UPDATE ON AN AUTOMATED IN-FIELD COTTON LINT MOISTURE MEASUREMENT SYSTEM

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Abstract

Prototypes of two devices to measure the moisture content of cotton in the field were built and data were collected with them. The first device was attached to the chute of the cotton harvester and measured samples while the machine was in use. The second device was attached to the tramper foot of a module builder and collected data while the module was being formed. Both devices show promise in assisting in the management of harvesting and scheduling modules for ginning based on moisture content concerns.

Introduction

Control of moisture during harvesting, storage, and ginning operations is critical to maintaining fiber and cottonseed quality. Resistance-based moisture sensors have been used in gins recently to provide excellent moisture measurements and moisture control (Byler and Anthony, 1996). Application of the resistance-based moisture measurement technology to harvesting and moduling operations would reduce fiber and cottonseed degradation during storage prior to ginning. When used in conjunction with harvesting, moisture measurements aid the farmer in understanding risk factors in terms of the potential for quality degradation due to seed cotton storage at higher moisture contents. Knowledge of moisture during moduling is useful in guiding continued harvesting as well as informing the farmer as to potential damage during storage. Risk assessment can be used to influence the storage time before ginning.

The purpose of this study was to evaluate new field methods to measure the moisture content of seed cotton during harvesting and module building to alert the operator and farmer to adverse conditions.

Procedures

Prototypes of two different measurement devices have been built at the U.S. Cotton Ginning Lab, Stoneville, MS. The first device repeatedly collects a seed cotton sample in a chute of a harvester, presses it against a metal measurement grid, and then releases it after measuring the moisture content (m.c.), Figure 1. This meter has a small computer in the cab of the harvester with a small display and a disk drive. Data are displayed on the LCD display and stored on the diskette for later analysis. For the second device, the measurement grid was fastened to the module builder tamper foot and the device collected data while the module builder was forming the module. One measurement was made each time the seed cotton was compressed. This device also had an LCD display to inform the operator of current conditions and a diskette drive for data storage, Figure 2. Both devices had a keypad so that identifying information could be added to the data file, such as the module number. Anthony and Byler (1998) described both devices in detail previously.

The only design problems in the past have been related to temperature, when the instruments were left in direct sunlight during very warm weather the microprocessor would overheat and stop running. In addition, when the device got very warm the display would become faded and difficult to read. During 1998 the microprocessor boards were replaced with ones which were rated to 85°C (185°F). After this upgrade no further problems were encountered with the microprocessor board. Displays with a higher temperature rating were added, but they could not be read in direct sunlight so the same displays were used as in 1997. As long as the display was kept shaded from the heat of direct sunlight, it remained readable.

Harvester

The m.c. sensor was installed in one chute of a two row harvester. Data were collected while harvesting. After the basket was dumped, nine seed cotton samples were placed in cans and sealed. Enough seed cotton was ginned in the field for nine additional samples of lint and nine samples of cottonseed which were all sealed in metal cans and returned to the lab for m.c. analysis by standard methods (Shepherd, 1972). The mean of laboratory m.c. values for the three samples was used in the analysis. The seed cotton for the lint and seed samples was obtained at the same time as that for the seed cotton samples and was from the same dump from the harvester but may not have been representative of the same cotton in the field. The measurements made while harvesting were identified so that they could be correlated with the samples made after the harvester dump, but it was unlikely that any of the same seed cotton was taken in the samples as was used for the harvester measurement.

Module Builder

The m.c. sensor was installed on a module builder and data were collected during harvest on 9 days between Sept. 16 and Sept. 29. A total of 3179 valid readings were obtained during that time. Periodically the automated tamping was interrupted for sample collection. Three tamps were made in one location for three separate readings of the same cotton. Then three seed cotton samples were obtained from the top of the module, in the same area of the module where it had been tamped, while module building was paused. In addition, samples were immediately ginned in the field to obtain three cottonseed and three lint samples. The seed cotton samples used for the lint and seed samples were

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obtained during the same time period as that for the seed cotton m.c. measurement and was at the same time as the module builder measurement. However, the samples were separate and may not have been representative of the same field seed cotton. The fiber m.c. may have changed while the samples were ginned in the field, even though they were ginned immediately after obtaining them from the module. All three types of samples were returned to the lab for moisture analysis by standard methods (Shepherd, 1972). The average of the three repeat samples was used in the analysis. In the data there were 46 sets of readings at different times.

Results

Harvester

Data were collected on Sept. 30. Three baskets of cotton for which samples were taken and all other periods when samples were not taken were analyzed as four different periods during the day. Table 1 shows descriptive statistics for the data. There was considerable variation in both the electronic and oven based readings themselves and not much variation between data collection periods. Neither of these observations is surprising. When the field readings and the lint m.c. by the oven method were examined, it was concluded that the actual m.c. of the cotton did not change during the day and that both instruments measured the same values within the accuracy possible with the naturally occurring variations in m.c. including those caused by the picker and weather conditions. The only pattern in the data was that all of the m.c. values tended to decrease during the day, which is reasonable, except the lint m.c. by the oven method. The reading of the lint m.c. by the oven method for the second period was lower than would be expected from the other data. This could have been caused by insufficiently random sampling, the standard deviation was also lower than would be expected from the other data. The standard deviations listed in Table 1 were mostly 1.0 or greater. This is considerably higher than would be expected due to the oven test alone and supports the idea that the actual m.c. of the samples varied quite a bit. Based on this data, it was concluded that the sensor produced reasonable data during the test and that there was no evidence that it could not be used for decision making.

