INITIAL DEVELOPMENT OF A NEW PORTABLE MOISTURE METER FOR COTTON

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Abstract

A battery powered, portable, moisture meter was developed for cotton using concepts of a recently patented resistance moisture meter. Similar designs have been used in non-portable applications with the Agricultural Marketing Service (AMS) classing offices and in cotton gins. The 8 in. by 9 in. by 10.5 in. meter weighs about 30 pounds including a 10 pound sample compression weight. The meter has a push button to signal when a reading is to be taken on the sample in the measurement chamber; the moisture content is then indicated on a liquid crystal display. The meter was calibrated using three replications of 16 cotton samples that had been equilibrated at several different relative humidities. No problems were encountered in the use of the meter and evaluation of data obtained with five independent sets of 16 cotton samples resulted in a standard difference between the resistance-based moisture reading and the oven moisture measurement of the same samples of 0.21 percent, wet basis.

Introduction

The quality of lint produced by a gin is dependent on the initial quality of the seed cotton and on the type and degree of drying and cleaning performed at the gin. Both the efficiency of the cleaning and the damage done to the fibers during cleaning are controlled, to a large part, by the moisture content of the fiber as it is being processed. Current recommendations are to gin with the fiber moisture content in the range 6 - 7 percent wet basis (w.b.) (Mayfield, et al., 1994).

Because of the importance of moisture content to processing and quality preservation in the gin, the currently available systems which could be used for moisture sensing in the gin were examined by Anthony and Byler (1994). Commercially available Near Infrared (NIR) based moisture meters have been used (Anthony, 1991; Byler, 1991), however these sensors are relatively expensive. Although moisture control is so important that in many cases relatively expensive moisture sensors can be justified, a less expensive alternative was sought. Moisture sensors based on complex impedance are described in the literature (Waldie, Hughs, and Gillum; 1983). This type of sensor could be used in automated moisture control, however, the instruments were not found to be commercially available.

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Resistance-based meters have been used in gins for many years and have been used in automated moisture control. They are less expensive than the NIR meters, but their design and use does not provide sufficient accuracy to keep the moisture content in the desired 6-7% range because the standard deviation of these meters is typically 1% (Anthony, 1994).

Work was begun in 1991 (Byler, 1992) to examine the resistance-based moisture measuring process in order to improve the accuracy. This study resulted in a new design of resistance moisture meter which appeared to have an accuracy at least as good as the oven method, against which it was calibrated and compared (Byler, Anthony, and Ramey, 1993). Over the next few years the main effort of this research was aimed at examining the possibility of using the meter to reduce the High Volume Instrument (HVI) strength measurement variation at the AMS classing office. The meter was used as a bench-type device in conjunction with an HVI color/trash meter and proved to be accurate, with no measurable drift, and reliable in use under classing office conditions (Byler, Anthony, and Ramey, 1993; Byler et al., 1994; Byler et al., 1995).

During 1994 work was initiated to adapt the meter which had been used in the classing office for gin application with samples automatically presented by a ram-type or paddle-type sampler (Byler and Anthony, 1995). The purpose of the study was to develop a resistance-based portable system for moisture measurement.

Materials and Methods

A prototype, battery powered, portable moisture meter was built, calibrated, and tested in 1995. The resistance moisture measurement system uses a CoreModule/PC (AMPRO, 1994) 8088 compatible CMOS processor board which consumes about 0.6 W. An interface board was fabricated to connect the CoreModule/PC to the resistance measuring electrodes. This interface uses only CMOS circuitry so it also consumes little power. The design of the system that is intended for automated laboratory or gin use does not have a display, but communicates the results to another computer for recording and display. Thus, a liquid crystal display and driver circuits were added for the portable moisture meter. The portable system has an on/off switch to conserve battery power and a push button to signal the system to measure the moisture content after the sample has been loaded into the sample chamber. A photograph of the meter is shown in Figure 1, and a schematic in Figure 2.

The meter is installed in an 8 in. wide by 9 in. high by 10.5 in. deep sheet metal box. This 756 $in.^3$ box has three compartments, 396 $in.^3$ are used for the microprocessor board, the interface electronics, the controls, the display, and the battery and power supply regulators. The sample chamber uses about 180 $in.^3$ and requires a weight to compress the sample against the electrodes in the bottom of the chamber. The weight is stored in a similar compartment which uses about 180 in.[3] All three of the compartments were larger than necessary.

