POTENTIAL METHODS OF MEASURING BALE MOISTURE CONTENT AT THE GIN

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Abstract

Interest has grown in the past few years in controlling the amount of moisture added to lint in a cotton gin after it has been ginned. Accurate and reliable measurement is necessary in order to control a process. Several experimental installations were made in three gins and operated during the 2000-ginning season that measured the moisture content (mc) of fiber after moisture addition. Four methods of measuring mc were examined. Resistance-type moisture measurements were made at the lint charger, tramper, and bale pusher near the bale press. Bale weight and force measurements were made during bale compression.

Introduction

Interest in adding moisture to lint after it is ginned has grown over the past few years. Until recently only a small amount of moisture could be added to the lint, which was already fairly dry, so control of the moisture addition was not much of an issue. In more recent years, equipment has become available which is capable of adding more moisture than before and gins have placed more emphasis on ginning at higher moisture content (mc) levels. This combination has created a situation where control of the moisture addition is essential. No process can be controlled which cannot be measured so a system to accurately measure the mc of lint after the moisture addition is needed. The moisture is added before it reaches the lint slide, so the mc could possibly be measured as the bale is being formed or soon after it is formed. A reliable and accurate bale mc sensor could be used for feedback to automatically change the control settings of the device that provides the moist air or could be used as an indicator that the ginner would use to optimize the settings. For control of the moisture addition, multiple readings per bale would be preferred to one reading per bale and the sooner the measurement is made after the moisture addition the better.

A resistance-based lint mc sensor developed by the Agricultural Research Service (Byler and Anthony, 1995; Byler and Anthony 1997) has been used for several years with the "Intelligin" gin control system marketed by Zellweger Uster, Inc. This sensor has been used successfully to control the drying performed in gins and has been reliable and accurate when installed and used correctly. Each resistance-based mc sensor used in this project consisted of multiple stainless steel strips embedded in a plastic base and connected to appropriate electronics. The resistance between these strips while they were pressed against the cotton sample indicated the sample mc.

The relationship between bale formation forces, bale density, and lint mc has been documented by Anthony and McCaskill (1973) and is described in the Cotton Ginners Handbook (Anthony et al., 1994). If the bale formation force required to achieve a known bale density is known then the relationship can be used to estimate lint mc.

The purpose of this project was to explore different methods of measuring the mc of cotton in the gin after moisture restoration and to develop an understanding of the difficulties associated with making this measurement.

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Methodology

The three gins chosen for installation of the experimental equipment were: Burdette Gin near Leland, MS; McClendon, Mann, and Felton Gin (MMF) near Marianna, AR; and Rolling Hills Gin near Albemarle, NC. All three gins had equipment for adding moisture to the ginned lint. Burdette Gin had a Samuel Jackson Lint Slide Grid system, Rolling Hills Gin had a Consolidated Moisture Restoration Condenser, and MMF had a Samuel Jackson Steamroller, Figure 1. The resistance-based moisture measurement devices were installed in three locations in each gin; in the bale charging area, on the foot of the tramper, and on the plate that pushes the bale into the bag and onto the bale scale. Each gin also had a hydraulic pressure transducer added to the bale press ram and included digital communication of the bale weight from the bale scale to the data-logging computer.

The resistance-based lint mc sensors, which had no internal memory, were controlled and read directly by the data-logging computer. So, they needed considerable attention from the data-logging computer for the period of time (up to 2 seconds) while each was actually making a measurement. One of these units was installed in the door of the charging area of the press so that lint was pressed against it between strokes of the tramper while ginning. A different portion of the lint forming the bale was measured on each cycle of the charging ram. This unit was connected to the data-logging computer through a cable that supplied power to the sensor and received signals from the sensor that the logging computer then converted to estimates of the mc of the lint based on calibration with well-conditioned lint. Figure 2 shows the lint charger moisture sensor from the inside of the box and Figure 3 shows the same sensor from the outside.

A second resistance-based mc sensor was attached to the foot of the tramper so that good contact would be made with a different portion of the bale on each stroke of the tramper, at least after a reasonable amount of lint had been placed in the charge box. Figure 4 shows the arrangement of this sensor on the tramper at MMF. A hydraulic pressure sensor was added to the system and connected to the logging computer so that the pressure of the tramper on the cotton could be estimated for each tramp. All three of the gins had hydraulically powered trampers. These sensor units were also connected by a cable to the data logging computer, however in this case the sensor moved nearly continuously, so additional attention had to be paid to the installation and quality of the cable.

