VARIETAL EFFECTS ON THE WHITE SPECK PHENOMENON

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Abstract

This paper examines the white speck phenomenon as seen in different varieties. Five varieties were grown in the same field, while 26 other varieties were from different locations across the cotton belt. AMS processed the 5 varieties in the same manner as the 26 varieties from the 26 Leading Variety Survey. The yarns were then arranged into a common warp to produce a filling faced sateen fabric, dyed and analyzed by image analysis for white specks. The fiber properties reported by AMS, along with AFIS fiber properties were correlated with the fabric properties. AMS fiber data includes classing data, HVI (MCI and Spinlab), Stelometer, Suter-Webb length array, Mic/Shirley FMT, S.A. non-lint content, Neps of raw cotton (AFIS-N (neps/gram), Raw stock neps (neps /100 sq. In.)). Image analysis by Optimas 5.2 software defined the appearance and quality of a finished fabric in terms of the white speck phenomenon. Defined as dye resistant neps, the white specks are composed of very immature or undeveloped fibers. Past research indicates that there is a connection between micronaire and the level of white speck. This study demonstrates what fiber properties are important in the prediction of a potential white speck problem. The study also compares carding with combing. Four varieties from the 26 Leading Variety Study by AMS were carded and combed; two Maxxa and two Royale cottons were employed for this research. Image analysis of the dyed fabrics showed combing reduces the white speck problem as compared with single carding.

Introduction

Defined as dye resistant neps, white specks appear as poorly dyed or undyed, undeveloped fibers in a finished, dyed fabric; they typically worsen during mechanical processing. In an experiment by Hebert, 96% of all neps studied contained immature fibers, while 50% of the examined neps were entirely immature fibers, and 46% of the neps in the finished fabrics were white specks (Hebert, 1988). To make the situation worse, immature fibers have an accelerated rate of sorption and desorption as compared to mature counterparts, and thus dispel dye more easily (Cheek, 1988), causing the neps to appear lighter in color on the dyed fabric surface. The variety of cotton is believed to be responsible for 30% of white specks, the location of growth accounts for an additional 30%, while the remaining 40% of the sources of variation are unknown (Bragg, 1992). This paper and other research indicate that processing may explain part of the remaining 40% of unexplained variation.

Due to the lost production time, as well as product value, it has been estimated that the United States textile industry recently lost approximately two hundred million dollars annually due to dye defects (Goynes, 1996). Examining the cause of neps, it was noted that neps originated from growth, harvesting, ginning, and processing (Wegener, 1980). These growth neps consist of mostly dead or immature fiber and are the ultimate cause of white speck neps. In addition, there are two other types of neps, mechanical and biological. Biological neps contain biological matter such as seedcoat, leaf or bract, and often show up as dark specks. Mechanical neps are composed of entangled fibers formed by the mechanical action of processing such as harvesting, ginning, opening, cleaning and carding. Finer fibers are particularly vulnerable due to their lack of longitudinal rigidity. Neps are often formed as fibers break during processing, which causes the fiber to coil itself, often involving other fibers in its recoiling, producing entanglements (Wegner, 1980). These entanglements are particularly devastating to immature fibers which lack the resilience to disentangle themselves (Bargeron, 1993). While subjected to these textile processing techniques, these colonies of immature fibers are separated into segments that are ultimately responsible for the white specks that appear in dyed fabrics (Watson, 1992).

Previous research has examined the white speck phenomenon and demonstrated correlations between processing and the white speck content of a finished fabric. Processing factors, such as time of harvest, number of lint cleaners used at the gin, opening line cleaning in the mill, single and tandem carding, combing and rewiring of the card all had an effect on white specks in the finished fabrics. Tandem carding in the mill, and high levels of lint cleaning at the gin have been shown to increase the white speck problem although they can improve some other qualities. The results identified minimal lint cleaning at the gin and less aggressive cleaning at the mill produced a smaller white speck content on the finished fabrics (Bel-Berger, 1995).

Four varieties from the 26 Leading Variety Study by AMS were carded and combed and the fabrics are analyzed for white specks. The combed samples produced fewer white specks than the carded fabrics. The condition of the card wire was also seen to have a dramatic effect on the white specks. Both combing and rewiring are found to reduced the white speck problem, while other processing seems to open and separate the immature fibers spreading the white speck problem (Bel-Berger, 1996).

