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EFFECT OF TEXTILE TREATMENTS ON WHITE SPECK COUNTS IN DYED YARN

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Abstract

The effects that textile processing change variables have on the occurrence of white specks in dyed cotton yarn are unknown. White speck levels after six different cotton card set up combinations were examined using dyed yarn as the counting media. By using the dyed yarn white speck counting methodology it was found to be possible to quantify the effects that specific cotton card set-up combinations have on white speck content of dyed cotton yarn.

Introduction

Immature and 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 neps remain un-dyed, that the more specific classification of "white speck" is used. The combination of low dye retention and high reflectivity give white specks their characteristic light shinny appearance on the surface of dyed cloth or yarn.

Current commercial fiber testing (HVI), based on average fiber properties, was not designed to measure or detect the presence of immature and dead fibers in the small quantities that have been determined to be detrimental to dyed finished fabric quality, (Zellweger Uster, 1999). It has been estimated that 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 test instruments, but are substantial enough to negatively impact the commercial value of the fiber to the end user.

When using modern textile equipment, the effects that textile-processing variables have on the occurrence of white specks in dyed yarn are unknown. This work examined yarn white speck counts after six different treatment combinations on a cotton card.

Procedures and Instrumentation

Four commercial cottons were pre-screened for the presence of white specks using dyed yarn as the screening media. Table 1 contains length and micronaire fiber values (HVI) for the four sample cottons. All cotton samples were opened and cleaned using the same equipment. After the initial cleaning the samples were separated into two equal parts. One half was labeled low cleaning intensity. The second half was subjected to an additional fine opener to achieve a high cleaning intensity. Cleaned cotton samples were used to supply fiber to a Trutzschler 903a high production cotton card. For each sample, the card was set up with six different setting combinations involving production rate, cylinder speed, and flat settings. Due to the large number of possible change variable combinations, over 30 on the card alone, it was determined that the treatments selected would have to be limited to those that would be expected to have an effect on white speck content. Table 2 contains the card treatment combinations utilized. After carding, all sample combinations were processed with a Rieter RSB 851 breaker draw frame and Trutzschler HSR 1000 finish draw frame. Roving for the spinning process was manufactured on a Saco Lowell Rovematic roving frame equipped with Suessen drafting.

From the cleaning and treatment combinations, a total of 48 spun yarn samples were produced on a Suessen Fiomax ring spinning frame. A 24/1 Ne yarn with a 4.2 Twist Multiple (20.6 turns per inch) was spun from each of the 48 yarn samples. A Model 44 Chavis yarn winder was used to place the 48 yarn samples onto individual perforated stainless steel dye tubes for package dyeing. A dye formula comprised of reactive dyes was utilized to obtain a dark navy blue color shade. This formula was used to dye all packages, in a single batch, using a Gaston County Package Dye Machine Model 702 RFC.

After the dyeing process, an Alfred Sutter yarn board winder was used to wind samples onto 7" wide by 11" long by 1/8" thick black rigid cardboard yarn boards. The Alfred Sutter yarn board winder was set to place a minimum of 200 linear yards of yarn per board.

Five boards of each dyed yarn sample were made for a total of 240 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. With five boards, the operator observed at least 1000 linear yards of dyed yarn for each sample.

A Leslie Hubble CAC 60-5 VeriVide light cabinet was used as a source of consistent lighting for counting of white specks. The VeriVide light cabinet was equipped with both artificial daylight (D75) and cool white (CW) light sources. It was found during the previous work that an operator’s ability to detect white specks was improved if both D75 and CW light sources were simultaneously utilized, (Simonton et al., 2001; Simonton et al., 2002). The lower work surface of the VeriVide light cabinet was equipped with an adjustable viewing platform. The angle from the light source to sample was set by the operator to achieve their best visual differentiation between the white specks and the adjacent yarn, (Boynton, 2000).