The third location for the resistance-based sensor was on the surface that pressed against the bale when it was pushed through the bagger and onto the bale scale. The arrangement of this sensor is shown in Figure 5 and Figure 6 shows this device in contact with a bale. This unit was capable of making several measurements while the bale was being transported, each measurement requiring no more than 2 seconds. But the repeated measurements were made on one portion of the lint in the bale unlike the other two approaches, which measured different portions of the bale during bale formation. The cable from this sensor to the data-logging computer was not subject to as frequent or as rapid motion as the cable for the tramper unit, but was longer and had to move a greater distance.

Data were also collected and recorded of the pressure exerted on the bale of cotton while it was being pressed. An electronic pressure transducer was installed on each bale press system to measure the ram pressure. Each gin had existing equipment to measure the bale weight, which was sent to the data logging system for use in mc determination. Estimates of the bale mc were then made from these two measurements.

A data-logging computer, Figure 7, was installed in each gin to control the data collection from the various sources, convert the raw data into estimates of the lint mc, and to record the data. One program residing on the data-logging computer controlled the process. The maximum pressure in forming the bale was needed, and that pressure only occurred for a short period of time per bale. Therefore, the highest priority of data collection was to record the highest pressure. When the system received a signal that the ram had started to press a bale other measurements were halted and 10 pressure measurements were made each second to get a pressure at or near the maximum. The next highest priority was to measure the resistance mc from the device pushing the bale onto the scale. If neither of these processes was occurring, the data-logger focused attention alternately on the charger and tramper mc measurement. The bale weight was received on the serial port and that data could be stored in a buffer, which was be read at a convenient time.

The equipment was installed soon after the start of the ginning season in each gin and operated until the end of the season. Data were downloaded from the data-logging computer periodically and examined. Samples of lint were taken manually from selected bales, placed in sealed metal cans, and the mc determined by the oven method as described by Shepherd (1972). These data were then compared to the measured data and the measured data were used to predict the oven mc data using SAS (1999) software by regression.

Results

At Burdette Gin data were collected from Sept. 15 through Nov. 3, 2000 pertaining to over 24,000 bales. At MMF data were collected from Oct. 11 through Nov. 21, 2000 covering over 30,000 bales. At Rolling Hills Gin data collection was begun on Oct. 3, 2000 and on the date this progress report was written they had not finished ginning for the season. Lint samples from individual bales were collected on several dates between Sept. 18 and Nov. 3 at Burdette Gin, between Oct. 12 and Nov. 21 at MMF, and on Oct. 26 and 27 at Rolling Hills Gin. Table 1 shows a summary of the results of the oven determination of the mc from these samples.

One of the interests of the project was to develop a method that would operate reliably in a cotton gin. All devices worked throughout the season at Burdette Gin and at Rolling Hills Gin. At MMR a minor cabling problem was encountered with the bale pusher sensor. No other equipment failures were encountered. Further data analysis will be completed after the end of the ginning season.

Summary

Several systems were installed in three separate gins to examine the reliability and accuracy in determining the lint moisture content of cotton bales in gins with moisture restoration systems. All methods proved to be acceptable as far as reliability was concerned. A considerable amount of data has been collected but data analysis could not be done adequately in time to report on the device accuracy.

Disclaimer

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U. S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

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Table 1. Summary of results of analysis of the moisture content of samples from individual bales determined by the oven method.

		Measured moisture content			
Name of gin	**Number of observations**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Burdette	1178	4.90	0.59	3.35	6.70
McClendon, Mann, and Felton	735	5.09	0.47	3.60	6.85
Rolling Hills	43	6.68	0.99	4.88	9.19

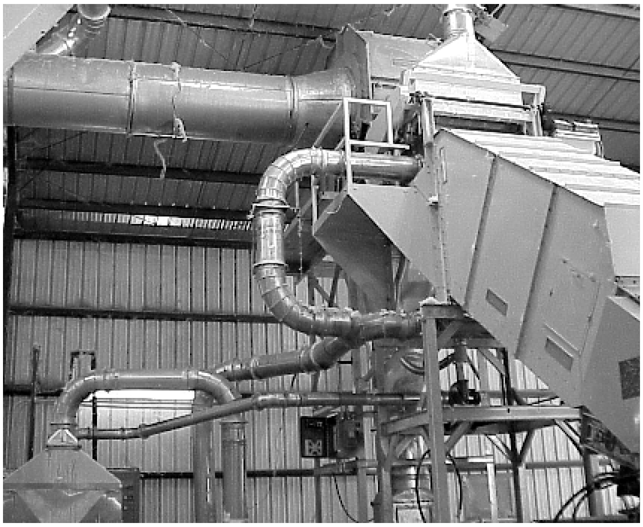

Figure 1. Moisture restoration system at McClendon, Mann, and Felton Gin.