To study the white speck phenomenon and the impact upon fabrics, image analysis by Optimas 5.2 software was employed to detect these undeveloped fiber communities while reporting the size, number, and area of the test site of

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the white specks. In addition to the fabrics, the fibers of the 26 leading varieties and the 5 varieties were also studied for their white speck content. Both fiber and fabric % White values were studied for correlations. Fiber properties were related to the fabric % White to determine the factors effecting the white speck phenomenon.

Materials and Methods

The 26 Leading Variety Study by AMS involved 26 bales of cotton collected (leaf grade had to be 4 or better and color grade 31 or 41 to be included in the survey) and processed on modern textile processing equipment. The cotton was opened, blended and cleaned on Truetzchler equipment. The control group, 5 varieties which were all harvested (161 days) from the same rain grown field in Stoneville, Mississippi, ginned using two lint cleaners and processed along with the 26 varieties. All fibers were carded on a Truetzchler Card at 70 pounds per hour. Drawing sliver was produced on a Reiter Breaker Drawing Frame. The combed samples were run through the Platt Saco Lowell Model 53 Lapper, followed by the Platt Saco Lowell Model 52 comber (16 -17% Nominal waste) followed by the Rieter RSB 51 Draw Frame. Carded stock and combed stock were then processed through the Platt Saco Lowell Finisher Drawing Frame. Roving was produced on a Saco Lowell Long Draft Roving Frame, 10 x 5, 1 Apron type, and 36/1 ring spun yarns were produced on a Saco Lowell Long Draft Spinning Frame, 2 Apron type. The fabrics are a 5-harness filling faced sateen with a common combed warp, 30/1 warp yarns. The experimental yarns have approximately 85% surface coverage. Table 1 describes the varieties used and their location of growth.

Dyeing

The fabric is finished with a 0.1% Prechem 70, 0.3% T.S.P.P. boiloff, a caustic scour of 1.1% Prechem SN, 1.1% Mayquest 80, 0.1% Prechem 70 and 0.7% Sodium Hydroxide (Caustic Soda), followed by the same boiloff procedure. The fabric was then bleached (0.1% Prechem 70, 0.5% Mayquest BLE and 3.0% Peroxide (Albone 35)) followed by an acid sour (0.1% Acetic Acid) and dyed with 2% Cibacron Navy F-G Blue, 0.5% Calgon, 8% Sodium Chloride, 0.8% $Na_2 Co_3$ (soda ash) and 0.5% Triton Tx-100. This dye has a high propensity for highlighting white specks in finished fabrics.

Fibers were dyed in quantities of 0.333 grams in a 250 cc water bath at 60 C for 60 minutes with constant stirring. Direct Red 81 dye was added in concentration of 25% on weight of fiber with 0.1% on weight of bath Triton X-100. Salt was added in three measures 15 minutes apart for a total measure of 25% on weight of fiber. After dyeing, the fibers were rinsed in cold water for 1 minute followed by a 45 second boiloff in 100 C water. Immediately following the boiloff, the fibers were rinsed in cold water for 1 minute. The fibers were then oven dried at 90 C for 45 minutes.

Image Analysis

Image analysis was done by the Optimas 5.2 software with Imaging Technology Color Frame Grabber (640 x480, 60 Hz), on a Gateway 2000 P5-75 computer complete with a dual monitor set up with a Sony Trinitron RGB Monitor. A Microimage Video Systems RGB/YC/NTSC color camera was used to extract the image and was placed 18.125 inches above the fabric sample. Four tungsten 120 V 300 W flood photography lights were used for uniform lighting on the fabric. The system was engaged and allowed to equilibrate for one hour. Using the % Areas and data collection macros, the ratio of the white speck area to the sampling area, or the % white, and the number of specks are detected. The black and white configuration was enabled to perform the analysis. A calibration was done to ensure the correct sample area was being used. The woven fabric sampleswith the region of interest (ROI) was set at 12 square inches with 24 images analyzed for a total viewing area of 288 square inches. Thedyed bale fiber samples were placed between two Plexiglas plates, and the ratio of the area of white to the ratio of the area of pink fiber. The color configuration was enabled to perform the analysis. Nine fiber plates for each variety were analyzed with each plate providing 4 testing areas of 12 square inches. To ensure that white specks were being detected properly, the threshold was set using several areas from the fabric and fiber samples and remained the same for the duration of the testing. The threshold dictated what was detected as white and thus contributed to the % white of the sampled area.

