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BALE MOISTURE ADDITION WITH A ROTOR SPRAY SYSTEM

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Abstract

Tests were conducted using a rotor spray system to apply moisture in the form of fine water droplets to cotton lint at the lint slide just before bale packaging. Initial cotton moisture content ranged from 5.0 to 5.5%, dry basis. Bales in this study were stored for 6 months and cotton quality degradation determined after each of these storage periods. Five levels of moisture addition were studied, including 6.3, 6.5, 7.0, 7.7, and 7.9 % moisture (after rewetting), in addition to bales with no additional moisture added. No significant changes in micronaire, strength, or color Rd were found. At moistures of 7.5% and greater, the color +b value decreased slightly and the decrease was statistically significant. When considering the moisture range used in this study, results are consistent with earlier studies.

Introduction

Systems have been in use for several years that use humidified air to restore moisture to baled cotton that was previously removed by drying in order to enhance the cleaning of seed cotton. Recently, water spray systems have been developed that use a water mist to restore moisture. Humidified air systems have been designed to be self-limiting in the amount of moisture added, making it difficult to exceed safe moisture levels for cotton storage. However, the spray systems are not self-limiting. Without careful management, cotton may be baled at moisture levels that will result in quality degradation during storage.

There are two basic types of spray systems that can be considered for use. An atomizing spray system uses fixed nozzles and pressurized water flow through a calibrated orifice to produce a mist of water droplets that can be as wide as the lint slide. A rotor spray system uses pressurized water flow through a larger orifice to control flow rate followed by the stream of water falling on a rotating disk which produces the water droplets. The droplets are sent in all directions, and a gated system is used to control the direction of the spray leaving the system, while the remainder of the spray is collected and recirculated. The gate system is used to quickly turn the spray on and off. In the system used in this study, the disks produced a spray stream that was about 4 inches wide. Although both rotor spray systems and atomizing nozzle spray systems add moisture as water droplets, a rotor spray system will generally apply moisture more uniformly across the width of the lint slide, and will produce a finer droplet size than would an atomizing nozzle system. However, rotor spray systems have more moving parts, and must mount closer to the lint batt as compared to an atomizing nozzle system. Both spray systems produce a fine water mist that does not penetrate the lint batt nearly as well as steam.

Moisture addition may be used to reduce problems associated with static electricity and to reduce the pressure needed by the bale press, resulting in energy savings. With a spray system, care must be used so the spray does not wet any part of the lint slide, because cotton will immediately stick to wet metal. The interruption of flow results in slugs of cotton that can cause machinery to choke and stop.

The objective of this study was to determine the effect that bale moisture addition using a rotor spray system had on fiber quality after a six month storage period and to determine an acceptable bale moisture range (within 0.5%) which would avoid any quality degradation, based on HVI results.

Materials and Methods

Seed cotton used in this study was a Delta and Pine Land upland variety that had been grown under normal production practices and harvested in good condition. All cotton for this study came from the same field and was harvested during the same timeframe and without excess moisture. Proper module storage conditions were followed and little, if any, quality degradation occurred between harvest and ginning.

Samples were ginned at the USDA, ARS, Southwestern Cotton Ginning Research Laboratory, Mesilla Park, New Mexico, on a Continental 93 gin stand at a rate of approximately 6 bales per hour. Seed cotton cleaning consisted of a 6-cylinder cleaner – stick machine – 6-cylinder cleaner combination. No seed cotton drying was done. Lint moisture content was approximately 5.0% before any additional moisture was added. One lint cleaner was used.

A Weko rotor spray system was installed at the top of the lint slide and used to add water droplets to the top of the lint batt in order to increase the average moisture content. The Weko system uses spinning discs to create a water spray and a slide gate to control where the spray is applied. Water that doesn't pass through the gate is re-circulated within the spray pump and line system. The system was calibrated by catching the spray during a 2 minute time period and calculating the average flow rate.

