COMPARISON OF UPGRADED FMTS AND OPERATOR EFFECTS. PART II. ADDITIONAL STUDIES

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Abstract

Two calibration protocols were developed to match between instrument readings of paired upgraded fineness and maturity testers (FMT, Micromat model). Each protocol is a two-step process that involves adjustment of the digital pressure indicator sensitivity followed by the *PL* and *PH* piston stroke lengths. In one protocol, instrument controls are set at responses corresponding to a range of Micronaires. For the other protocol, the controls are set using a high Micronaire cotton. The calibration procedures are described and evaluated over a range of Micronaire values.

Introduction

Headspace resistance standards (HRS) were used to recalibrate and control the FMT during routine analysis (Montalvo and Faught, 1997 and 1998). A leak detector module was installed to monitor the rate of air leakage into the negative pressure system of the instrument. Elimination of drift in FMT readings over a 6-week period was demonstrated. Other improvements included defining an acceptable sample weight range and controlling temperature changes and other contributing factors which could lead to biases and affect precision. Two FMTs — the one at the Southern Regional Research System (SRRC) and another at the Agricultural Marketing Service (AMS)— have been upgraded with the indicated improvements. This paper focuses on two calibration protocols to match between instrument readings of the upgraded instruments.

Materials and Methods

Samples

The cottons were provided by the Agricultural Marketing Service (AMS) in Memphis, TN to use as in-house quality control samples. There were seven cottons with a wide range of Micronaires (5.76, 5.54, 5.31, 4.93, 4.24, 3.63, and 3.15). A bulk sample of each cotton was cleaned by carding.

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FMT

The Shirley Developments Limited (SDL) 089 Micromat Tester is the latest in the series of FMT instruments developed to measure the maturity and fineness of cotton. (Names of companies or commercial products are given solely for the purpose of providing specific information). An electronic balance with an interface to a microprocessor with floppy and hard disk drives, and a monitor for displaying results are included. There are two operational modes: *Pause* and *Automatic*. *Pause* allows for changing FMT settings as, for example, the flow controllers. The *Automatic* mode is used in routine analysis. In this mode, the computer accepts the sample weight, the instrument automatically goes through the *PL* and *PH* stages of operation, and ejects the specimen from the sample chamber. *PL* and *PH* values are stored in the computer. Equations were derived to compute various measures of maturity and fineness (Montalvo and Grimball, 1994.)

Calibration Protocol I

This protocol is a two-step process. Step 1: Operate the SRRC FMT in the *Headspace Resistance Standards Recalibration* phase (see below) except note the procedure to here determine declared HRS pressure drops. With 4 L/min of air flowing through the HRS select a *PL* tube that gives a pressure drop of about 250 mm water. Record this pressure drop as the declared HRS *PL* pressure drop. With 1 L/min of air flowing through the HRS select a *PH* tube gives a pressure drop of about 210 mm water. Record the declared HRS *PH* pressure drop. Connect the same HRS to the AMS FMT. Operate the AMS FMT in the *Pause* mode. With 4 and then 1 L/min of air flowing through the HRS adjust the digital pressure indicator sensitivity (DPIS) control on the AMS FMT to minimize the observed HRS *PL* and *PH* differences between the two instruments. In the *Automatic* mode, observe the HRS *PL* and *PH* values on the AMS FMT and record these values as the declared values.

Step 2: Operate the SRRC FMT in the *Routine Analysis* phase. With 4.0 g specimens of the 4.24 Micronaire cotton in the sample chamber, observe the sample *PL* and *PH* values. Compute mean *PL* and *PH* values. Operate the AMS FMT in the *Routine Analysis* phase. With 4.0 g specimens of the 4.24 Micronaire cotton in the sample chamber, observe the sample *PL* and *PH* values. Compute mean *PL* and *PH* values. Adjust the *PL* and *PH* piston stroke lengths on the AMS instrument until the *PL* and *PH* values are matched on both FMTs.

Calibration Protocol II

This protocol also is a two-step process. Step 1: Operate the SRRC FMT in the Leak Detection phase except do not turn on the FMT vacuum pump. With no air flowing through the SRRC FMT, connect a digital pressure indicator calibrator to the funnel glued to the sample chamber lid using a flexible hose. Using the vacuum pump in the calibrator, evacuate the FMT to give a 400 mm water pressure drop reading on the digital monitor of the calibrator. Adjust the FMT DPIS control to get 400 mm water pressure drop. Repeat this procedure on the AMS FMT. Step 2: Repeat step 2 given above except use the 5.31 Micronaire cotton.