Two lantern batteries are connected in series to make a 12 V nominal power supply. Commercially available DC/DC converters are used to provide the regulated 12 V and 5 V power required to power the system. The complete system weighs 29.5 lbs, including 2.5 lbs for the batteries and 10.1 lbs for the weight used to compress the samples against the electrodes. A future design goal is to reconfigure the system and to reduce the total weight of the system.

The unit was calibrated in much the same way as previous units which were used at the classing offices and in the gin. Cotton which had been grown at the Stoneville Research Station was cleaned and ginned under normal conditions with normal cleaning. The non-lint content of the lint used in calibration was 3.0% as determined by a Shirley Analyzer (ASTM, 1985a.). The ginned lint was then stored under 5 different relative humidities for three or more days to produce samples with various moisture levels. For the calibration phase, four different samples were taken from four different relative humidity treatments on three separate days, for a total of 48 different samples. Each sample moisture was measured four times with the resistance meter, then the moisture content was measured by the oven method (ASTM, 1985b.). Regression was used to calculate coefficients which predicted the oven moisture content based on the resistance measured by the meter.

For the calibration check phase, separate samples were used to verify the calibration. Four different samples were taken from four different relative humidity treatments on five separate days, for a total of 80 different samples. Four readings were taken with the prototype meter on each sample using the moisture prediction equation determined in the calibration phase and then the moisture was measured with the oven method. The moisture content of the test samples as determined by the oven method was compared to that predicted by the resistance method.

Results and Discussion

During the calibration phase, the resistance measurements were used to predict the oven moisture measurements using regression to estimate appropriate coefficients. The standard error was 0.25 percent w.b. This was about the same error that occurs in the oven moisture data. The range of moisture contents used in the calibration was from 5.1 to 9.5 percent w.b. Those resulting coefficients were entered into the software in the portable meter so that the moisture content of the sample would be displayed in percent w.b.

On each of five other days, four lint samples were chosen at four moisture levels, resulting in a total of 80 samples, and four resistance-based moisture readings taken of each sample. The samples were then submitted for oven moisture determination. Figure 1 shows the results of plotting these 320 observations of the moisture content as measured by the experimental device and the oven method. Because of the large number of points in the plot, the points with the larger errors are emphasized. Forty-six percent of the readings by the two methods differed by less than 0.15. The standard error between the measurement by the oven method and the resistance method is the best statistical indicator of how good the meter works, the standard error in this test was 0.21 percent w.b. for the 320 observations. In addition to being accurate, the meter functioned well during the testing. Unfortunately, time constraints did not allow the testing of the device under ginning conditions.

The power supply is important in any portable device. This portable moisture meter worked well for the first prototype, but the battery life is about 35 hours. The efficiency of the DC/DC converters was found to be only 51%. In lap top computers power supply efficiencies can exceed 90%. With such a power supply, the battery life should be about 60 hours, which may be enough to run the entire ginning season. Rechargeable batteries are another alternative for a commercial version of the device.

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References

1. Mayfield, W.D., W.S. Anthony, R.V. Baker, and S.E. Hughes. 1994. Effects of Gin Machinery on Cotton Quality. In *Cotton Ginners Handbook*. Agricultural Handbook Number 503. USDA, ARS. pp. 237-240.

2. Anthony, W.S. 1994. Portable Moisture Meters. In *Cotton Ginners Handbook*. Agricultural Handbook Number 503. USDA, ARS. pp. 310-314.

3. Anthony, W.S., and R.K. Byler. 1994. Status of Gin Process Control Systems. Proc. Beltwide Cotton Conferences, National Cotton Council. Memphis TN. pp. 170-171.

4. Anthony, W.S. 1991. Field Evaluation of Infrared Moisture Meters. *Ap. Eng. In Ag.* 79(5):509-14.

5. Byler, R.K. 1991. Experience With Dryer Control Based on Infrared Moisture Meters. Proc. Beltwide Cotton Conferences, National Cotton Council. Memphis TN. pp. 1000-1002.

6. Waldie, A.H., S.E. Hughs, and M.N. Gillum. 1983. Automatic Moisture Sensor for Measurement and Control of Cotton Ginning Processes. *J. of Eng. for Ind.* 105:27-30.

7. Byler, R.K. 1992. Resistance-Moisture Content Relationship for Cotton Lint. Proc. Beltwide Cotton Conferences, National Cotton Council. Memphis TN. pp. 1389-1392.