An operator was selected for the yarn board reading process based on their past white speck reading performances, (Simonton et al., 2001; Simonton et al., 2002). The “reading” process involved placing each board into the viewing box of the VeriVide light cabinet. 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. The operator, on side “A” first and then on side “B”, counted white specks. The operator performed a total of four readings with the first reading being discarded as a stabilizing run. With an operator making three readings on 240 boards a total of 720 board readings were collected.

Analysis

The limited number of cotton samples was not adequate for determining the distribution of the data collected. The combination of the data being discrete and derived from a counting technique leads to the assumption that the distribution would be non-normal and at best Poisson in nature, (Hayter, 1996). Since the counting variances were not homogenous, the data was transformed in order to meet the conditions required for analysis of variance. The square root transformation is commonly used to stabilize variance and improve the normal approximation of the distribution, (Box et al., 1976 and Krifa et al., 2002). This transformation is adequate when the variance is proportional to the mean, which is the case for Poisson distributions, (Box et. al, 1978). The transformed white speck count data made it possible to utilize an Analysis of Variance (ANOVA) to examine the interactions between factors.

A Wilcoxon Match Pairs Test for dependent samples was used to examine the difference between the operator’s three readings. It was found that reading 2 was statistically different from reading 3 (p-value 0.004) and reading 4 (p-value 0.001). Readings 3 and 4 were not significantly different (p-value 0.4092). This would suggest that even with discarding reading 1 that the operator was most likely still stabilizing during reading 2. Using the Spearman R correlation, readings 2, 3, and 4 did correlate well at 0.995 and above, which demonstrated the proportionality of the three readings. Graphic representations of the three readings, by sample, are contained in Figure 1. Figure 1 visually demonstrates the operator’s consistency reading-to-reading.

For each reading, the average white speck count per sample was obtained by averaging the counts from each samples’ five yarn boards. Co-efficient of variation (CV%) was used to compare the operator’s reading-to-reading variation for the 48 samples. CV% were expressed by the following formula:

$$CV\% = (s / m) * 100 \tag{1}$$

where:

s - Standard deviation for each sample between readings 2,3,4,
m - average of readings 2,3,4 for each sample.

Sample variation (CV%) reading-to-reading ranged from 0.05% to 4.10%. The overall reading-to-reading CV% averaged 1.43%. Figure 2 contains a graphic depiction of the individual reading-to-reading CV% for all 48 samples. The CV% of the five boards within each of the 48 samples was also examined. The CV% within the five boards for all samples averaged 11.50%, with a low of 4.99% and a high of 28.40%.

Statistica™ software was utilized to perform an ANOVA on the stabilized count data. Results of the ANOVA are contained in table 3. No two-way interactions were found to be significant. When examining the individual effects “cotton” and “treatment” were both significant, while “cleaning intensity” was not. Graphic depiction of the summary results for each treatment effect is contained in Figure 3. In figure 3, it can be seen that white speck counts for treatments 1 through 4 were relatively close with 5 and 6 being at higher levels. This is supported by a Newman-Keuls test for homogeneity. The test was performed at an alpha of 0.05 and found that treatments 1 through 5 were homogeneous and treatment 6 was not homogeneous with treatments 1 through 4 but was homogeneous with treatment 5. A summary of the Newman-Keuls test is contained in Table 4.

The white speck counts for the four sample cottons, broken down by treatment, are contained in figure 4. Figure 4 gives a graphic depiction of the cotton's reaction or lack of reaction to treatments. As expected, the two cottons with the higher micronaire values (1 and 3) had fewer white specks than did the lower micronaire cottons (2 and 4). The graph also demonstrates why micronaire can be misleading for predicting white specks. Cottons 1 and 3 had relatively the same micronaire readings (4.5 and 4.6) but have different white speck levels. Treatments 1,3, and 4 were at the same production rate and cylinder speed but different flat settings. The lower production rate (50 kg/hr) combined with closer flat settings was "expected" to yield the lowest yarn white speck counts. However, treatment 3 combined these setting parameters and resulted in a higher white speck count than the other two treatments in this group for all four cottons. This suggests that more aggressive settings could work to spread the problem or is just not an effective treatment combination for white speck removal.

