A PILOT STUDY: USING DYED COTTON YARN FOR QUANTIFICATION OF WHITE SPECKS

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Abstract

Current commercial fiber testing was not designed to measure or detect the presence of dead or immature fibers in the small quantities that has been determined to be detrimental to the quality of dyed finished products. The methodology described in this study, utilizing dyed yarn, offers a promising media for an accurate and repeatable applied test method for the quantification of white specks. It is a logical assumption that white specks appearing on the surface of dyed yarn will also appear, to a certain degree, on the surface of cloth made from this yarn. A tool, based on dyed yarn will be a proactive approach of quantifying white specks that can be tailored to a yarn spinner, knitter, and dyer's specific end use.

Introduction

According to the American Society for Testing and Materials, the general definition of a nep is "a tightly tangled knot-like mass of unorganized fibers," (ASTM D-123-96 1999; p.43). In most cases, fiber neps are made up of at least five or more fibers with the average number being sixteen or more, (Hebert et. al, 1988). Immature or dead fibers are finer in structure, due to their lack of secondary wall development and have a higher propensity to form neps than do more mature fibers, (Hebert et. al, 1988). In an un-dyed state, entangled fiber clusters could be generically classified as neps. It is only after the application of dye, when some of the neps remain un-dyed, that the more specific classification of "white speck" is used. This propensity to form neps, in combination with the lack of dye retention and high reflectivity, gives the white speck its characteristic light shinny appearance on the surface of dyed cloth or yarn.

In most cases, current commercial fiber testing cannot predict the immature or dead fibers content of a raw fiber sample. Only in extreme cases will fiber properties measured by commercial HVI (High Volume Instrument) be an indicator of immature or dead fiber content in a bale of cotton, (Zellweger Uster, 1999). Current commercial fiber testing, based on average fiber properties, was not designed to measure or detect the presence of dead or immature fibers in the small quantities that have been determined to be detrimental to dyed finished goods quality. It has been estimated that even in fabric with severe white speck contamination the percentage of white speck fibers (by weight) is most likely less than 0.10% of the total fibers, (Watson, 1989). These amounts would be too small to have significant effects on the average fiber properties as measured by current commercial HVI.

The success of any textile operation, as in any business, depends on management's ability to predict the quality level of their finished product based on the quality level of the components used in that product. Methodology utilizing dyed yarn can offer the predictive tool required for a proactive response to white speck contamination by spinners, dyers, and knitters. Such a tool will allow the pre-screening of yarn before fabric formation and dyeing.

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Procedures

Yarn selected for this study was taken from an inventory of commercially spun 30/1 Ne 100% cotton ring spun yarn. The 30/1 yarn count was selected based on Van der Sluijs and Hunter's work on the relationship between yarn count and the appearance of neps. Van der Slujis and Hunter found that neps appear more frequently on the surface of finer yarn counts, in comparison with coarser yarn counts, (Van der Sluijs and Hunter, 1999). Yarns were also selected based on white speck levels derived from the International Textile Center's (ITC) screening test for dyed knit cloth.

The ITC's current screening test involves using a 3" by 10" template that has cut from it, ten randomly placed squares of one square inch each. The template was randomly placed on the outside surface of knit cloth dyed with Direct Blue 80. Direct Blue 80 was selected by the ITC based on past experience and the work of Smith. Smith categorized dyes by their ability to cover dead or immature fibers. The Direct Blue 80 dye was found to be sensitive to dead or immature fiber (white specks), (Smith, 1991). The white specks appearing in each open square of the template were counted. Multiple replications were achieved by randomly moving the template to different locations on the cloth. Replications were summed to give an "average white speck count per 10 square inches". The same dye procedure utilized in the ITC screening test was used for both yarn and knit portions of this pilot study.

A MacBeth BBS-562 Lablite was utilized as a source of standard lighting for the entire study. The Lablite is equipped with both Horizon (yellow) and Daylight (blue-white) light sources. The total wattage of light available was a nominal 1050 watts. It was found during the initial setup that the operator's ability to detect white specks was improved if both horizon and daylight light sources were used simultaneously. For this study, the floor of the Lablite viewing box was equipped with a stationary alignment stop. The stop helped to insure accurate repetitive placement of samples to be viewed. The angle from the light source to sample was set, by placement of the alignment stop, so the operator could achieve the best visual differentiation between the white specks and the adjacent yarn or knit, (Boynton, 2000).