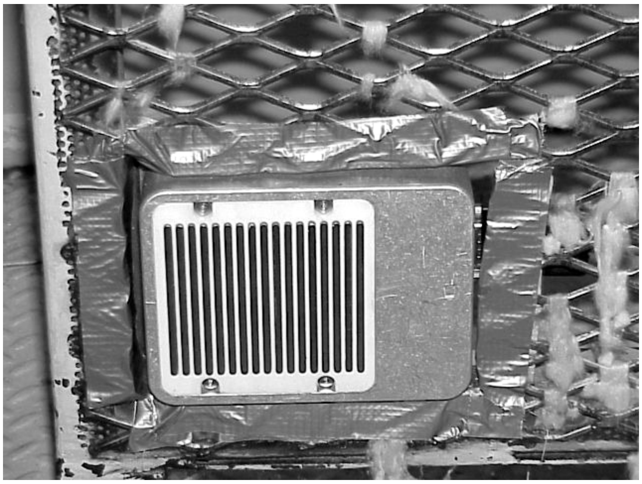

Figure 2. Inside view of resistance-based moisture sensor located in the lint charger at Burdette Gin.

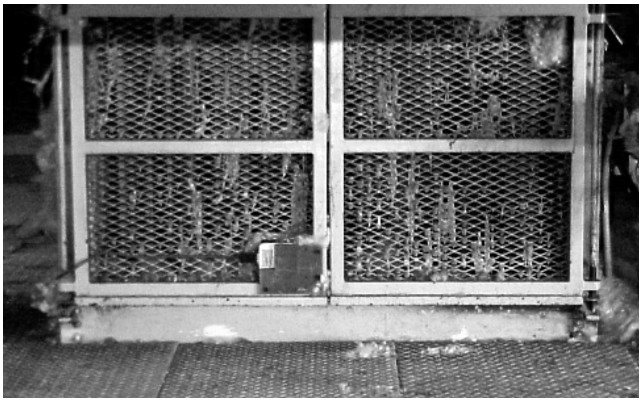

Figure 3. Outside view of the charger moisture sensor at Burdette Gin.

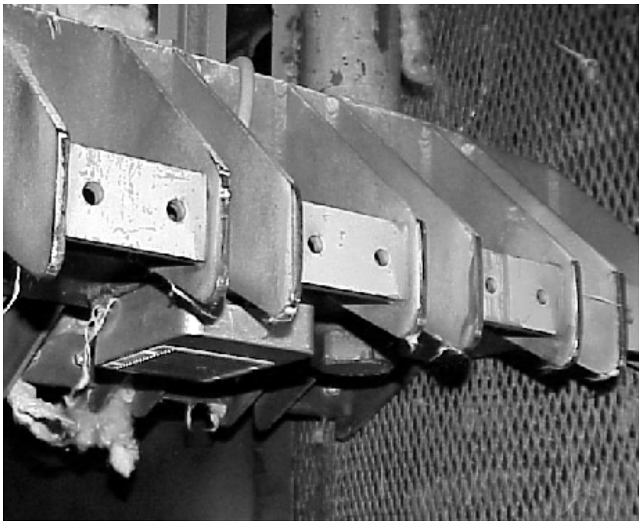

Figure 4. Lint moisture sensor attached to tramper at McClendon, Mann, and Felton Gin.

Figure 5. Bale pusher with moisture sensor at Burdette Gin.

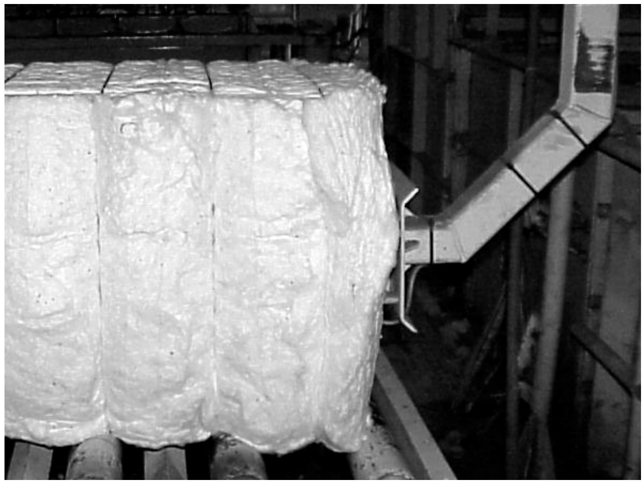

Figure 6. Bale pusher with moisture sensor in contact with a bale at Burdette Gin.

Figure 7. Data logger and cable interface at McClendon, Mann, and Felton Gin.