Advanced Fiber Information System

AFIS, by Zellweger Uster utilized an electro-optical sensor to detect fiber properties and their distributions. Sampling was done by the hand generation of five half gram slivers, approximately twelve inches in length, of fibers pulled from various points in the bale. Fibers were individualized by separating trash from lint using aerodynamic methods similar to carding. Trash was removed through counter flow slots and then measured with the trash sensor. The five thousand fibers were then passed before the optical sensor where they generated electrical signals (Uster AFIS). These signals were then interpreted as fibers, neps, or trash, and then analyzed for length, diameter, maturity and fineness. The fineness and maturity measurements are from the F & M module. The five repetitions of the five slivers were then utilized to calculate the mean, standard deviation, and percent coefficient of variation for each parameter. The parameters of utmost importance for this study are measurements of maturity. Micronafis, similar to micronaire, is a measure of fineness and maturity in micrograms of one inch of fiber. Theta detects the circularity, or the degree of thickening, and is based on the cross sectional area and the perimeter. The more circular the fiber (values close to 1) the more mature the sample. Conversely the flat, non circular fibers are immature. The coefficient of variation of the circularity was another parameter that was measured. The Theta cv% is a good indicator of the variability of the maturity of the fiber. The larger the Theta cv%, the more immature the fiber sample. AFIS Nep was the number of neps per gram of fiber. Immature Fiber Fraction, % IFF, measured the percentage of fiber with values of Theta less than 0.25.

Agricultural Marketing Service Data

AMS provided fiber properties of the varieties studied. Among these were the Micronaire reading as determined by HVI-MCI, a measure of the resistance of air flow through a beard of cotton (Hamby, 1965), and the Raw Stock Neps generated by a miniature card and reported as neps/100 sq. in. of fiber.

Results and Discussion

Initially, no correlations between fiber and fapric properties were obvious. When the control group was analyzed separately very high correlations were seen between several maturity fiber measurements and white speck in the fabrics. With the control group, true differences for levels of white specks between varieties can be seen. The combed varieties also fell into a distinct group. Knowing that the bales for the AMS Study had to be very clean, we can surmise that the maximum level of lint cleaning was used, which would be two lint cleaners, with the exception of #4 and#23 where three lint cleaners were available. Also #13 through #16 were stripper harvested , and they would have had additional pre-cleaners at the gin. In order to successfully study the impact of fiber properties on the white speck content of the finished fabrics, four divisions of the study must be made as demonstrated by Figures 1 - 3. For each grouping, linear regression analysis was performed to study the impact of individual fiber properties on the fabric % White. The critical fiber properties were identified by having the highest R^2 values and then multiple regression analysis was performed to derive a % White predicting equation based on those critical fiber properties. The 5 varieties, fabrics 31-35, with their known processing are in one group with the fiber properties displayed in Table 2. The Maxxa variety for the control group may have a higher level of immature fiber than normal, in that it was harvested approximately two weeks earlier than normal. The standard processed fibers of the 26 leading varieties, fabrics 1-3, 5-12, 17-22, 24, plus the 5 varieties, fabrics 31-35, are in their own grouping and have fiber properties featured in Table 2. The standard fabrics have standard pre-cleaners at the gin, followed by one or two lint cleaners as far as it could be determined. Due to the level of leaf acceptable for the leading variety survey, most of these would have two lint cleaners, but some cases may have only 1 lint cleaner. The combed fabrics 25-30, are in another grouping with the fiber properties in Table 3. The aggressively or over processed samples of the stripper harvested, fabrics 13-16, and the possible three lint cleaned samples, fabrics 4 and 23, are in yet another group with the fiber properties in Table 4.

For the control group (5 varieties), the most prevalent correlations were between the fabric % White and the fiber % White (See Figure 8). All maturity measurements of the five variety fibers, except the Maturity Ratio, had a strong correlation with the fabric % White. Fiber properties that best correlated with the fabric % White included Theta cv% (thcv), AFIS Nep Size (size), HVI Micronaire (mic), and Raw Stock Neps, (raw). The Theta cv% is an indirect measure of maturity; the more immature fibers, the greater the variation of the thickening of the fiber. With an $R^2 = 1$, the following equation used the previously mentioned fiber properties to predict the white speck content of the fabric:

% White = 1.284869+.004359*(thcv)-1.75323*(size)-.0371*(mic)+.001347*(raw).