A Chavis yarn winder was used to place all fifteen yarn samples onto stainless steel dye tubes for dyeing. After winding, they were package dyed, in a single batch, using a Gaston County Package Dye Machine.

After the dyeing process, an Alfred Sutter Yarn Board Winder was utilized to wind samples onto 7" wide by 11" long by 1/8 inch thick black rigid cardboard yarn boards. The Alfred Sutter Yarn Board Winder was electronically set to place 16 equally spaced wraps per inch on each board for a horizontal distance of 5.75 inches. With this setup each board had 28.11 linear yards of yarn per board viewing side, for a total of 56.22 linear viewing yards per yarn board.

Five replications of each dyed yarn sample were made. This gave a total of 75 yarn boards, each having "A" and "B" sides. The "A" and "B" designations were arbitrary designations for the purpose of preventing the operator from reading the same side twice. Five replications yielded a total of 281.1 linear yards of yarn on the face of the boards per sample yarn. Using basic textile mathematics, 281.1 yards of 30/1 Ne cotton yarn will weigh 5.07 grams, (Quigley et. al., 1977).

The board "reading" process involved placing each sample into the viewing box of a MacBeth BBS-562 Lablite The operator positioned each board in the viewing box with the aid of a stationary alignment stop. After positioning the board the operator used a counting technique that traversed from left to right, then right to left, while moving from top to bottom. A pointed probe was used to help the operator maintain focus while counting. A single operator, on side "A" first and then on side "B", counted white specks. This procedure was repeated on three separate occasions in order to check the operator effect on repeatability.

Each of the fifteen sample yarns was used to knit individual single knit jersey fabric. A Lawson Hemphill FAK (Fiber Analysis Knitter), equipped with 20 needles per inch, was utilized to produce single knit jersey tubes that weighed approximately 10 grams each. Five replications of each of the 15 yarn samples were made giving a total of 75 knit tubes. The knit tubes were sub-labeled with A, B, C, and D sides. "A" side was designated, as the outside front and "B" side was the outside back of the knit tube. "C" and "D" sides were obtained by turning the tube inside out. "C" was the inside front opposite "A" and "D" was the inside back opposite "B". Side designations were for sample orientation. Each knit tube was also marked with a white 4" orientation line located under the sample number on the "A" side. Due to the thin nature of the knit goods, the orientation lines could easily been seen from the "C" side when the cloth is turned inside out.

The knit tubes were simultaneously dyed using the Gaston County Laboratory Dye Beck. After dyeing and drying the knit tubes were transferred to the MacBeth BBS-562 Lablite for "reading". A 4" by 9" template, made from 3/16" black foam board, was placed inside of each knit tube before viewing. This gave a total of 36 square inches per side. With four sides being viewed per sample reading a total of 144 square inches were viewed. The same counting process used for the yarn was also utilized for the knits. The operator, first on the "A" side and then on the "B" side, counted white specks. The knit sample was then turned inside out and placed back onto the template. Once the template had been placed inside of the knit tube, the orientation line on the "A" side, as seen from the "C" side, was used to achieve correct alignment. This procedure was repeated on three separate occasions to check the operator effect on repeatability.

Analysis

Figure 1 outlines the operator's reading-to-reading white speck counting performance for yarn boards. The same information for the knits is contained in Figure 2. It is apparent from comparing the charts that there is not the same level of operator variability reading to reading for the yarns when compared to the knits.

Operator reading-to-reading performance was checked by a direct comparison between the three readings. The same technique was used for both yarns and knits. The comparison was accomplished by utilizing the following formulas:

$((R1 - R2)/R1)*100$ = % difference Reading 1 to Reading 2
$((R2 - R3)/R2)*100$ = % difference Reading 2 to Reading 3
$((R3 - R1)/R3)*100$ = % difference Reading 3 to Reading 1

The results of theses comparisons can be seen in Figures 3 and 4. Both charts use the same scale so that a direct visual comparison can be made. It is apparent in comparing Figures 3 and 4 that the operator performance reading to reading for the yarn is much less variable than for the knits.

