A PROTOTYPE YARN EVALUATION TESTER TO RAPIDLY ASSESS COMPARATIVE WEAVABILITY OF WARP YARNS WITHOUT WEAVING

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Abstract

The art of weaving continues to be the most predominantly used method of converting textile fibers into fabrics for various end-use applications, including apparel. In fact, the weaving is by far the largest textile manufacturing sector, worldwide. However, the weaving process is complex and costly. Reliable prediction of weaving performance of a warp yarn without actual weaving can be cost effective and hence beneficial to a weaving mill in negotiating price contracts with their customers (buyers of the mill output). Although the weaving performance or the so-called weavability of a warp yarn depends on many factors, including the warp yarn quality and preparation, fabric construction and structure, type and speed of weaving machine, and quality of filling yarn, the quality of greige warp yarn considerably influences the yarn's endurance in weaving and ultimately determines its weaving performance and hence the weaving productivity, which, in turn, essentially determines the profitability of the textile mill.

In an ARS-USDA-supported research project to explore feasibility of ***size-free weaving*** of cotton yarns, a prototype Yarn Endurance Tester (YET) was developed in collaboration with the Louisiana State University, Baton Rouge, LA, to cost effectively expedite the research on size-free weaving of different yarns with minimum actual weaving, since the weaving process, as mentioned previously, is very costly, complex, and, above all, very time consuming in a laboratory scenario. The development of YET basically involves comparative assessment of a greige yarn's relative resistance to attrition (i.e., damage or failure), when subjected to limited weaving-like actions. Since the inherent, basic quality attributes of a greige warp yarn are known to ultimately influence the weavability or performance of its sized/slashed version, it is believed that a yarn's evaluation on YET, coupled with the yarn's basic quality characteristics, will be very useful in predicting weavability of the yarn in actual weaving. Obviously, the YET would be equally useful in predicting weavability of conventionally sized yarns for traditional weaving, as well. A brief description of the YET is the basis of this manuscript for the Cotton Beltwide '08 Conference on Cotton Utilization.

Introduction

The Agricultural Research Service of the United States Department of Agriculture (USDA) has recently achieved an exciting milestone in cotton textile processing by producing significant quantities of cotton twill fabrics from *size-free* warp yarns on a modern high-speed, flexible-rapier weaving machine operating under mill-like conditions (Sawhney 2003, 2005; Singh, 2007). However, the quality of woven fabrics is not fully satisfactory and hence commercially acceptable. Research collaboration with Louisiana State University aims (a) conduct comprehensive mechanical analyses of weaving process towards developing successful technology for "size-less weaving"; (b) fully understand the fundamentals of size-free weaving; and, (c) determine causes and cures of the fabric defects encountered. In order to understand and analyze the weaving performance and the quality of fabric produced by "size-free" weaving it is essential to investigate factors that can contribute to successful weaving, such as the yarn structure, warp preparation, and weaving conditions. These factors are critical because of their influence in (size-

less) weaving. During the study and limited (actual) weaving experiments of size-free weaving, it was established that actual weaving experimentations on industrial/commercial weaving machines, in order to comprehensively understand all the influencing parameters in size-free weaving, could be very costly, time consuming, and, hence, prohibitive. Therefore, it was decided to design and fabricate a lab-scale "Yarn Endurance Tester (YET)," which will closely simulate the weaving actions and conditions on the individual size-less warp yarns intended for size-free weaving and assess the yarns' relative or comparative weaving endurance, as expressed or determined by the "damage" (or, the end-point failure) they suffered due to the limited weaving-like attrition on the YET.

The following paragraphs briefly describe the design objectives and fabrication steps of YET and the motivation and goal for future studies, if any:

- To efficiently explore feasibility of size-free weaving of certain cotton yarns/fabrics in a lab-setup.
- Design and fabricate a prototype Yarn Endurance Tester (YET), which simulates abrasion/attrition of a warp yarn in a weaving process and thus gives a comparative assessment of the yarn endurance in actual weaving.
- Study the inherent, basic attributes and/or quality of a greige warp yarn and compare their influence on the yarn's weavability (performance during weaving, with or without the traditional sizing).

The following hypotheses were established:

- A lab-scale YET should be able to simulate the weaving process effectively and several "weaving parameters and conditions" can be evaluated in a reasonable time-frame.
- The YET should be able to incorporate fundamental studies on quantifying damage of a warp yarn during the weaving-like conditions.

Research Approaches and Methodologies

It was expected that the development of the proposed device (YET) would allow us to conduct laboratory-scale experiments at LSU without having to always use the weaving facilities that were available at SRRC-ARS-USDA in New Orleans. The YET should also be able to simulate almost all the weaving conditions and a number of other variables that influence yarn abrasion, including (a) effects of the interacting surfaces (metallic or non-metallic), (b) effects of profiles and surface coatings of various critical components, viz., reed dents, heddles, etc., (c) effects of tension fluctuations, (d) effects of yarn (linear) density, (e) effects of yarn hairiness, and (f) effects of yarn twist.

After several iterations of design, the YET finally was fabricated, as shown in Figure 1, which has the following critical features:

- Implementation of real time tension measurement capability.
- Implementation of automated Digital image capturing/processing capability.
- Evaluation of the yarn-metal interaction (effects of various surface engineered or coated metals on yarn abrasion).
- Implementation of oscillating/vibrating metal components simulating the real weaving environment (heddles and reed-dents).
- The device should be compact and modular so that experiments can be conveniently conducted at the desired research locations (the LSU University lab and the SRRC Textile Pilot Plant).