Using the fiber properties of Theta cv% (thcv), and HVI Micronaire (mic), to predict the % White of the **control** fabrics (#31-#35) (see Fig.4), an $\mathbf{R^2 = 0.978}$ was generated using the following equation to predict the white speck. These fiber properties are easily or readily available and have good correlations with the fabric % White. Thus it is recommended to predict the fabric white speck this equation should be used with the two readily available variables of Theta cv% (thcv), and HVI Micronaire (mic):

1) % White = -.05125+.002955*(thcv)-.01339*(mic).

Due to the high correlation with the fiber properties and the fabric % White for the 5 varieties, those fiber properties were used in a regression analysis with the **standard** fabrics 1-3, 5-12, 17-22, 24, plus the 5 varieties. Using Theta cv% (thcv), AFIS Nep Size (size), HVI Micronaire (mic), and Raw Stock Neps (raw) (see Fig. 5), an $\mathbf{R^2 = 0.816}$ was generated. The following equation was developed to predict the white speck content of a finished fabric that underwent traditional recommended processing; the fibers were not combed.

2) % White = -0.16678+.002568*(thcv)+.155104*(size) -.00811*(mic) -.00033*(raw).

With the addition of another fiber measurement known as AFIS Nep, the regression produced an $R^2 = 0.817$, which indicated that the AFIS Nep was not crucial to predicting the white speck content of a finished fabric. Using readily or easily available fiber properties of Theta cv% (thcv), and HVI Micronaire (mic) in a regression analysis with fabrics #s1-3, 5-12, 17-22, 24, plus the 5 varieties, fabrics# 31-35, the fabric % White can be indicated with an R^2=0.61 with the equation:

% White = -0.0314 + 0.002011*(thcv) - 0.00913*(mic).

The **combed** samples, fabrics #25-#30, used the fiber properties of Theta cv% (thcv), AFIS Nep Size (size), HVI Micronaire (mic), and Raw Stock Neps, (raw), to predict the % White of a fabric (Fig. 7). An $\mathbf{R^2 = 0.889}$ was generated using the following equation to predict the white speck

$$\textbf{3)}\ \%\ White = -.09459+.000458*(thcv)+.197153*(size)-.0164*(mic)+.000439*(raw).$$

Using only the fiber properties of Theta cv% (thcv), and HVI Micronaire (mic), (Standard AFIS and HVI data) to predict the % White of combed fabrics an $R^2 = 0.772$ was generated using the following equation to predict the white speck.

$$\%\ White = -.01465+.000831*(thcv)+-.00336*(mic).$$

These correlations with the fabric % White were improved when Raw neps and Nep size were included. It was noted that as AFIS Nep Size increased, so did the % White in the Carded fabrics, but an inverse relationship was seen for the samples that were combed. So it seems that the larger the size of the nep, the more easily it is removed by combing, which would make perfect sense. Thus it is recommended to predict the impact of combing on the fabric white speck the equation which includes AFIS Nep Size should be used if the data is available.

When studying the effects of aggressive or over processing on the white speck, stripper harvested fabrics, #13-#16, and fabrics that were believed to have experienced 3 lint cleaners at the gin, fabrics #4 and #23, were used. Theta cv% (thcv), AFIS Nep Size (size), HVI Micronaire (mic), and Raw Stock Neps, (raw) were again the most crucial fiber properties (Fig. 6) and resulted in an $\mathbf{R^2 = 0.994}$. Thus the following equation should be used when studying the impact of **harsher fiber processing** on the white specks of the finished fabrics

$$\textbf{4)}\ \%\ White = -.24907+.011448*(thcv)+.343134*(size)-.06878*(mic)-.00761*(raw).$$

Using Theta cv% (thcv) and HVI Micronaire (mic) fiber properties regression analysis resulted in an $R^2 = 0.470$ for stripper harvested fabrics #13-16, and fabrics that were believed to have experienced 3 lint cleaners at the gin, fabrics #4 and #23, were used. Thus the following equation should be used when studying the impact of harsher fiber processing on the white specks of the finished fabrics when using only two fiber properties

$$\%\ White = -.00969+.00174*(thcv)-.00913*(mic).$$

Using equations 1, 2, 3 and 4 to predict the white speck from fiber properties results in an $R^2 = 0.943$ as seen in Fig. 9.