The operators' performance reading-to-reading was also checked using Statistica software. A t-test for dependent samples was used to make the reading-to-reading comparisons. It was found that there was a statistically significant difference between reading 1 and reading 3 for the yarn with a p-value of 0.00761. The knits were also tested and it was found that there were statistical significance between reading 1 and reading 2 with a p-value of 0.006515 and also between reading 1 and reading 3 with a p-value of 0.000120. The complete results of this test are contained in Figure 5. It was interesting to note that in both test the p-value between reading 2 and reading 3 were not significantly different. This would suggest some type of learning curve exist. In this study it appears that if a learning curve does exist it is less for dyed yarn than it is for knits.

The FAK knits, in this study, have notably different levels for the A B (outside) and the C D (inside) within the same sample. This difference could be attributed to the FAK knitter, mechanical manipulations of the actual knitting process, knit fabric construction, or other unidentified factors. The difference in the outside to inside of the knit sock is shown in Figure 6.

It is apparent that some type of relationship must exist between yarn and knit white speck levels. When a comparison between average white specks per sample in yarn knits was made it revealed a simple correlation of 0.889. Figure 7 shows the actual counts of both count medias

Conclusion

The purpose of this study was to determine if white specks could be detected and quantified in dyed cotton yarn. Test results indicate that dyed yarn does have the potential of offering a stable media for white speck quantification. In comparison to FAK knit cloth, using yarn for white speck detection is much less variable for an operator reading-to-reading. From a predictive and proactive standpoint, yarn seems to offer the most practical and useful test media from a commercial application standpoint.

It is suspected that the relationship between yarn white specks and their appearance in the finished product will be not only product specific but also mill specific. Factors such as the type of knit or weave construction, types of dyes, type of knitting machine or loom used, and machinery condition will determine at which point that yarn white speck levels will become a problem in the finished product. Future work will have to address these issues.

This study was limited in nature by the use of only one yarn count and dye. An expansion of this study will include multiple yarn counts, from the multiple cottons, with multiple dyes for each. This should help to address the relationship between yarn count and the surface appearance of white specks. Yarn test data should also be included to see if any type of meaningful relationship can be established between yarn test data and yarn white speck counts per unit length. The multiple dyes will also help determine the relationship between yarn count and white speck coverage by different dyes.

Future plans include using the manual visual techniques developed as a baseline test to facilitate the development image-analysis techniques based on dyed yarn. This technique will be used to formulate prediction models that are based on the relationship of white specks per unit of length and their appearance in the face of a fabric.

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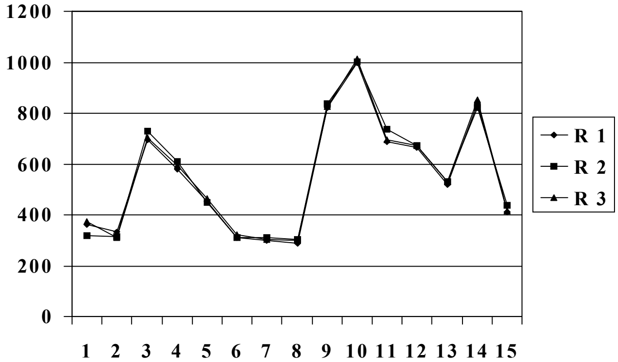

Figure 1. Three Readings of Yarn Board White Speck Counts.

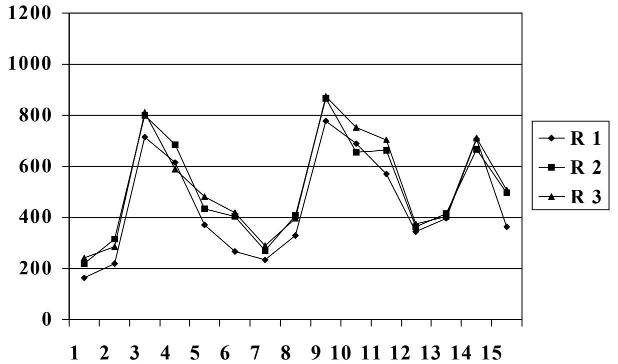

Figure 2. Three Readings of FAK White Speck Counts.

