ANALYSIS OF WHITE SPECS IN COTTON BY NIRHVI: A FEASIBILITY STUDY

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Abstract

Past research has indicated that a nondestructive NIRHVI measures a number of fundamental fiber properties of wall thickness and perimeter on cottons with precision equal to the primary methods used to calibrate the NIRHVI. This feasibility study was designed to determine if the use of an NIRHVI could be extended to measuring white specks and short fiber weights and counts.

Introduction

Past research has indicated that nondestructive VIS/NIR spectroscopy using a HVI measures the fundamental fiber properties of wall thickness, perimeter, maturity ratio, percent maturity, and percent thickness on raw and clean cottons with precision approaching that of the primary methods used to calibrate the HVI (Buco, Montalvo, Faught, Grimball, Stark, & Luchter, 1995; Buco, Montalvo & Faught, 1998). An NIRHVI is fast, with all spectral data collected in 30 seconds on a cotton sample. In contrast, measurement of white specks by image analysis is a time-consuming process, requiring the processing of bales, spinning of yarns, weaving of fabric, dying, and measurement by image analysis algorithms. The purpose of this study was to determine the feasibility of using a NIRHVI on cottons in a rotating mode to measure % white as determined by image analysis. AFIS short fiber content was available for all samples in this study and was included in the analyses.

Materials and Methods

Cotton samples were obtained from three sources: four cottons from a four extreme variety study; 31 cottons from a leading variety study; and 59 cottons from Australia. All samples were measured in a rotating sample mode by a NIRSystems Model 6500 spectrophotometer mounted in a HVI configuration, image analysis, and AFIS.

Four Extreme Variety Cottons

Four cotton fiber varieties were grown under irrigated conditions in the same field in the San Joaquin valley in California. The cottons consisted of two typically rain grown and two irrigated varieties. DP-90 is a commercial Delta Upland fiber, STV-825 is a Mississippi hybrid variety and EA-C30 (experimental – bred to mature early) and EA-C32 (Prema) are Acala cottons. Full size production equipment was used throughout the study. The cottons were spindle picked and then ginned at Mesilla Park, NM, followed by two saw-type lint cleaners. All yarn and fabric processing was done at the USDA Southern Regional Research Center in New Orleans. A lay down of three bales was used for each variety. Equal amounts were processed from each of the three bales to make four lots of equal weight per variety. The opening process was the same for all lots: Hopper, Superior Cleaner, Buckley beater, Kirshner beater, and then chute feed to the cards. Two of the four lots for each variety were single carded using the Mark IV card. The other two lots were tandem carded using the Mark IV tandem card. The tandem carded lots were not used in this study. The first drawing had eight doublings to 55 gr./yd. and the second drawing had eight doublings to 55 gr./yd. Roving was 1.25 hanks with medium soft twist. Both 30/1 and 40/1 yarns with a 3.8 T.M. were spun on a Roberts Arrow, 240 spindle spinning frame with spindle speed of 9500 rpm. Fabrics were woven from 30/1 warp yarns and 40/1 filling yarns for all varieties to produce four fabrics. The fabric construction consisted of 74 ends per inch and 120 picks per inch. The experimental yarns have 100% surface coverage.

Leading Variety Cottons

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 26 varieties were from different locations across the cotton belt. An additional five varieties were grown in the same field at Stoneville, MS. and were processed in the same manner as the 26 varieties from the 26 Leading Variety Survey. The cotton was opened, blended and cleaned on Truetzchler equipment. The control group, five 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 dyed fabrics were a 5-harness filling faced sateen with a common combed warp, 30/1 warp yarns, 72 ends per inch and 120 picks per inch filling. The experimental yarns had 85.8% surface coverage due to a combed common warp being used.

Australian Cottons

Thirty 30 cotton samples consisted of eight different Australian varieties collected during the 1998 crop year. The eight varieties were grown at four different fields. (Two varieties had only three locations, due to timing problems). The seed cottons, 1500 kg per sample, 30 samples, were baled using a small wool bale press at the field. The 1500 kg samples were split into two 750 kg samples at the gin and were ginned using one lint cleaner on one set and two lint cleaners on the second set of samples. All of the samples were processed through one gin in one line with common equipment settings, preserving the individual identities of the lots. One sample was not processed through two lint cleaners, resulting in 59 samples. The bulk of the ginned cottons were sold, reserving 50 lbs. of each of the samples to be processed into fabrics using the same processing as the leading variety study. The dyed fabrics were a 5-harness filling faced sateen with a common combed warp, 30/1 warp yarns, 72 ends per inch and 68 picks per inch filling. The experimental yarns had 81.1% surface coverage due to a combed common warp being used.

NIRHVI

An HVI unit was stripped down and a sample presentation system, a pneumatic arm with plunger, and a VIS/NIR spectrophotometer were installed on the HVI bench. A 5.5" diameter cell over a quartz bottom held a cotton sample and the fiber mass was pressed against the quartz with a plunger. The pneumatic arm with a plunger consisted of a 0.25" metal rod fitted through a bushing and mounted on the horizontal, triangular plate of a pneumatic arm. A flat 4.8" diameter sample plunger was attached to the lower end of the rod. An NIR Systems 6500 scanning spectrophotometer was installed on the HVI bench under the quartz. The HVI was operated in a rotation mode, with the sample on the quartz rotated at 2 rpm. The spectrophotometer measured the spectral region from 400 to 2498 nm in 2 nm increments. The "VIS" detector measured 350 points from 400 nm to 1098 nm and the "NIR" detector measured 700 points from 1100 nm to 2498 nm.