Varietal Results*

Level of % White	Range	Varieties
Excellent	0 - 0.01	Combed Acala Royale Combed Acala Maxxa
Good	0.01 - 0.015	Combed Pima S-7 Deltapine 50 Deltapine 51
Acceptable	0.015 - 0.02	Deltapine 90** Deltapine 20 Deltapine 5415** Mississippi Delta (MD) 51** Acala Royale Stoneville 453
Borderline	0.02 - 0.025	Stoneville 453 Deltapine 5690**
Poor	0.025 & up	Acala Maxxa*** Paymaster HS-26 Paymaster HS-200 Deltapine 5415

* Since growing, harvesting and ginning conditions were not controlled, results may be due to these conditions rather than variety. Note Combed samples had the least white speck.

**Control Varieties, same growing, harvest ginning and mill conditions giving true varietal results.

*** All control varieties harvested at 161 days which is approximately two weeks early for Maxxa which may have caused a high level of immature fibers.

Conclusions

Even though this study was meant to be a variety study, it turns out that processing plays a starring role in the production of white specks on finished fabric, particularly processing at the gin. From the control data, the most critical fiber properties were identified as Theta cv%, Micronaire, AFIS Nep Size, and Raw Stock Neps which were used in the predicting equations. Using the more readily available fiber properties of Theta cv% (thcv) and HVI Micronaire (mic), predicting equations were generated but had lesser R^2 values than the equations using the four critical fiber properties. Theta cv%, or the variation of the degree of thickening was an indicator of maturity; the more mature fibers would have less variability in the thickening than the immature fibers. Micronaire is also another indicator of maturity. AFIS Nep Size demonstrates to what extent the processing has fluffed up the immature fiber clusters that turn into white specks on the finished fabric. The larger the nep size, the more of a white speck problem will develop. Combing removes white specks, thus nep size is a critical fiber property for predicting the level of white speck removal by combing. Raw Stock Neps measure the number of neps in 100 square inches of fiber web. This also reveals whether the fabric will have a white speck problem, since the more neps in the fiber, the greater the potential for white specks on the finished fabric. The Raw Stock Nep test is very tedious and time consuming and therefore probably not that useful a tool to industry.

Due to the level of leaf acceptable for the leading variety survey, most of the standard varieties would have two lint cleaners, but some cases may have only 1 lint cleaner which would explain the R-square for this data being lower than the control group, since the number of lint cleaners was not reported.

From this study several equations were developed to predict a white speck problem from fiber properties alerting how profound of an effect processing has on the white speck. The control group provided a means to predict the white speck potential from fiber properties only, since processing was the same for all varieties. Thus, when comparing just varietal effects that equation can be used. When the standard, typical processing samples were added to the five varieties, the R^2 = .81, indicating that processing determined the remaining criteria for white speck prediction. Thus when processing differences are present, and they are known to be typical, the corresponding equation should be used. When the fibers were believed to be aggressively processed such as stripper harvesting or three lint cleaners at the gin, that corresponding equation should be used. To study the impact combing would have on the fibers, the combing equation should be used. Equations were generated using the critical fiber properties Theta cv%, Micronaire, AFIS Nep Size, and Raw Stock Neps and the more readily available fiber properties of Theta cv% (thcv) and HVI Micronaire (mic).

White speck neps originate at the fiber growing stage and are generally due to variety, and growing conditions. Once the cotton is harvested, cleaning alters the level of white specks seen in the finished fabrics. With increased cleaning at the gin, mills receive less value for their money, in that the cotton has higher short fiber content and a higher level of white specks in the finished fabrics. Gin cleaning should be minimal and used only as a step in cleaning with the most rigorous cleaning done at the mill. The varietal results are only clear when all processing is controlled. The level of cleaning (extra precleaners for stripper harvest and the number of lint cleaners) should be reported along with fiber properties so that mills can estimate the propensity for white specks in the finished fabrics. With this data available mills would at least be able to compile data from their fabrics which do end up with a white speck problem and would eventually be able to determine what are minimum requirements in fiber properties with known levels of gin cleaning for their products. With known processing, it is conceivable that only micronaire and AFIS Theta cv% would be the two fiber properties to track. Mills would benefit by having better quality fabrics in that they would know to comb the fibers with a propensity for unacceptable levels of white speck, or use those cottons for white or pale shades.