Treatments 2, 5, and 6 were at the same production rate (80kg/hr), different cylinder speeds, and different flat settings. The white speck count results from treatment 2 were very similar to those obtained with treatments 1, 3, and 4. The common factor between the treatments was cylinder speed (500 rpm). This indicates that cylinder speed, in combination with flat settings, could be a very important setting combination that could reduce white speck content in dyed yarn even at higher production rates.

Conclusion

The dyed yarn white speck counting methodology is a useful tool for measuring the effect of textile processing treatments on the white speck content. The operators' variation reading-to-reading was very similar to that of prior work. This consistency implies that the dyed yarn white speck counting system addresses issues that contribute to operator variability. However, it was apparent that the large number of boards per reading (240boards * 2 sides per board = 480 sides per reading) was approaching the physical limits of the operator from a fatigue standpoint. The work did highlight some promising areas for future examination. It appears that some textile machine settings, such as cylinder speed and flat settings could be a very important combination that effect white speck content in dyed yarn. The work also indicates that white specks could also be reduced at higher production rates by utilizing a treatment combination involving cylinder speed and flat settings.

There is a need to examine the entire process with factors other than white speck counts being taken into consideration. While some textile settings have a positive effect on white speck counts they could have a negative effect in other areas such yarn quality and waste generation. These detrimental effects could far outweigh the benefits gained in white speck reduction. The white speck problem must be addressed from a systems approach where all key input variables and their resulting responses are taken into consideration.

Future

Work will be expanded to include a larger number of sample cottons as well as more textile change variables. A balanced test design will allow the examination of individual variables as well as the interactions between variables. To handle the larger volume of samples there are plans to expand capabilities beyond the physical limitations of human inspection by utilizing an image analysis system for the quantification of white specks on dyed yarn.

References

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Table 1. Cotton Fiber Properties.

Cotton	1	2	3	4
Mic	4.5	3.5	4.6	3.7
UHML (inches)	1.08	1.09	1.12	1.16

Table 2. Card Treatments Utilized.

Treatments	Production (kg/h)	Cylinder Speed (RPM)	Setting of Flats* (1/1000")
1	50	500	11-10-10-9-9-9
2	80	500	11-10-10-9-9-9
3	50	500	10-9-9-8-8-8
4	50	500	12-11-11-10-10-10
5	80	570	10-9-9-8-8-8
6	80	460	12-11-11-10-10-10

Table 3. ANOVA Results (alpha 0.05).

Effect	p-level	Significant
(1) Cleaning Intensity	0.8715	No
(2) Treatments	0.0011	Yes
(3) Cotton	0.0001	Yes
1,2	0.9968	No
1,3	0.9880	No
2,3	0.6642	No

Table 4. Newman-Keuls Test Results (alpha 0.05).

Treatment	Mean (Sqrt)	1	2
1	9.454	****	
2	10.369	****	
3	10.472	****	
4	11.453	****	
5	12.696	****	****
6	14.676		****