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Each cotton sample was divided into four 40 g specimens. Thirty 1-second spectra were obtained during one rotation of the sample and averaged to produce one average spectra per specimen. The NIRHVI was operated in a nonconditioned lab.

Dyeing and Image Analysis

The fabric was 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% Na2 Co3 (soda ash) and 0.5% Triton Tx-100. This dye has a high propensity for highlighting white specks in finished fabrics.

Image analysis was done by WSA, version 2, developed Bugao Xu. Four 5 inch by 5 inch samples of each fabric were scanned on a HP Scanjet 6300c with default settings. Minimum pixel size was set to 3 pixels for all cottons. Since each set of cottons was processed in different dye lots, contrast levels were sent to match hand counts on random samples within each dye lot. Contrast level was set at 36 on the four extreme varieties, 38 on the leading variety cottons, and 42 on the Australian varieties. Using the % Areas and data collection macros, the ratio of the white speck area to the sampling area, or the % white was determined.

AFIS

The Advanced Fiber Information System, AFIS, was developed to rapidly measure essential cotton fiber property distributions such as length, diameter, maturity, fineness, and neps. The Australian cottons were measured on the AFIS located at Cotton, Inc. The four-variety and leading variety cottons were measured on the AFIS located at SRRC. Five sets of 5,000 fibers were measured for each of three samples taken from a different location from each bale for a total of 75,000 fibers per cotton.

NIRHVI Calibration

Using the VIS/NIR spectral data of NIR Systems 6500, principle components analysis was independently applied to the 350 data points from the "VIS" detector and to the 700 points from the "NIR" detector to obtain 10 principal components for each set of points. Visual inspection of plots of predicted values against actual values indicated that a curvilinear model would be appropriate. Therefore, the 20 principal components (10 VIS components and 10 NIR components) were entered as linear components into a backward stepwise regression along with the squares of the first five principal components from each of the VIS and the NIR regions. A probability of .15 was used for exclusion in the model to select predictive components on the basis of the stepwise F-test. Independent models were obtained for %white, short fiber weight, and short fiber count. Three outliers were removed in the regression process.

Results and Discussion

The cotton properties for the 94 cottons are summarized in Table 1.

The root mean squared deviations (RMSD) and R^2 results of the stepwise regression models for the NIR HVI are presented in Table 2. The results demonstrate that measurement of cotton fibers by an NIRHVI in an unconditioned lab can be used to predict %white of dyed fabrics with good precision (see Figure 1). Further improvement should be expected once the NIRHVI is installed in a conditioned lab setting and samples are allowed to equilibrate to room conditions prior to measurement.

In order to gain some understanding of the relationship between NIR/VIS measurements and %white, the principle component plots were visually inspected. This inspection revealed a large cyclical noise component in the underlying spectra, perhaps due to the age of the electronic and lamp components of the spectrophotometer. It is anticipated that replication of the NIRHVI measurements with a newer spectrophotometer with an improved signal to noise ratio would lead to improved results. The functional relationship between NIR/VIS measurement of fibers and %white will require study in order to enhance the measurement process

Measurement of short fiber count and short fiber weight was accomplished with better precision than %white and further demonstrates the ability of the NIRHVI to measure multiple fundamental fiber properties simultaneously. Indeed, this is one of the NIRHVI's many advantages – it can measure multiple properties simultaneously. Additional properties can be measured in the future by adding additional data processing algorithms.

The results justify industry evaluation of the NIRHVI.

References

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Table 1. Properties of 94 cotton samples.

Property	Mean	Minimum	Maximum
% White Speck Area	0.0376	0.0092	0.1013
AFIS short fiber weight	8.838	3.020	13.000
AFIS short fiber count	22.788	9.340	32.100

Table 2. Measurement of properties by NIRHVI.

	Number of samples	RMSD	R^2
% White Speck Area	91	0.0082	0.836
AFIS short fiber weight	91	0.779	0.890
AFIS short fiber count	91	1.713	0.918

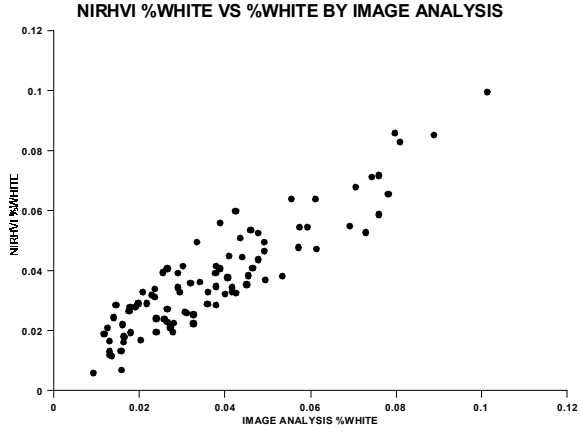

Figure 1. NIRHVI % white by image analysis % white.