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EFFECT OF WASHING AND DRYING OF A COTTON WARP ON ITS CHARACTERISTICS AND WEAVABILITY

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Abstract

In a continuous process, a warp of 100% cotton yarn was uninterruptedly washed in boiling water containing a soap and a wetting agent and dried under a nominal tension/stretch on three (3) steam heated (200F) cans on a conventional "dummy" slasher (i.e., without using a sizing mix) before being wound on to a loom beam. The beam was installed on a slightly modified fly-shuttle loom and the (size-free) washed warp was woven, under almost mill-like speed and conditions, into an open-construction twill fabric. The warp yarn was tested, mainly for its tensile characteristics, before and after the washing and drying and the washed warp was evaluated for its weavability. Results have shown that the tensile breaking strength of the washed/dried yarn is about 20% greater than that of the original, greige yarn and the weavability of the washed warp is satisfactory, although it can not be positively determined at this time that the satisfactory weaving performance of the warp indeed was due to the increased yarn strength alone. About 65 meters of an open twill fabric was woven without a single yarn failure.

Introduction

Production of woven cotton fabrics involves an almost essential process of *warp yarn sizing* to assist efficient weaving. However, a fabric woven from a sized warp must be *desized* to completely remove all ingredients or chemicals of the size formulation used. Both the warp sizing and the subsequent fabric desizing are centuries-old textile processes that are very complex, costly, and environmentally-sensitive. This is because of the wastage of expensive chemicals, energy and water involved in these two processes and also because of waste water treatment that is mandated by the Environmental Protection Agency (EPA). The textile industry wants to reduce and preferably eliminate the warp sizing, which automatically would reduce or eliminate fabric desizing and ultimately lower production costs and environmental risks.

We at SRRC have developed a multi-pronged research approach to try to eliminate warp sizing and achieve efficient (size-free) weaving. The approach basically consists of: 1) improving greige yarn structure and quality; 2) improving warp preparation without sizing; and 3) minimizing yarn abrasion during weaving. Results of a recent, size-free weaving trial, which simultaneously involved all the three improvements mentioned above and which was conducted on a commercial weaving machine operating under mill-like conditions, have been extremely encouraging in the sense that we were able to *efficiently weave for the first time ever* about 65 meters of a 100% cotton twill fabric of a relatively open construction without a single yarn failure. However, since several factors were simultaneously involved in this "sizeless weaving" trial, it is difficult to know at this time whether the increased tensile strength and/or any other related yarn effect due to the washing and drying was indeed a major contributing factor in the yarn's satisfactory weaving performance. Independent studies of these various factors/variables with appropriate controls in the planned weaving trials in the future with different materials and machines should give us additional information in this regard as well as assist us in the fundamental understanding of the size-free weaving and its potential problems. In the meantime, this paper briefly describes the method of ordinary (plain) washing and drying of a cotton warp without the traditional warp sizing, the effect of washing and drying on the warp yarn tensile properties, and the weaving performance of the warp.

Materials and Procedures

Acala cotton (1 3/16"; 4.0 mic.; 32gf/tex) was used to produce a 20/1 Ne, combed, rotor-spun yarn for both warp and filling, using almost customary mill equipment, procedures and conditions. The greige yarn was tested for its tensile properties according to standard (ASTM) procedures. A set of warp beams was prepared on a conventional warper, ensuring a consistent tension on each yarn package in the creel. The set was placed behind an old, conventional slasher. The size box of the slasher was filled only with boiling water containing a rice soap and a non-ionic wetting agent to assist a thorough washing and also some surface lubrication *(due, in part, to the dissolution of natural sugars and waxes and the action of squeeze rolls to bring the dissolved/loosened waxes on to the yarn surface)* of the yarn. The yarn continuously and uninterruptedly passed through the boiling water bath and then over only three (3) steam-heated cans or cylinders to dry under nominal tension (0.8 % stretch) before being lightly lubricated with molten paraffin wax (or, preferably a vegetable oil), leased, and wound on to a loom beam. The washed and dried yarn samples were tested for tensile properties. The beam was mounted on a Draper 52" wide X-P loom, which had its critical components, viz., reed, heddles and drop-wires, specially coated with Teflon to minimize yarn abrasion during weaving. A 2/1-twill fabric of a rather light construction (52 epi x 44 ppi) was woven under almost mill-like speed and conditions. The yarn weavability was assessed according to warp yarn failures during weaving. The warp yarn abrasion, hairiness, and lint-accumulation and the fabric appearance/hand were subjectively evaluated.