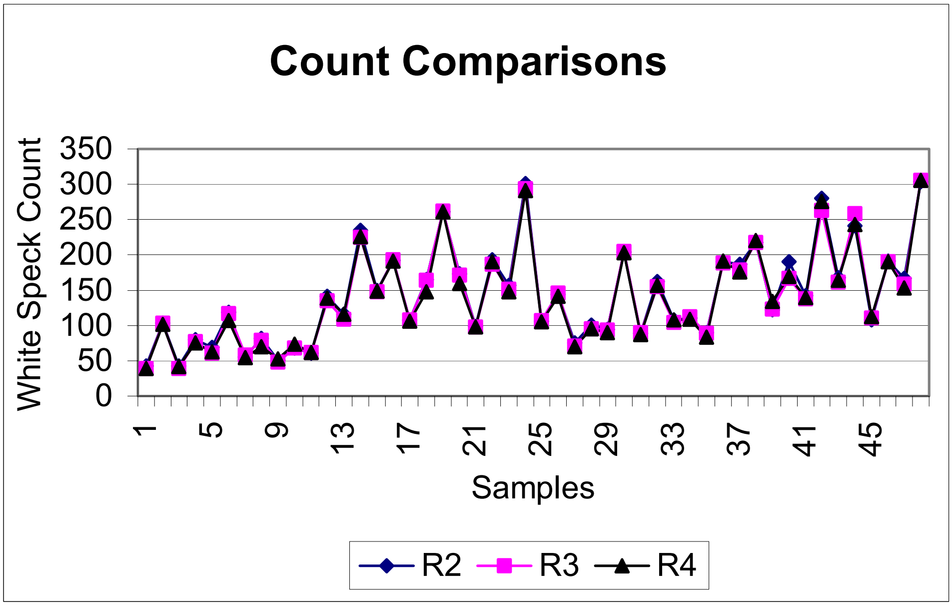

Figure 1. Readings 2, 3, and 4 White Speck Count Comparisons.

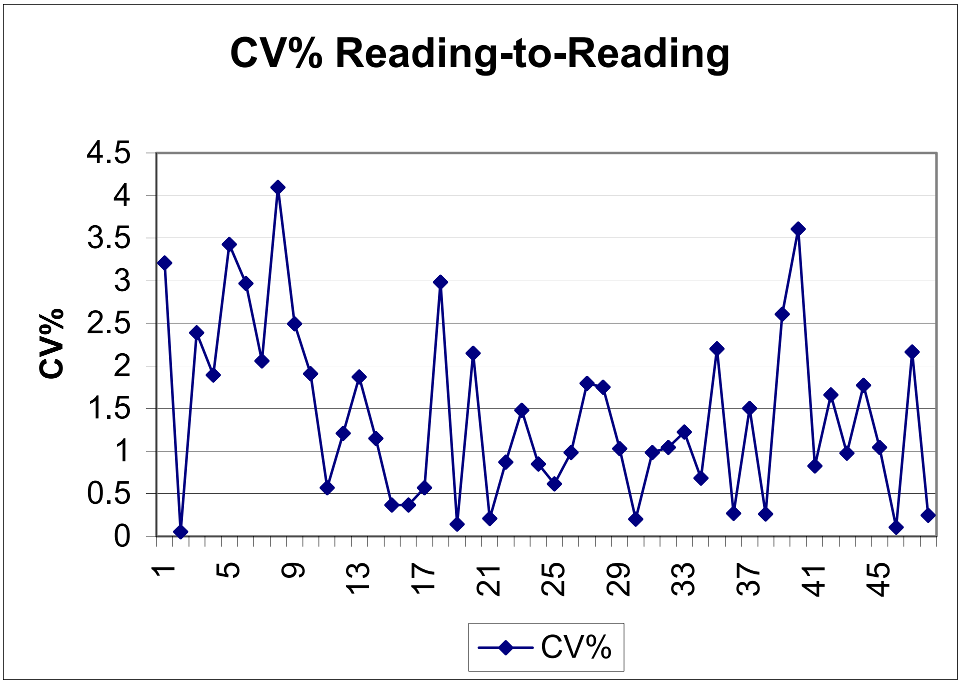

Figure 2. CV% Comparisons.