Leak Detector Module (LDM) and Headspace Resistance Standards (HRS)

The LDM was constructed from a series of valves mounted on plywood which was attached to one side of the FMT. The LDM was then connected to the FMT air flow system. The LDM has three operational phases: *leak detection*, *headspace resistance standards recalibration*, and *routine analysis.* *Leak detection* allows for sealing the airflow system, evacuation of the system, and the quantitative determination of air leakage rate into the system. *Headspace resistance standards recalibration* allows for monitoring the variability of both the digital pressure indicator and the flow controllers by recalibration of the digital pressure indicator. *Routine analysis* allows for analysis of cotton specimens and calls for periodic HRS recalibration of the digital pressure indicator to maintain FMT calibration over time. (See Montalvo and Faught, 1977, for construction of the HRS from narrow diameter copper tubes. See Montalvo and Faught, 1999, for work prior to this paper regarding calibrating the FMT with cotton, "transferring the calibration" to HRS, and then using the HRS to recalibrate the FMT.)

Headspace Resistance Standards Recalibration Phase

Set the LDM to *HRS Recalibration*. Close the lid of the empty sample chamber and connect the flexible hose from the funnel (glued to the lid) to the HRS manifold. Open the HRS *PL* ON-OFF valve making sure that the HRS *PH* ON-OFF valve is closed. Operate the instrument in the *AUTOMATIC* mode and observe the HRS *PL* value on the digital pressure gauge. When the piston stroke changes to *PH*, open the HRS *PH* ON-OFF valve and close the HRS *PL* ON-OFF valve. Observe the HRS *PH* value. If the observed pressure drops across the HRS are not within the declared specifications, operate the instrument in the *PAUSE* mode and readjust the flow controllers as necessary. Confirm that the FMT is in recalibration by operating the instrument in the *AUTOMATIC* mode while observing the HRS *PL* and *PH* values.

Routine Analysis Phase of Calibration Protocols I and II

For this practice, the LDM remains in the HRS recalibration position, but the flexible hose from the funnel to the HRS manifold is disconnected. A typical routine analysis operational cycle is outlined in Table 1. The number of cotton specimens analyzed in a cycle is limited to 6 to insure there is insignificant drift in instrument readings.

Five of the seven cleaned cottons were selected to evaluate a calibration protocol. For each cotton run on each upgraded FMT, mean *PL* and *PH* values were computed based on 24 replicates. The total number of specimens analyzed was: 2 FMTs x 2 calibration protocols/FMT x 5 cottons/calibration protocol x 24 specimens/cotton = 480 specimens.

Results and Discussion

Given the mean SRRC FMT *PL* and *PH* readings for a set of five cottons, the goal is to calibrate the AMS FMT in a way that minimizes the mean differences in readings between the paired instruments. Two calibration protocols to match the responses are studied in this paper.

Calibration Protocol I

The digital pressure indicator sensitivity of the AMS FMT was matched to the SRRC FMT in a dynamic way — with air flowing through the system — using HRS that gave pressure drops of 250 mm water (HRS *PL*) and 210 mm water (HRS *PH*). Then the AMS FMT *PL* and *PH* piston stroke lengths were adjusted relative to the SRRC settings to get the same between instrument readings using a 4.24 Micronaire cotton. Finally, the five cottons were analyzed on the AMS FMT as unknowns and mean values computed.

A plot of the mean differences between the instrument readings versus the AMS Micronaire of the five cottons is shown in Figure 1. The *PL* differences at all Micronaires are very small, < 1 mm. Thus we write

$$PL_{\mathrm{AMS}} = PH_{\mathrm{SRRC}}. \qquad (1)$$

The plot reveals *PH* differences which increase with decrease in Micronaire. When the mean AMS *PH* values were linearly regressed on the mean SRRC *PH* values, the coefficient of determination (R^2) was 0.999 with slope and intercept, respectively, of 0.992 and -0.269 mm water. This leads to the following equation for matching the values

$$(PL_{\mathrm{AMS}} - 0.269)/0.992 = PH_{\mathrm{SRRC}}. \qquad (2)$$

It is apparent that only a small correction is needed.

Calibration Protocol II

The digital pressure indicator sensitivity of the AMS FMT was matched to the SRRC FMT in a static way — with no air flowing through the system. A digital pressure indicator calibrator was used to match the digital pressure indicator on both FMTs. Then the AMS FMT *PL* and *PH* piston stroke lengths were adjusted relative to the SRRC settings to get the same between instrument readings using a 5.31 Micronaire cotton. Next, the five cottons were analyzed on the AMS FMT as unknowns and mean values computed. Also, the *PL* and *PH* piston stroke length (PSL) were readjusted several times and the five cottons again analyzed each time and means computed.