Results

As shown in the Table, the yarn after washing in the boiling water and subsequently drying under nominal stretch (0.8 %) shows more than 20% increase in its tensile strength compared to that of its greige stage. Although the yarn shrinkage, which most probably occurred during the yarn's "washing and drying" treatments, could not be precisely determined, the 20% increase in yarn strength appears to be a significant factor in the yarn performance during weaving. The breaking elongation of the washed and dried yarn however is unexpectedly and abnormally low. Furthermore, its standard deviation (SD) and coefficient of variation (CV) are high, which can not be explained at this time but will be appropriately investigated and possibly controlled in the future size-free weaving investigations.

The weaving performance of the sizeless warp was surprisingly good in the sense that not even a single yarn strand, among about 2000 being evaluate, failed or broke during the entire weaving trial that produced about 65 meters of fabric. It indeed was an encouraging development in cotton textile processing. The fabric hand was smooth, presumably due to the increased yarn hairiness generated during weaving. However, it is interesting to note that the increased yarn hairiness absolutely did not interfere with either the (clean) shed formation/opening or the (obstruction-free) filling propulsion/insertion. No fiber-to-fiber or yarn-to-yarn entanglement ever occurred or was ever observed. Also, the amount of lint collected from underneath the loom was not abnormal or excessive even though the mechanical actions of weaving certainly produced additional hairiness due to the yarn abrasion. Instead, it appeared that the increased yarn hairiness was actually beneficial by providing a sort of "cushion" against any progressive yarn abrasion. Visual observations of the warp during weaving clearly showed that a significant yarn abrasion occurred (as indicated by development of increased yarn hairiness) immediately after the yarn entered the drop-wire banks and then the rate of progressive increase of yarn hairiness seamed to be much lower as the warp raced forward. This indicated that the increased hairiness generated by the drop-wires perhaps helped in subsequently curbing aggressive yarn abrasion in the heddles and reed (sweep) regions and consequently minimizing progression of hairiness. Also, since no warp yarn failed despite the (observed) increasing yarn hairiness during weaving, it may be concluded that the increased hairiness (resulting from excessive abrasion of the *size-free* warp) may not be as detrimental and critical to weaving as previously thought. Planned size-free weaving trials on a high speed rapier weaving machine (and, later, perhaps on an air-jet weaving machine) would show whether or not the increased yarn hairiness of a size-free warp actually interferes with the shedding and filling-insertion systems of these modern weaving machines. However, based on the observations made on the present weaving exercise on a fly-shuttle loom, it seems that it probably will not, since a significant increase observed in the number of protruding and projecting fibers on the yarn surface during the present weaving exercise really did not create any "fiber clinging" or any "yarn obstruction" problem. The shed formation was very clean and obstruction-free and no shuttle deflection/filling failure ever occurred. In fact, it now appears that the traditional size itself (*if and when improperly applied, dried, or damaged (during weaving))* may be responsible for causing the common fiber-to-fiber and yarn-to-yarn entanglements during weaving, because of adhesive nature of the size. In the absence of warp size, other adhesive, or any contaminant (such as cotton's natural sugar/wax, etc.), a thoroughly washed and dried, size-free warp may, therefore, prove to be free of the perceived problems of fiber clinging and/or yarn entanglements that normally are encountered in weaving *sub-sized* yarns.

Conclusion

The washing and drying (under certain tension/stretch) of a cotton (warp) yarn considerably increases the yarn's tensile breaking strength. Although it is not yet known whether the increased yarn strength particularly is a critical contributing factor in the yarn's weavability, the washing and drying of the yarn seems to minimize and possibly eliminate the problems of fiber-to-fiber clinging and yarn-to-yarn entanglements, which would greatly assist weaving size-free cotton yarns. Based on the satisfactory weaving performance of a washed, size-free cotton warp, it seems that size-free weaving is feasible at least for certain types of yarns, fabrics, and weaving machines, which in itself is an exciting development and perhaps a pioneering milestone in textile processing. If commercially scalable, the size-free, washed cotton warps for weaving could offer great economic and environmental incentives by minimizing use of costly energy, water, and complex chemicals.

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References

Sawhney, A.P.S., Price, J.B., and Parachuru, R. Weaving sizeless cotton warp yarns - Progress Report #2. Proc. Beltwide Cotton Research Conferences, NCC, Memphis, TN. Proceedings Disk, 2002.

Table 1. Yarn Properties.

Greige Yarn
-Nominal Size = 30 tex (20/1 Ne)
-Mean S.S. Bkg. Strength =485.5 (Std. Dev. 29.1) gf
-Mean Strain-at-break = 8.2 (Std. Dev. 0.53) %
-Mean Tenacity at Break =17.5 (Std. Dev. 1.05) g/tex
Washed & Dried Yarn:
-S.S. Bkg. Strength =597.6 gf (Std. Dev. 41.1 gf; CV6.9%)
-S.S. Bkg. Elong.=3.5 % (Std. Dev. 0.46 %; CV 13.5%)