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Table 1. Varieties Studied and their Location of Growth

ID	Variety	Location of Growth
1	Deltapine Acala 90	Southeast: Alabama
2	Deltapine Acala 90	Southeast: Georgia
3	Deltapine 5415	Southeast: South Carolina
4	Deltapine 5415	Southeast: Georgia
5	Deltapine 50	South Central: Mississippi
6	Deltapine 50	South Central: Missouri
7	Deltapine 20	South Central: Mississippi
8	Deltapine 20	South Central: Tennessee
9	Deltapine 51	South Central: Mississippi
10	Deltapine 51	South Central: Tennessee
11	Stoneville 453	South Central: Missouri
12	Stoneville 453	South Central: Tennessee
13	Cargill Paymaster HS	Southwest: Lamesa, Texas
14	Cargill Paymaster HS	Southwest: Lamesa, Texas
15	Cargill Paymaster HS	Southwest: Abilene, Texas
16	Cargill Paymaster HS	Southwest: Lubbock, Texas
17	Deltapine 50	Southwest: Corpus, Texas
18	Deltapine 50	Southwest: Harlingen, Texas
19	CPCSD Acala Maxxa	Far West: North San Joaquin
20	CPCSD Acala Maxxa	Far West: South San Joaquin
21	CPCSD Acala Royale	Far West: North San Joaquin
22	CPCSD Acala Royale	Far West: South San Joaquin
23	Deltapine 5415	Far West: Arizona
24	Deltapine 5415	Far West: California
25	Pima S-7	Far West: Arizona
26	Pima S-7	Far West: California
27	CPCSD Acala Maxxa,	Far West: North San Joaquin
28	CPCSD Acala Maxxa,	Far West: South San Joaquin
29	CPCSD Acala Royale,	Far West: North San Joaquin
30	CPCSD Acala Royale,	Far West: South San Joaquin
31	Deltapine 5690	South Central: Mississippi
32	Maxxa	South Central: Mississippi
33	Deltapine 5415	South Central: Mississippi
34	Mississippi Delta 51	South Central: Mississippi
35	Deltapine 90	South Central: Mississippi

Table 2. Fabric & Fiber Properties for Standard Processed (including Control) Samples.

ID	Fabric % White	Fiber %White	Theta %CV	AFIS Nep Size	Mic (rgd)	Raw Stock Neps
1	0.0178	0.0116	45.17	0.718	4.5	20
2	0.0192	0.00579	44.99	0.715	4.6	16
3	0.224	0.00863	43.96	0.725	4.1	19
5	0.142	0.00638	44.69	0.715	4.4	23
6	0.145	0.00854	44.63	0.693	4.5	16
7	0.218	0.00223	45.61	0.72	3.9	28
8	0.233	0.00813	44.89	0.728	4.1	22
9	0.126	0.004	42.14	0.713	4.6	16
10	0.128	0.00723	42.81	0.715	4.7	16
11	0.22	0.0129	46.03	0.728	4.2	23
12	0.0177	0.00836	44.61	0.73	4.5	24
17	0.0122	0.00861	41.46	0.735	4.4	16
18	0.0109	0.0154	44.62	0.705	4.1	20
19	0.024	0.0174	46.35	0.73	4.3	23
20	0.0234	0.0115	47.6	0.723	4.2	21
21	0.0196	0.0137	44.15	0.72	4.2	18
22	0.0143	0.0146	42.81	0.733	4.3	19
24	0.0154	0.0156	44.97	0.728	4.3	26
31	0.022	0.00754	44.44	0.75	4.4	16
32	0.0378	0.0176	47.3	0.77	3.8	28
33	0.0155	0.00501	43.15	0.75	4.4	18
34	0.0164	0.00307	42.72	0.75	4.5	15
35	0.0185	0.00808	44.27	0.75	4.5	20

Table 3. Fabric and Fiber Properties of Combed Samples

ID	Fabric % White	Fiber %White	Theta % CV	AFIS Nep Size	Mic (rgb)	Raw Stock Neps
25	0.0122	0.00682	48.96	0.71	4.1	27
26	0.0121	0.00838	47.26	0.715	3.9	18
27	0.0113	0.0174	46.35	0.73	4.3	23
28	0.00908	0.0115	47.6	0.723	4.2	21
29	0.00729	0.0137	44.15	0.72	4.2	18
30	0.00636	0.0146	42.81	0.733	4.3	19

Table 4. Fabric and Fiber Properties of Aggressively Processed Samples.