8. Byler, R.K. W.S. Anthony, and H.H Ramey. 1993. Moisture Effects on Strength Measurement at the Classing Office. Proc. Beltwide Cotton Conferences. National Cotton Council. Memphis TN. pp. 1099-1100.

9. Byler, R.K., W.S. Anthony, P.B. Beaton, H.H. Ramey, and J. Boyd. 1994. HVI Strength Correction for Measured Moisture Content: Testing. Proc. Beltwide Cotton Conferences. National Cotton Council. Memphis TN. Pp. 1426-1428.

10. Byler, R.K., W.S. Anthony, H.H. Ramey, and J. Boyd. 1995. HVI Strength Correction Using a Resistance Moisture Sensor. Proc. Beltwide Cotton Conferences. National Cotton Council. Memphis TN. pp. 1268-1271.

11. Byler, R.K. and W.S. Anthony. 1995. Development of a Moisture Sensor for Gin Use. Proc. Beltwide Cotton Conferences. National Cotton Council. Memphis TN. pp. 692-3.

12. AMPRO. 1994. CoreModule/PC Technical Manual. AMPRO Computers Inc. Sunnyvale, CA. Rev. A, 143 pp.

13. ASTM. 1985a. Standard Test Method for Non-lint Content of Cotton. D2812-81. Annual Book of ASTM Standards, Section 7, Textiles. Vol. 07.02, pp. 626-633.

14. ASTM. 1985b. Standard Test Method for Moisture in Cotton by Oven-Drying. D2495-75. Annual Book of ASTM Standards, Section 7, Textiles. Vol 07.02, pp. 559-565.

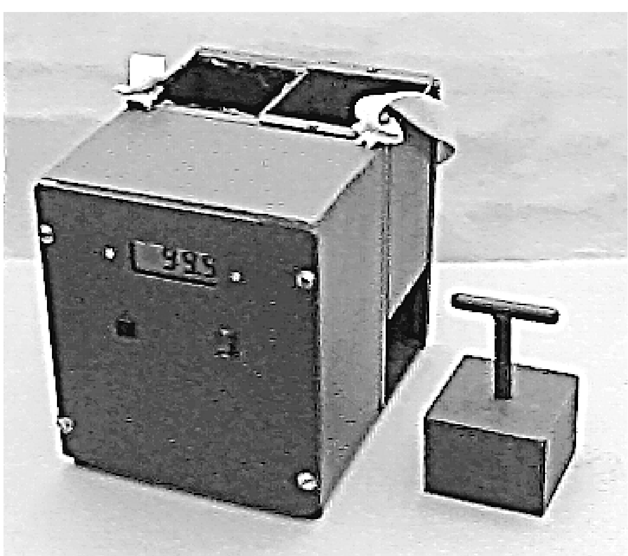

Figure 1. Photograph of the prototype resistance moisture meter

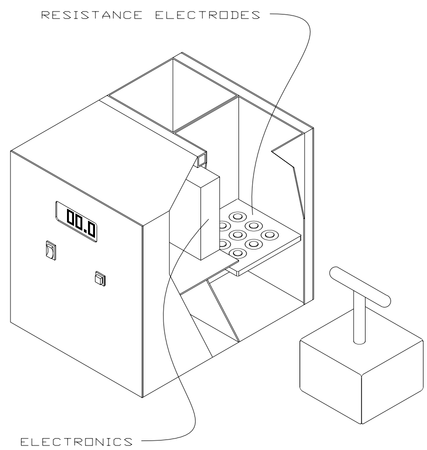

Figure 2. Schematic of the meter, showing the resistance measurement grid and electronics.

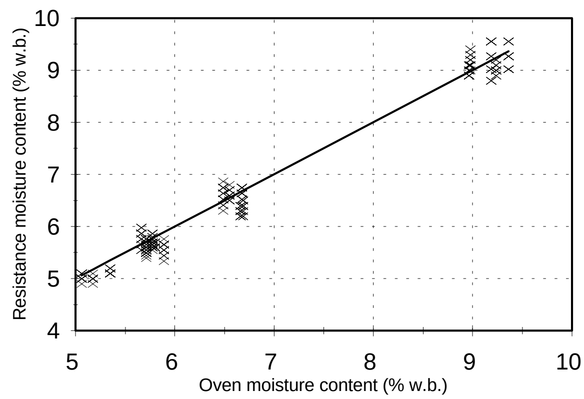

Figure 3. Moisture content as measured by the oven and resistance methods for 320 observations.