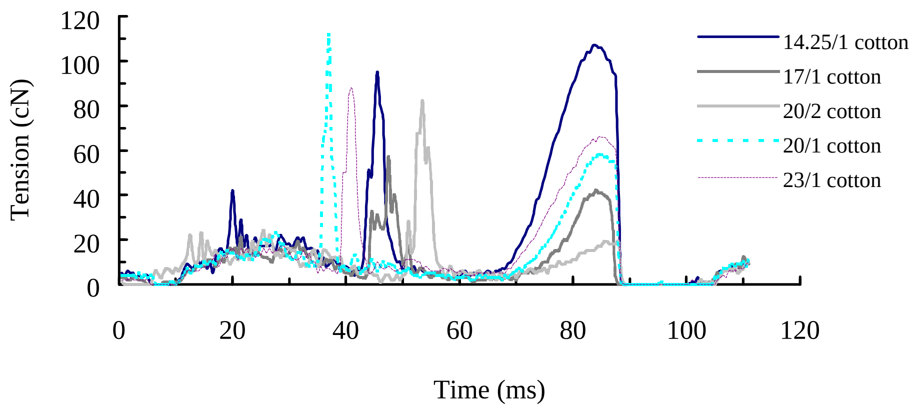

FIGURE 4. Comparison of filling tensions

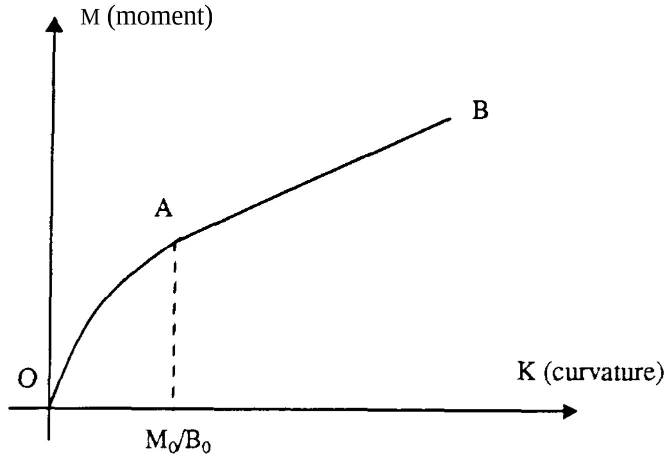

FIGURE 5. Typical fabric moment-curvature relationship.

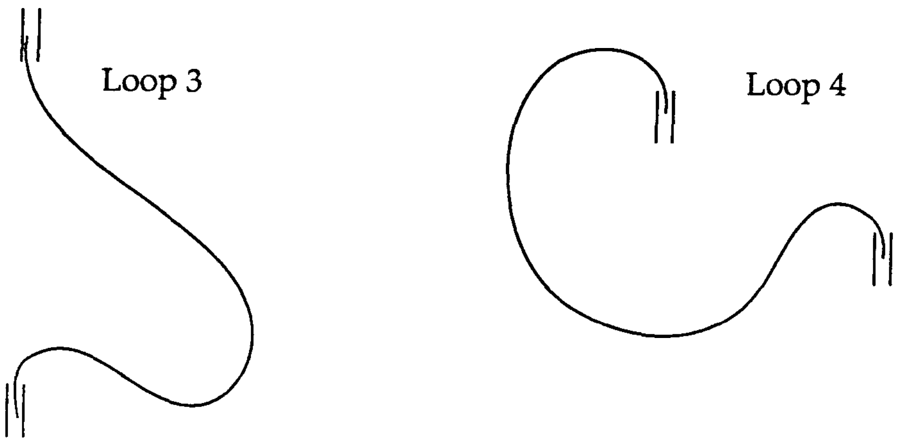

FIGURE 6. Loop types 3 and 4 investigated for on-line application.