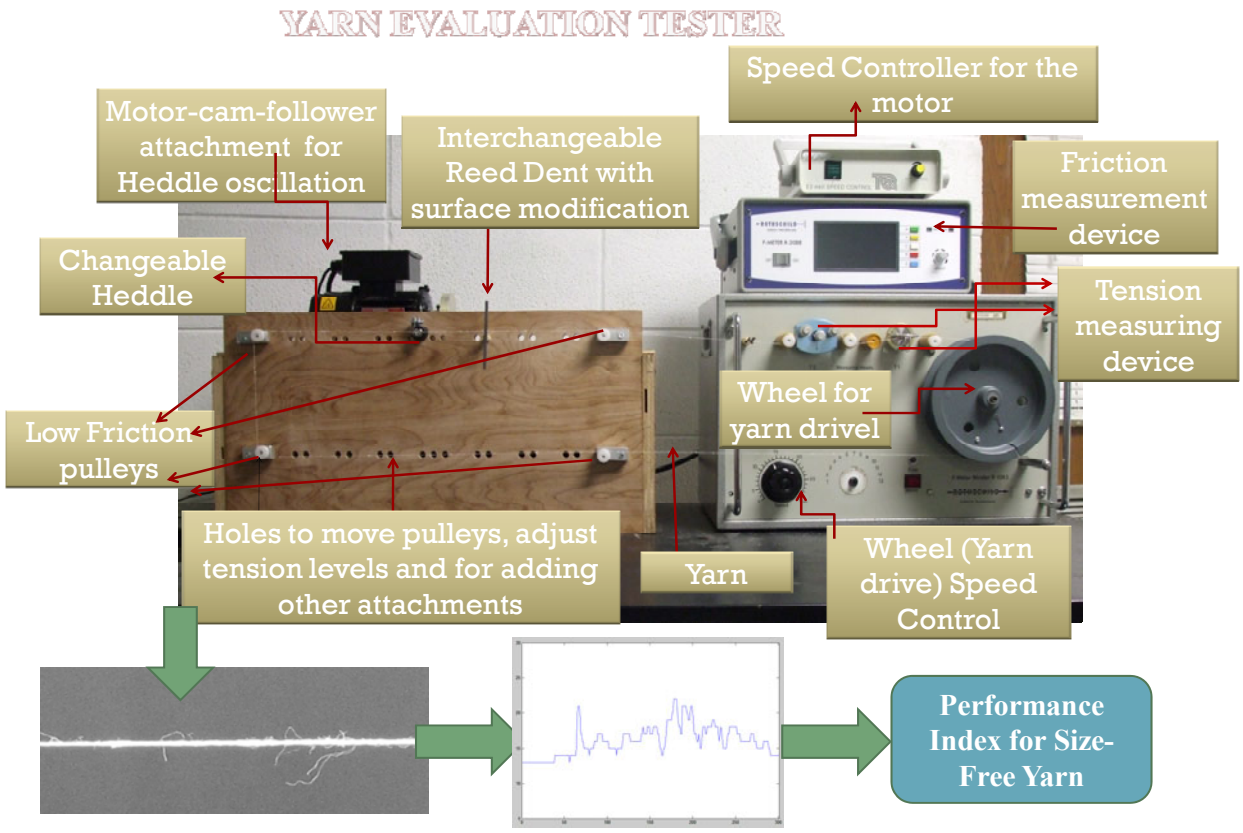

Figure 1: Yarn Endurance Tester and Experimental Setup

The combination of real time tension measurements as well as real time Digital Image Processing (DIP) facilitates an opportunity to obtain experimental data corresponding to various weaving conditions and parameters. For example the DIP is used for detecting, identifying and even quantifying yarn abrasion at varying weaving speeds and frictional surfaces/contacts. Recent tests have confirmed that the gradual, progressive abrasion occurring on yarn can be quantified by DIP (Sawhney , 2007), which can be used for characterizing the weavability of the yarn. The YET may be used to conduct a wide range of experiments that are beneficial to the fundamental study of size-less weaving, in order to ultimately develop a successful size-free weaving technology.

Conclusions and Future Work

In order to study the most critical factors of size-less weaving, a multi-purpose lab-scale YET is fabricated and embedded with continuous digital image acquisition and processing. By using YET following studies are undergoing and/or planned for future to evaluate the weaving variables that affect weaving performance of a size-free warp yarn: (a) Frictional effects of the interacting surface (metallic or non-metallic); (b) Effect of surface profiles and coatings of critical components, viz. heddles, reed; (c) Effects of yarn tension fluctuations; (d) Effects of yarn type, density, strength, breaking-elongation, co-efficient of friction, defects, and other characteristics; (e) Effects of yarn hairiness; and (f) Effects of yarn twist. Depending upon the requirements, the design of YET may be modified to enhance its capabilities. It is envisioned that the YET can be equally useful for predicting weavability of traditionally sized/slashed warp yarns, as well. The YET may also be a very useful research tool for conducting yarn frictional analysis and determining effects of repeated dynamic yarn tension fluctuations on the yarn abrasion.

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