FAST DETERMINATION OF MATURITY AND FINENESS BY NIR WITH A DIODE-ARRAY HVI. PART 3. HVI OPERATION

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Abstract

Two fast diode-array high volume instruments (DA HVIs) to measure cotton quality parameters nondestructively were built. An on-line sample processing rate for routine analysis of maturity and fineness was estimated from an off-line application that utilized 1200 cottons to calibrate each DA HVI. The actual sample calibration rate was: 240 duplicate spectra/hr alternating between two DA HVIs or 30 samples/hr/HVI. The estimated on-line sample processing rate for routine analysis is: 240 samples/hr/HVI using two specimens per sample and duplicate spectra or 4 samples/min/HVI. The calibration protocol emphasized precision over speed to produce the best possible calibration algorithms whereas the routine analysis protocol provides for a practical compromise between speed and precision.

Introduction

Recent work indicates that fast diode-array high volume-instrumentation (DA HVI) has the potential to measure cotton maturity and fineness in an on-line application (Buco, Montalvo, Faught, Stark, and Luchter, 1996). A recent off-line application of the fast DA HVI was calibration with 1200 cottons provided by Cotton Incorporated. The results of this study will be presented elsewhere. The purpose of this paper is to calculate the rate at which these calibration samples were actually analyzed on each of two fast DA HVI units and thus demonstrate a plausible on-line processing rate for routine analysis.

Materials and Methods

Samples. The samples originated at the Agricultural Marketing service (AMS) and were part of the 1994 Check Cottons. AMS forwarded the cottons to Cotton Incorporated to conduct additional analyses. The remaining portion of each cotton was shipped to SRRC by Cotton Incorporated. Two 30 g specimens of each of the 1200 cottons were placed in separate bags.

iode-Array High-Volume Instrumentation. Two Spin-lab colorimeter-trash meter HVIs were stripped down and to each were installed a sample presentation system, a pneumatic arm with a round plunger, and the fast DA spectrophotometer (KES Analysis, Inc., NY, NY). In brief, a cotton specimen was placed in a cylindrical sample cell with quartz bottom, the fiber mass pressed against the quartz with the plunger, and a reflectance spectrum collected by the diode-array placed under the quartz.

The diode-array has separate light source and detector modules. In our two prototype DA HVI units, both modules were placed off-center and several inches from under the quartz window of the sample cell. The fast DA HVI measures the reflected light intensity at 152 data points spanning the spectral region from 400 to 1700 nm. Spectral acquisition time is one sec.

A surface area of 19 square inches is available (the sample cell is 5" in diameter). A 30 g specimen was analyzed corresponding to a cotton cross-sectional density over the quartz of 1.53 grams per square inch. The force on the plunger which presses the cotton against the quartz was at least 2 lbs per square inch or a minimum of 40 lbs of total force.

Table 1 outlines the calibration protocol in analyzing the first specimen of the 1200 cottons on both DA HVIs. The second specimen of a sample was analyzed immediately after the first using the same protocol.

Performing the calibration protocol required four technicians: one to open boxes of specimens and bags, one to take specimens out of the bags and to replace them after measurement, and one operator for each of the two DA HVI units.

Results and Discussion

The calibration spectra allow for development of algorithms to predict maturity and fineness in routine analysis of unknown cottons. Example reflectance spectra of a high and low maturity cotton in the wavelength range from 500 to 1700 nm are depicted in Figure 1. Absorption of incident radiation by the cotton below about 750 nm is due to the colored impurities in the cotton. Above 750 nm, the absorption is due to the cellulose in the fiber wall and is controlled by the fiber's wall thickness and cross-sectional perimeter. Only the NIR portion of the spectrum is needed in measurement of maturity and fineness by the DA HVI.

Note that the calibration protocol in Table 1 includes alternating a specimen between two HVIs and two spectra on each to two (reverse) sides of a specimen to maximize precision of the mean spectra. The actual processing rate for calibration is summarized in Table 2. This rate was computed from the observed spectra/hr. and breaks down

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as follows for 1 side of the same specimen measured on both HVIs:

8 seconds delay to allow plunger to reach equilibrium
4 seconds for 4 1-second spectra
-18 seconds manual sample handling
30 seconds/side/specimen = 30 samples/hr.

For routine HVI analysis, the emphasis must be on speed and the number of bale specimens needed to represent the bale means. Two specimens per bale is consistent with existing HVI protocols. Thus, the HVI processing rate computation is based on automatic sample handling and duplicate analysis -- two specimens and two spectra per specimen but only 1 side/specimen. The processing rate for routine analysis can be calculated from the actual calibration rate data and comes out at 4 samples/min for each HVI:

4 seconds delay to allow plunger to reach equilibrium
2 seconds for 2 1-second spectra
-1.5 seconds automatic sample handling
7.5 seconds/specimen = 4 samples/min.

Note that automatic sample handling should be used to sustain this processing rate over the work day otherwise the actual processing rate will be limited by sample handling.

References

Buco, S.M., J. G. Montalvo, S. E.Faught, E. Stark, and K. Luchter. 1996. Determination of wall thickness and perimeter by FMT and diode-array HVI. Part 1. Data analysis and results. Proceedings Beltwide Cotton Conferences. 1289-1290.

Table 1. DA HVI calibration operation on both DA HVIs.

1.Open sample bag containing 30 g specimen and remove cotton.
2.Place specimen in sample cup, add foam pad to smooth out irregular cotton cross-section densi-ties in the cup.
3.Position cup on first HVI and press both safety switches. Computer activates plunger and sets a 4 second delay to allow plunger to reach equilibrium. The diode-array makes two 1-second NIR measurements. Computer releases the plunger.
4.Transfer cup to second HVI and reanalyze.
5.The cotton is flipped over, cup repositioned on first HVI and reanalyzed.
6.Transfer cup to second HVI and reanalyze.
7.Remove foam pad and return specimen to bag.

Table 2. Processing rates for calibration and routine DA HVI analysis.

CALIBRATION ALTERNATING BETWEEN TWO HVIs
(ACTUAL RATE)

a. 1200 cottons x 2 specimens each = 2400 specimens
b. 2400 specimens x 2 HVI's x 2 sides/specimen x 2 replicates/side = 19,200 spectra or (16 spectra/sample)
c. Measurement rate = 480 spectra/hr = 30 sec/side/specimen or 60 seconds/specimen = 30 samples/hr.
d. White standard and paper check samples run at intervals

ROUTINE DUPLICATE ANALYSIS
(CALCULATED)

e. 4 samples/min for each DA HVI
f. Automated sample handling should be used

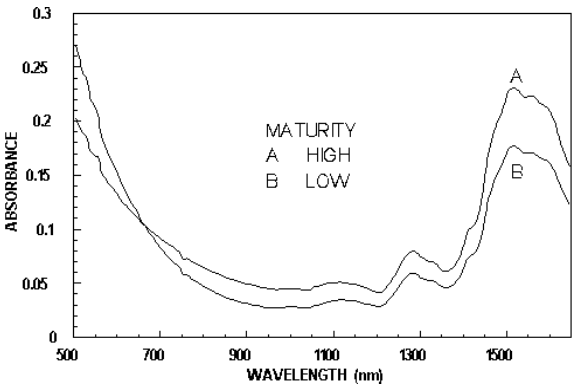

Figure 1. Cotton reflections spectra produced by the diode-array high volume instrument.