ID	Fabric %White	Fiber %White	Theta %CV	AFIS Nep Size	Mic (rgb)	Raw Stock Neps
4	0.0216	0.00535	43.67	0.72	4.7	20
23	0.0307	0.0154	45.54	0.755	4.3	27
13	0.0245	0.0251	43.56	0.75	3.8	29
14	0.0244	0.00799	40.47	0.725	4.5	17
15	0.0418	0.0255	45.41	0.758	3.9	29
16	0.0216	0.0131	43.72	0.72	4.4	23

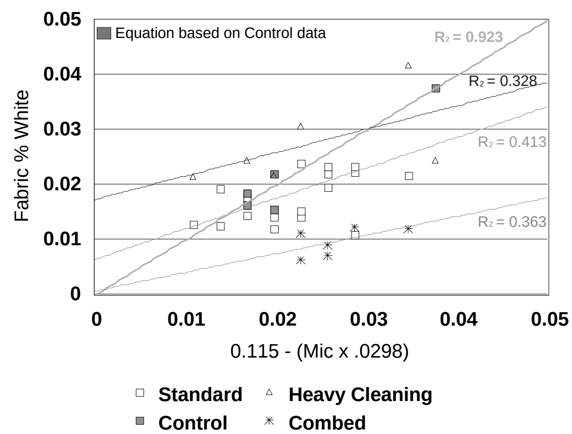

Figure 1. Micronaire Predicting White Speck on Fabric.

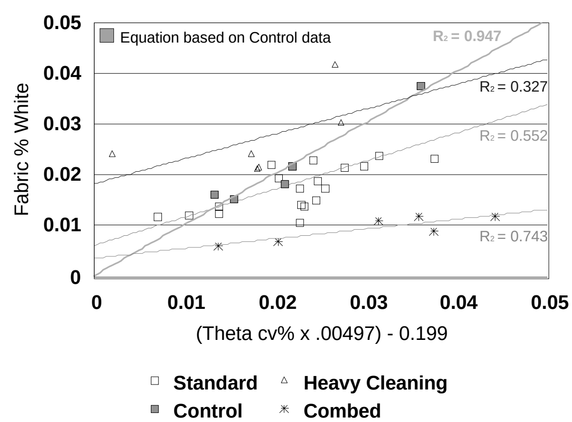

Figure 2. Theta (n) cv% (AFIS) Predicting White Speck on Fabric.

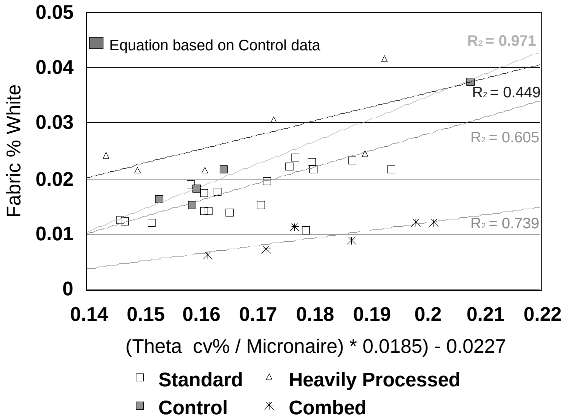

Figure 3. Theta cv% / Micronaire Predicting White Speck for Fabrics.

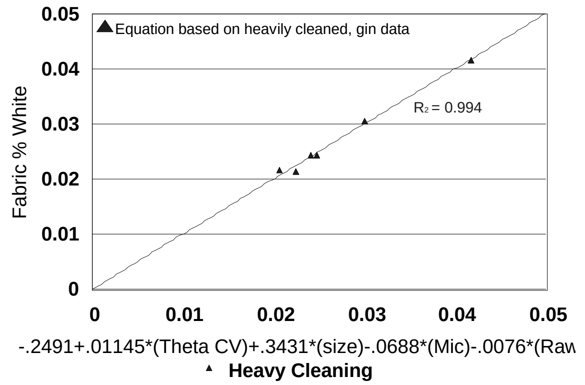

Figure 6. Predicting Fabric White Speck from Fibers with Heavy Gin Cleaning.

