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WEAVING SIZELESS COTTON WARP YARNS - PROGRESS REPORT #2

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Abstract

A real weaving test/trial of a size-less warp of singles cotton yarns was successfully conducted, to the best of our knowledge for the first time ever, on a commercial fly shuttle weaving machine under mill conditions. The results were most encouraging and, in fact, exceeded our expectations. During the current, second year of the project on sizeless weaving, we had the dropwires, heddles, and reed of a 52" wide Draper, X-P loom coated with Teflon^{R} to minimize yarn abrasion during weaving. After mechanically refurbishing and tuning the loom, we first started weaving a conventionally-sized, control warp segment that had been wound on the top of the experimental sizeless warp section on the same loom beam. The conventionally sized portion of the warp was intended as a control. Although the control warp itself ran reasonably well, we had a very high number of loom stoppages mainly due to mechanical failures (associated with the picking and checking mechanisms) of the weaving machine. We spent a considerable amount of time adjusting and tuning the machine. At any rate, in early September (2001), we started our first weaving test/trial with the sizeless segment of the warp, which was a 30-tex, combed Acala cotton, rotor-spun yarn produced about a year ago [1, 2]. We are extremely pleased to report here that the test was a complete success and the results exceeded our expectations in the sense that not even a single yarn, among about 2000 being evaluated, failed or broke during almost 1 ½ hours of machine running time, *which indeed is an exciting new milestone in cotton textile processing.* Although the fabric construction and structure were light, the loom was run at its normal speed. On September 6, we tried a 50% higher pick density (30 ppi v/s 20 ppi on September 5) and the loom still wove a fabric without a single yarn failure or breakage. On December 5, 2001, we ran a weaving test with 40 ppi and had no yarn breakage. That indeed was a remarkable accomplishment beyond our expectation. Although a slightly excessive yarn hairiness (perhaps caused by the yarn abrasion against the loom components) was observed, it absolutely did not interfere with either the (clean) shed formation or the (trouble free) weft insertion mode (shuttle). The yarn wove without difficulty into a 2/1 twill fabric of smooth hand. However, it may also be noted that this success was attained with a particular set of yarn and weaving conditions, which only indicates that the sizeless weaving is feasible and promising. We must conduct a number of additional investigations and weaving trials with other yarns, fabric styles, machines, and processing parameters and conditions to fully develop a new wholesome technology and a fundamental knowledge of sizeless weaving.

Introduction

As it was briefly mentioned in Progress report #1, we have developed a multi-pronged research approach for developing a wholesome technology for weaving cotton yarns without, or with reduced, traditional warp sizing. Our basic research strategy continues to be to try to solve, without the conventional warp sizing, the yarn- and weaving- sensitive deficiencies and problems that currently are addressed by the use of conventional sizing. In other words, we are trying to improve yarn characteristics and modify weaving machine and conditions that are deemed critical for efficient weaving - whether the conventional or the size-free weaving.

Since the characteristics of a yarn's constituent fibers and the spinning system/method play very important and significant roles in the physical, mechanical and functional properties and, hence, in the processing attributes (weaving) of the yarn, we selected the most desirable/optimum fiber quality, fiber processing, and spinning method to obtain desired yarn properties that, hopefully, would take care of the obvious and anticipated problems of sizeless weaving. Also, since we know that a yarn's abrasion resistance against the loom's critical components is the most critical parameter for efficient weaving, we decided to modify the weaving machine and conditions to minimize the yarn abrasion during weaving. For that purpose, we had the loom reed, heddles and drop wires coated with Teflon. Furthermore, to minimize incidence of loom stoppages that are due to the so-called "clean" or "unknown" (reason) warp yarn failures/breakages during weaving, we have developed a comprehensive theory which, although it still has to be experimentally validated, explains why and how a clean yarn break occurs without any physical evidence, known cause, or obvious reason. It is hypothesized that a probable cause of a so-called clean or unknown yarn failure during weaving is the significant disparity, difference, or variation in the (winding) tension of individual yarn strands among the several thousand yarns that comprise a loom beam. Although simultaneous measurements of actual running tensions of several individual yarns during weaving have yet to be completed to validate the hypothesis, it is predicted that a clean warp yarn break can only occur when the yarn tension (in case of certain, relatively tightly wound strands) gradually increases as the weaving progresses and ultimately exceeds the yarn's endurance limit (breaking strength). The theory behind this hypothesis is that the several thousand individual yarn strands comprising a loom beam generally have different winding tension levels. However, the cloth take-up and the warp let-off mechanisms on a weaving machine *are not equally sensitive* and/or synchronized in the sense that the take-up mechanism takes up and winds the woven fabric on to the cloth roll *with an utmost precisioned rate* (especially on modern high speed weaving machines), while the let off mechanism, although it mechanically senses and tends to maintain an almost constant tension of the *entire warp sheet* of all the yarns, is incapable of maintaining a consistent tension *among the warp sheet's several thousand individual yarn strands* (on the loom beam). Obviously, as the weaving progresses and the woven cloth is taken forward at a **precisely constant** rate by the take-up mechanism, the relatively tightly wound individual yarn strands in the warp sheet would progressively get even tighter because the (warp) yarn let-off mechanism is not that precise and, thus, does not deliver the warp at the same precisely constant rate as the cloth take-up. The warp let-off mechanism operates by means of a pressure sensor (whip roll), which *only senses the sum of the tensions/pressures of all the yarns in the warp sheet, i.e., it does not sense or control the individual yarn tension, which, in the case of some tightly wound yarns, can keep on increasing until the yarn breaks.*

