ON-LINE MEASUREMENT OF FABRIC MECHANICAL PROPERTIES FOR PROCESS CONTROL

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Goal

Develop an on-line system for the measurement of fabric mechanical properties.

Abstract

The four principal fabric properties of interest to this research are tensile, bending, compression and surface character. Literature review in these areas have been completed. 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. Arrangements have been made with Avondale Mills to conduct on-line fabric tension measurements. A computerized yarn tension measurement system and digital camera equipment have been ordered.

1. Yarn Tension

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 warn 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 warn 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 warn tension in various operating periods changes with different cams. The effect of changing warn 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. A computerized yarn tension measurement system has been ordered for this project.

2. Fabric Tension

Arrangement with Avondale Mills was made to use their facilities as a test platform for an on-line tension detection device for denim at the weaving machine. The device is based on optical variation of light reflectance which occurs as denim tension increases because the warp beam is running out and turning increasingly fast. Testing the principle has begun on static samples. We designed a test clamp to secure the fabric at various levels of strain achieved at the Instron tester. At each level of strain, we have recorded a load and taken reflectance measurements to determine whether differences exist and if there are any relationship present. The data were and we have noted a very strong relationship between strain in the warp direction and increasing reflectance from the filling. Work is continuing on determination of the mechanism responsible for this relationship. Digital camera equipment has been ordered and work is continuing to design a mount for the equipment which can be used at a running weaving machine. This step could be completed in October, depending on the arrival time of the equipment. Initial running trials will be at AU on either/both the Tsudakoma air jet and Sulzer TW- 11 machines. Plant trials at Avondale will begin very shortly after trials in the weaving lab have concluded and final designs for camera mount and recording procedures have been determined.

3. Bending Properties

The four principal fabric properties of interest to this research are tensile, bending, compression, and surface character. In the reporting period we have completed the initial literature review on the subject. The initial thrust is to explore the possibilities of measuring bending behavior on-line and demonstrate the principles through theoretical analysis. 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.

Literature cited

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