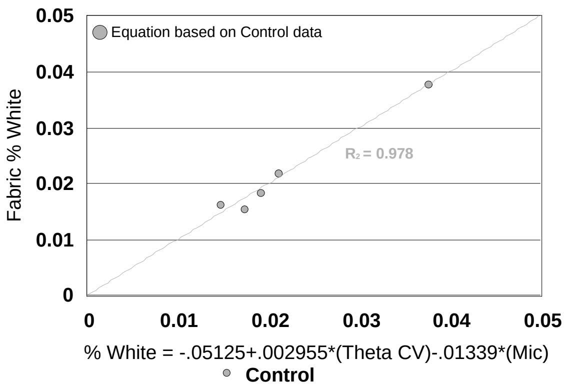

Figure 4. Theta cv% & Micronaire Predicting White Speck for Control Fabrics.

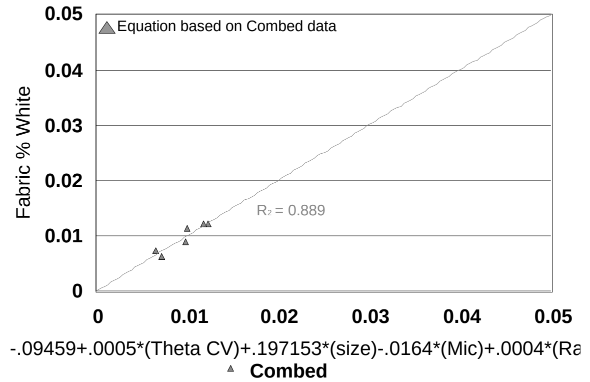

Figure 7. Predicting Fabric White Speck for Combed Fabrics.

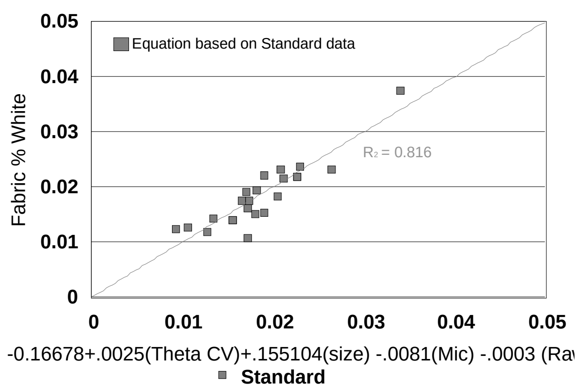

Figure 5. Predicting Fabric White Speck from Fibers with Standard Gin Cleaning.

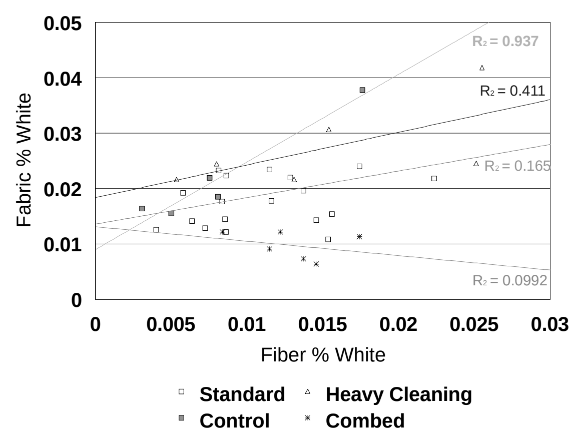

Figure 8. Dyed Fiber Maturity Test vs. Fabric White Specks.

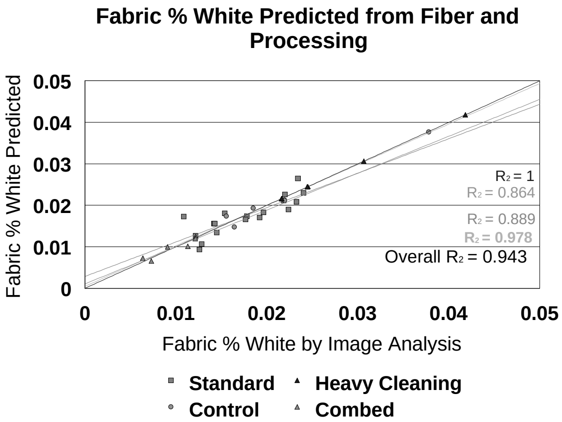

Figure 9. White Specks Predicted from Fiber Data and Processing vs. Image Analysis % White of Dyed Fabrics.