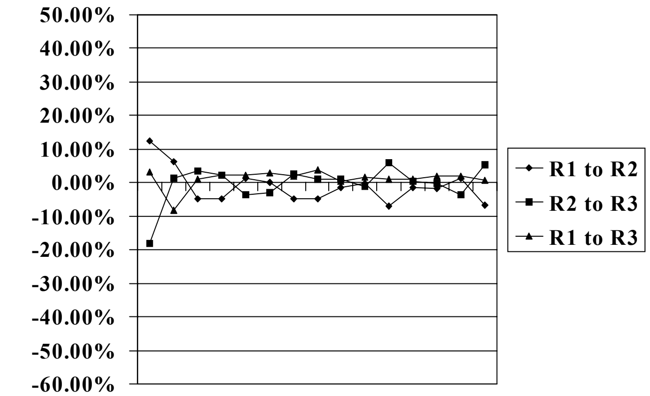

Figure 3. Operator Performance for Yarn Reading to Reading.

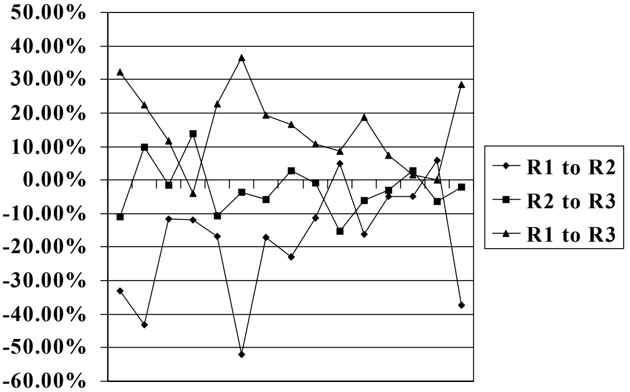

Figure 4. Operator Performance for Knits Reading to Reading.

	t Value	p-value
Yarn R1 to R2	.1929	-1.314
Yarn R1 to R3	.00761	-2.744
Yarn R2 to R3	.9259	.09337
Knit R1 to R2	.00615	-4.391
Knit R1 to R3	.00120	-5.261
Knit R2 to R3	.30153	-1.073

Figure 5. Comparison: Reading-to-Reading.

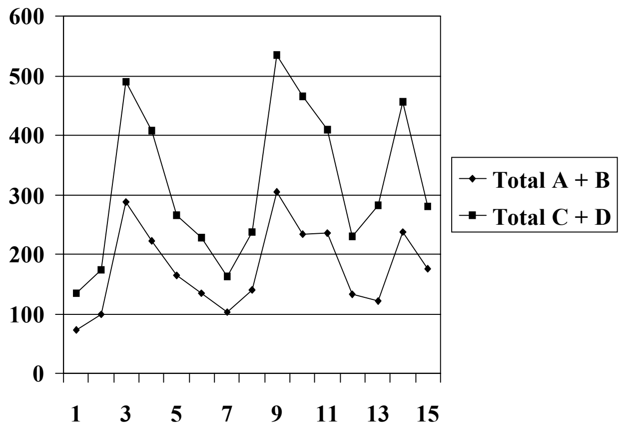

Figure 6. Comparison: Average Sides A and B (Outside) to Sides C and D (Inside).

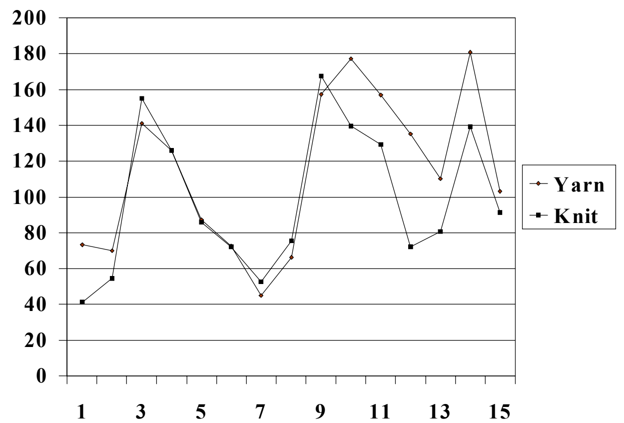

Figure 7. Comparison: Average per Sample FAK and Yarn White Speck Counts.