Module Builder

During the harvest season the module builder was used for nine days to make 18 modules and made a total of 3179 measurements while personnel from the Cotton Ginning Lab were available for data collection. The number of measurements varied from 228 to 515 per day. This resulted in about 177 m.c. readings per module. Of the 3179 measurements, 132 had reference samples of lint, seed, and seed cotton taken with three repeated readings obtained with the tamper at 46 different times.

Simple descriptive statistics were calculated for the measurements made with reference data available, Table 2 for the 132 measurements of each variable. There was some range in the observed m.c., but none of the cotton would be considered as wet. This harvest season had relatively few days with rain and there was adequate time to harvest with good conditions.

The m.c. measured by the experimental device was used to predict the lint m.c. measured by the oven method using several models by regression. The model:

$$mlint = 0.7404 * mmc \quad (1)$$

where: mlint = the m.c. of the lint measured by oven methods,
mmc = the m.c. measured by the experimental device.

was chosen as the best with a standard error of 0.54. Likewise, the m.c. measured by the experimental device was used to predict the seed cotton m.c. and the model:

$$msc = 0.56 + mmc \quad (2)$$

where: msc = the m.c. of the seed cotton measured by oven methods.

was chosen as the best with a standard error of 0.73. The prediction of seed cotton m.c. is reliable only when the lint and seed are at equilibrium. Finally, the m.c. measured by the experimental device was used to predict the cottonseed m.c. and the model:

$$mseed = 5.04 + 0.506 * mmc \quad (3)$$

where: mseed = the m.c. of the cottonseed measured by oven methods.

was chosen as the best with a standard error of 0.55. The prediction of cottonseed m.c. is reliable only when the lint and cottonseed are at equilibrium. All three of the models were significant at the 0.0001 level or better, meaning that there clearly was a relationship between the m.c. measured by the experimental device and the standard methods. Ideally the slope in equation 1 should have been 1.0. The pressure used in the measurements affects the reading, higher pressure produces higher m.c. readings, and the pressure under the ram in the module builder was probably greater than that used in calibration. This factor may account for the differences in the readings. The analysis showed that after using the equations 1 through 3, the measurements in the field predicted the m.c. measured by oven methods with acceptable accuracy and shows that the device should be able to provide guidance about the expected storage of a module with minimal loss. For example, when equation 1 was used to predict the lint m.c. and the result compared to the oven data for lint, 55% of the two readings were within ±0.4% and 67% were within ±0.5. Precise measurement of m.c. was not necessary for this instrument. A device to assist in management of harvesting and ginning was being tested. One guideline of acceptable m.c. which could be used was 12% (Willcutt et al., 1989). Based on this guideline and equation 2, an indicated m.c. of above 11.4 would be the maximum allowable for long term storage in the module, although m.c. this high was not experienced in 1997 or 1998. This device would provide valuable management information during a ginning season when the weather was less than ideal to allow modules of higher m.c. to be ginned promptly.

Summary

Prototypes of two devices which indicate the moisture content of cotton samples in the field and could be fit to existing harvesting equipment were built and tested. The devices have worked in the field for two years, in limited testing. Both devices need a display which can be read in direct sunlight in August across the Cotton Belt, but are otherwise acceptable for field use. The data obtained with them was accurate enough to provide valuable guidance in the scheduling of harvest and ginning operations based on the m.c. of the harvested cotton.

References

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Table 1. Descriptive statistics of the moisture content (m.c.) data in percent wet basis collected on the harvester.

Period	Variable	Number of observations	Mean of readings	Standard deviation
1	Measured lint m.c.	147	7.9	1.0
	Oven lint m.c.	9	7.4	1.0
	Oven seed cotton m.c.	9	10.8	1.8
	Oven cottonseed m.c.	9	11.7	0.7
2	Measured lint m.c.	171	7.1	1.0
	Oven lint m.c.	9	5.9	0.5
	Oven seed cotton m.c.	9	9.8	1.2
	Oven cottonseed m.c.	9	10.5	0.8
3	Measured lint m.c.	164	6.4	0.9
	Oven lint m.c.	9	7.4	1.1
	Oven seed cotton m.c.	9	9.5	0.9
	Oven cottonseed m.c.	9	9.6	0.4
Other	Measured lint m.c.	105	6.8	1.4

Table 2. Descriptive statistics for the moisture content (m.c.) measurements in percent wet basis made with reference data for the module builder meter of 132 values.

	Mean	Standard deviation	Minimum observed	Maximum observed
Lint m.c. by experimental sensor	7.45	0.76	5.8	9.5
Lint m.c. by oven method	5.51	0.82	4.0	7.3
Seed cotton m.c. by oven method	8.00	1.06	5.8	10.8
Cottonseed m.c. by oven method	8.82	0.67	7.2	10.4

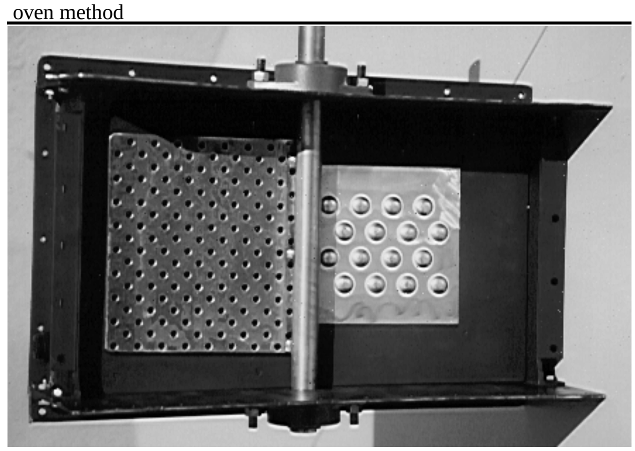

Figure 1. The cottonseed sampler and moisture measurement grid which was located in one chute of the harvester.

Figure 2. The display and data logger were located in box in center of the figure on the module builder.