A plot of the mean differences between the instrument readings versus the AMS Micronaire of the five cottons is shown in Figure 2 for *PL*. The *PL* PSL for the AMS instrument had been initially set relative to the SRRC FMT using the 5.31 Micronaire cotton (curve B). When the cottons were run as unknowns, no difference was found between the AMS and SRRC readings for the 5.31 Micronaire cotton, indicating an excellent match.

However, the other four data points on line B show two distinctive trends, depending on the Micronaire range of values. Above 5.31 Micronaire, the differences in the *PL* readings between the two instruments is almost independent of Micronaire. Below 5.31, there is a significant increase in the differences with decrease in Micronaire.

These effects were studied in more detail by varying the *PL* PSL. With increase in PSL (curve A), the cotton is compressed to a greater extent and, consequently, the differences between the instrument readings increases. Nonetheless, curves A and B show the same trends with varying Micronaire.

When the PSL was decreased (curves C and D), the cotton is compressed to a lesser extent, and the differences are smaller and eventually become negative. The essentially straight line (D) is the result of the greater change in the between instrument differences at the lower Micronaires. Thus, at the *PL* PSL corresponding to D, the correction factor to relate the *PL* between FMTs is independent of Micronaire. The equation for matching the values is given by

$$PL_{\mathrm{AMS}} + 3 = PH_{\mathrm{SRRC}}. \tag{3}$$

Essentially the same equation was found relating the *PH* values between FMTS.

References

Montalvo, J.G., Jr. and Faught, S.E. 1998. Analysis of cotton maturity and fineness by multiple NIR HVIS. Part 2. Reference method. Proceedings Beltwide Cotton Conferences. 2, 1625-1628.

Montalvo, J.G., Jr. and Faught, S.E. 1997. Fast determination of maturity and fineness by NIR with a diode-array HVI. Part 2. Reference method, Proceedings Beltwide Cotton Conferences. 1, 554-555.

Montalvo, J.G., Jr. and Faught, S.E. 1999. Headspace resistance standards for the Shirley Developments Limited Micromat Tester, Textile Res. J., in press.

Montalvo, J.G., Jr. and Grimball, R. 1994. SRRC maturity and fineness equations, version 1.0 software.

Table 1. FMT *routine analysis* phase for calibration protocols I and II - one operational cycle.

1. Connect air flow from funnel to manifold.
2. Switch the LDM to *HRS Recalibration* phase and verify instrument is in calibration. If recalibration is necessary, adjust flows as described in the section on *Headspace Resistance Standards Recalibration* phase.
3. Uncouple airflow from funnel to manifold.
4. Analyze six cotton specimens.
5. To analyze additional specimens go to STEP (1).

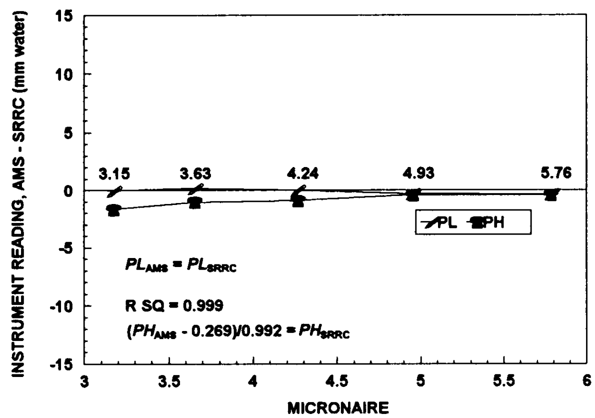

Figure 1. Calibration protocol I results showing mean differences between instrument readings versus Micronaire.

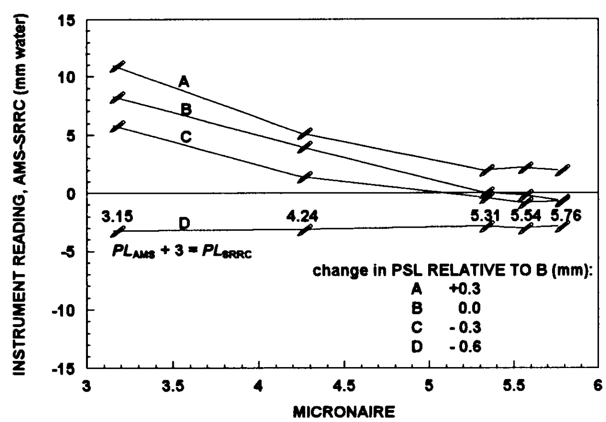

Figure 2. Calibration protocol II results showing mean differences between PL instrument readings versus Micronaire and piston stroke length.