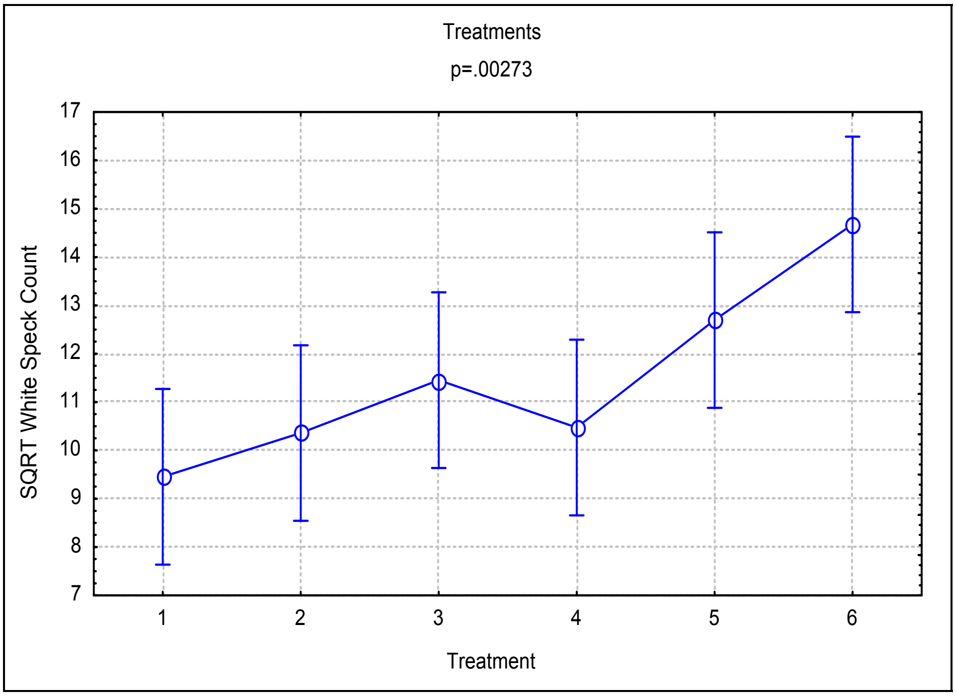

Figure 3. Card Treatment Effects.

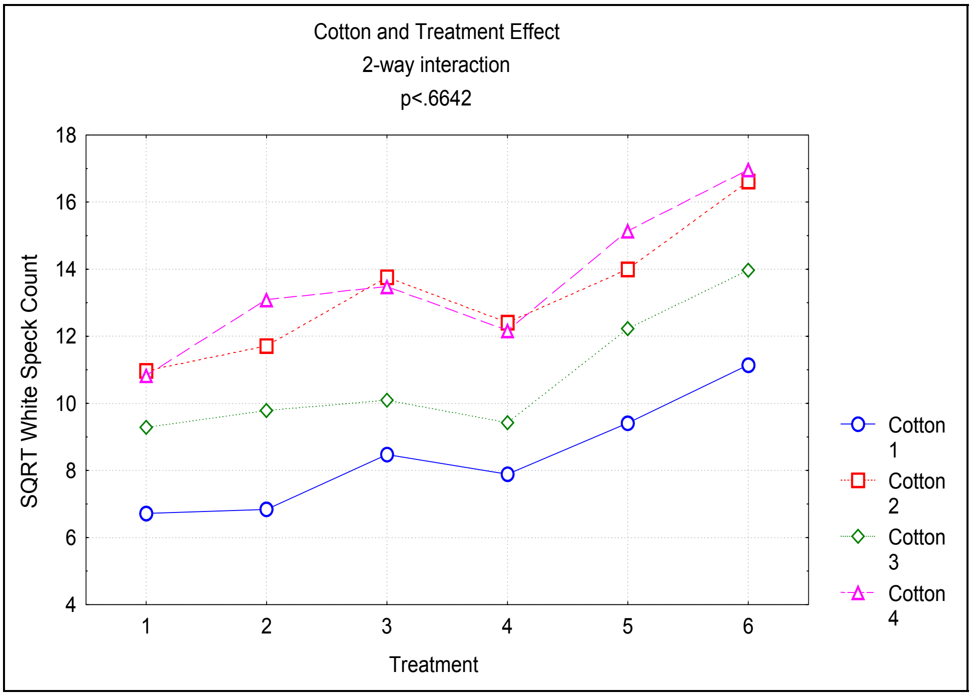

Figure 4. Cotton and Treatment Effect.