Two tests were conducted, one with ginning and moisture restoration in October 2003 and 6 months of storage and another with ginning and moisture restoration in December 2003 and 13 months of storage. For the test begun in October 2003, a control treatment with 5% lint moisture was used along with target moisture levels of 6.5, 7.0, 7.5, 8.0, and 8.5%, requiring the addition of approximately 7.2, 9.6, 12.0, 14.4, and 16.8 pounds of water, respectively, to a target bale weight of 480 pounds. For the test begun in December 2003, lint moisture was 5.9% before moisture restoration and treatments with target moisture levels of 8.0, 9.0, and 11.0% were used, requiring the addition of approximately 10.1, 14.9, and 24.5 pounds of water, respectively, to a target bale weight of 480 pounds. All treatments had 3 one-bale replications.

Immediately after ginning, bales were tied with steel bale ties and were placed in 6-mil polyethylene bags and vent holes were covered with strips of clear plastic tape. Open bag ends were sealed completely with duct tape. This was done to limit moisture loss or gain during the storage period.

Moisture samples were collected from the lint cleaner and the lint slide during gin tests. Two samples were collected from the lint cleaner during each test in order to determine the lint moisture of each test before any moisture restoration. Four samples were taken during each test from the lint slide after moisture restoration. These were hand-grabbed from a point approximately one-third of the way in from the edge of the lint slide. Care was taken so that the hand-grabbed sample included lint all the way through the batt, and that the amount throughout the batt thickness was nearly uniform. Samples were placed in sealed cans and lint moisture was determined using an air oven procedure based on weight change during two hours at 220^{o}F. Moisture tests were run in the same day as they were collected.

Samples for USDA, AMS high volume instrument (HVI) analysis and classification were collected from the lint slide during gin tests. One sample from each test was collected and placed in a plastic bag for storage. Samples were held at the collection site until all samples were collected and could be shipped together for analysis.

Upon completion of the four consecutive days of ginning tests in October 2003 and the three consecutive days of ginning tests in December 2003, bales were shipped from the USDA, ARS, Southwestern Cotton Ginning Research Laboratory in Mesilla Park, New Mexico, to the USDA, ARS, Cotton Quality Research Station in Clemson, South Carolina, by truck. Therefore the majority of the storage period was in Clemson.

Bales from the October 2003 test were stored for six months and opened in April 2004. As each bale was opened, it was divided into 10 layers (figure 1) and 1 sample from each layer was randomly selected among the 14 openings in a template (figure 2). One moisture sample was run from each layer. One composite sample for each bale was submitted for HVI analysis and classification. Microbial and spinning tests were also done on the fiber and are reported on by Chun and McAlister (2005).

Figure 1. Photo showing a bale immediately after opening with the 10 sampling layers marked.

Figure 2. Photo showing the template used to specify 14 locations within each layer from which 1 sample was randomly selected for each layer.

Bales from the December 2003 test have been stored for 13 months and are scheduled to be opened shortly. Therefore, data for those tests is not yet available.

Results and Discussion

Moisture content of the ginned lint cotton showed some variability over time. Initial samples taken to determine the settings for the rotor spray system during each test showed a lint moisture of 5.1%. However, moisture content of the three control bales (no moisture added) averaged 5.6, 5.1, and 4.5%. The range of moisture for these individual bales was 0.2 percentage points. Although the variability was greater than desired, the results were not greatly affected.

Moisture contents of the cotton bales with restored moisture were slightly below the target values (table 1). For the target moisture levels ranging from 7 to 8.5 %, the moisture content measured by averaging 4 samples was 0.5% below the target value. This could be due to variation in the lint moisture from the expected value of 5.1%, to variation in the ginning rate from the expected value of 6 bales per hour, or due to evaporation of the water droplets from the spray system and lint before packaging into the bale. The range of moisture within samples from each individual bale ranged from 1 to 2 percentage points, with a greater range for the bales with higher moisture. Moisture loss from the polyethylene-wrapped bales during the six month storage period ranged from 0.5 to 1 percentage points for the bales that had moisture added to them at ginning. The range of moisture among the 10 samples taken from each bale after storage was about 1 percentage point in all cases.

Table 1. Moisture content (dry basis) of bale at ginning and after 6 months of storage.