In a nutshell, our multi-pronged research approach basically involves:

- Attaining greige yarn attributes that are required for efficient weaving without the traditional warp sizing. For example, low hairiness, high abrasion resistance, and high and uniform tensile properties of a yarn are considered critical for efficient weaving. So, we selected a good cotton and tried to modify yarn structure, improve yarn quality, and manipulate processing parameters to attain yarn properties that at least are deemed desirable for sizefree weaving.
- Modifying weaving machine and conditions to solve anticipated problems of sizeless weaving. Since excessive yarn abrasion is known to be detrimental to efficient weaving, we tried to minimize the yarn abrasion during weaving by coating critical loom parts with Teflon.
- Conducting real weaving experiments with sizeless cotton yarns to identify, analyze and possibly remedy the yarn failures to develop a fundamental knowledge of actual causes of yarn failures in weaving.

Experimental

Using Acala cotton, we produced an Ne 20 (30 tex) rotorspun combed yarn for both warp and filling. The yarn was appropriately cleared and ultimately wound on to warper beams with an almost consistent tension of about 12-15 grams per strand. The warp set was passed through a slasher whose (size) boxes were filled with only boiling water containing 1% Triton X-100, which is a nonionic emulsifier/wetting agent. No traditional size or sizing formulation was used for about half of the set (~ 75 yards), which was simply immersed in the boiling water, squeezed, dried on only 3 drying cylinders, kissed with a molten wax/lubricant, and wound on to the weaver's beam. Thereafter, the remaining warp set (~75 yards) was conventionally sized (with 6-8% PVA), slashed and wound on to the top of the sizeless warp section on the same beam.

A 52-inch wide Draper X-P loom running at 190 ppm was used for weaving experimentation at SRRC Textile Pilot Plant (Mill). The loom was modified in the sense that its critical components, viz., reed, heddles and dropwires, were coated with Teflon to minimize yarn abrasion during weaving. Otherwise, the loom, weaving and environmental conditions were pretty much similar to typical mill conditions. The nominal or intended fabric construction was a 2/1 twill with 48 x 48 epi and ppi, respectively. It was a 40-inch wide fabric weighing approximately 3.5 oz/sq. yd.. However, to establish optimum warp tension and weaving conditions, we first started the loom with the filling insertion of only 20 ppi. After about an hour of weaving, we increased pick density to 30 ppi and wove the yarns for another 30 minutes.

Results and Discussion

As reported previously in Progress Report # 1, the open-end, rotorspun combed yarn was tested according to standard test procedures and found to be of excellent quality and characteristics that were deemed most desirable for sizeless weaving. As soon as we are able to collect specimens (of sufficient length) of the sizeless and sized sections of the warp, we should have some meaningful tests conducted on the said yarns. However, the actual weaving results exceeded our expectations in the sense that not even a single yarn strand failed or broke during almost 2 ½ hours of running with three pick levels, viz., 20, 30 and 40 ppi. Although there was some hairiness (fibers projecting or protruding from the yarn surface) observed in the warp near the dropwires, it absolutely did not interfere with the weaving process, i.e., with the shed formation and/or the filling insertion. The shed formation was clean and no fiber-to-fiber or yarn-against-yarn clinging was noticed. The shuttle flight also was unaffected by the said hairiness. The projecting fibers seemed to easily slip against each other without causing any difficulty or problem.

Conclusion

An exploratory of sizeless weaving has been successfully conducted, which revealed that the sizeless weaving of single's cotton yarn is feasible and promising for at least some types of yarns and fabric styles. Additional, planned experimentations with different yarns, fabrics and weaving machines are expected to yield information that would be very helpful in developing a new technology for sizeless weaving and understanding the real causes of yarn failures during weaving.

Note

This manuscript is a summary of the progress made, during year 2001, on the ARS-CRIS project on "size-free" and/or "less-size" weaving of cotton yarns. It was prepared on October 26, 2001, for presentation (as a proceeding) at the Jan '02 Beltwide Cotton Conferences in Atlanta, GA.

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