Target moisture, %	Moisture content before bale press, %		Moisture content after storage, %	
	Average	Range	Average	Range
5.0	5.1	4.4 – 5.7	5.2	4.6 – 6.0
6.5	6.3	5.5 – 6.6	5.8	5.5 – 6.1
7.0	6.5	5.9 – 7.3	5.9	5.4 – 6.6
7.5	7.0	6.2 – 7.6	6.0	5.4 – 6.5
8.0	7.5	6.1 – 8.7	6.7	6.1 – 7.1
8.5	7.9	6.5 – 8.2	6.7	5.5 – 6.9

Micronaire data showed no significant differences from the 3.9 average value (table 2). Individual samples showed no more than a 0.1 difference from the average reported in the table. A similar study by Hughs et al. (2004) reported differences in micronaire values after a six month storage period for bales with moisture added. Closer examination indicated that the differences they reported were significant only when the bale moisture was 10% or above. Since the bale moisture in this study was 8% or less, the results here are consistent with those reported by Hughs et al.

Table 2. Average HVI micronaire and strength data from samples collected at ginning and after 6 months of storage.

Moisture at bale press, %	Micronaire at ginning	Micronaire after storage	Strength at ginning	Strength after storage
5.1	3.9	3.8	29.0	27.8
6.3	3.9	3.9	29.2	28.1
6.5	3.9	3.9	29.3	28.4
7.0	3.9	3.8	29.3	28.7
7.5	4.0	3.9	29.1	28.9
7.9	4.0	3.9	28.3	28.5

Strength data showed no significant differences occurring as a result of storage (table 2). The variation in strength values among bales with the same treatment was 1 to 1.5 grams/tex, so the small differences seen in the table were not statistically significant. This result agrees with that reported by Hughs et al. (2004).

Color Rd, percent reflectance, data showed no differences occurring as a result of storage (table 3). All treatment averages were 81 with individual values ranging from 80 to 82 percent reflectance. A similar study by Hughs et al. (2004) reported differences in color Rd values after a six month storage period for bales with moisture added. They found that reflectance decreased (color darkened) for bales with added moisture after six months of storage. Closer examination indicated that the differences they reported were significant only when the bale moisture was 10% or above. Since the bale moisture in this study was 8% or less, the results here are consistent with those reported by Hughs et al.

Table 3. Average HVI color Rd and +b data from samples collected at ginning and after 6 months of storage.

Moisture at bale press, %	Color Rd at ginning	Color Rd after storage	Color +b at ginning	Color +b after storage
5.1	81	81	8.0	8.1a
6.3	81	81	8.1	8.2a
6.5	81	81	8.0	8.3a
7.0	81	81	8.2	8.2a

7.5	81	81	8.1	8.9b
7.9	81	81	8.1	8.8b

Color +b, or yellowness, data showed a slight increase in yellowness in some samples occurring after six months of storage (table 3). Variation among bales with the same treatment 0.2 to 0.5 units and the increase in yellowness was statistically significant at 7.5% moisture and above. The small color change would generally not be noticeable after bleaching of the fiber. These color changes are consistent with expectations resulting from the study of Nickerson and Tomaszewski (1959) who reported that cotton lint will yellow when exposed to high humidity and temperatures over 50°F during prolonged storage. Results here are consistent with those of Hughs et al. (2004) who reported that cotton bales with increased amounts of added moisture showed a progressive increase in yellowness.

A microbial analysis and spinning tests were also conducted from cotton in this study. Results of these analyses can be found in Chun and McAlister (2005).

Summary

Tests were conducted using a rotor spray system to apply moisture in the form of fine water droplets to cotton lint at the lint slide just before bale packaging. Initial cotton moisture content ranged from 5.0 to 5.5%, dry basis. Bales in this study with results reported herein were stored for 6 months and cotton quality degradation determined after each of these storage periods. Five levels of moisture addition were studied, including 6.3, 6.5, 7.0, 7.5, and 7.9 % moisture (after rewetting), in addition to bales with no additional moisture added. These moisture levels are averages of samples collected from the lint slide and were slightly less than the target moisture levels of 6.5, 7.0, 7.5, 8.0, and 8.5 %, respectively.

No significant changes in micronaire, strength, or color Rd were found. At moistures of 7.5% and greater, the color +b value decreased slightly and the decrease was statistically significant. When considering the moisture range used in this study, results are consistent with earlier studies. Ginners should note that when using a spray system, an increase in yellowness would be expected for samples stored in polyethylene bags at moistures of 7.5% and higher for storage periods of 6 months or more.

Disclaimer

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References

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