PRELIMINARY RESULTS FROM MOISTURE ADDITION DURING GINNING

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Abstract

Research results over the years have shown that fiber quality is improved when lint moisture content at the gin stand is in the range 6 to 7 percent wet basis. However, under many conditions lint is drier than that when it arrives at the gin. This paper describes preliminary results of using the equipment normally considered to be the second stage of drying in the gin to humidify the seed cotton rather than dry it. The test resulted in higher lint moisture levels before and after the lint cleaners and also improved fiber quality properties from AFIS measurements of samples obtained while ginning.

Introduction

The moisture content (mc) of the lint portion of seed cotton substantially affects its ability to withstand the forces of ginning and also affects the ease with which trash is removed from the seed cotton (Anthony, 1990). Cotton gins use drying systems to reduce the seed cotton mc before cleaning and ginning. In general, drier seed cotton is easier to clean; however, drier cotton lint is more susceptible to damage during ginning and cleaning (Hughs, Mangialardi, and Jackson; 1994). The damage is revealed by higher short fiber content and more fiber neps. The overall quality of fiber produced by gins would be improved if the moisture control system were able to add moisture to the lint as well as take it out. The optimum mc for fiber seed separation is 6.5 to 8 percent wet basis (Griffin, 1977) or even higher (Moore and Griffin, 1964); however due to the reduced cleaning efficiency the optimum mc for ginning is considered to be in the range from 6-7 percent wet basis (Hughs, Mangialardi, and Jackson; 1994).

The ideal moisture control system would be able to monitor the lint mc and dry the lint if needed, leave the lint mc unchanged if it came to the gin in the optimal range, and add moisture to the lint if it came to the gin dryer than optimal. The capability for the gin to add moisture is called "moisture restoration" and is described and supported in both the older Cotton Ginners Handbook (Griffin, 1977) and the current version (Hughs, Mangialardi, and Jackson; 1994). Most current mc control systems are capable of only drying lint that comes to the gin at higher than optimal mc.

The purpose of this work was to determine if significant differences in measured lint mc can be achieved after ginning and lint cleaning by conditioning the seed cotton with moist air in what is normally the stage two drying equipment as well as examining the effect of the conditioning procedures on fiber quality.

Methodology

A commercially available device, a Samuel Jackson Humidaire unit, was reconfigured so that it would produce either warm dry air for drying, or warm moist air for moisture restoration. The air from the Humidaire unit was used to pick up the cotton after the stick machine after which it went through a tower drier and was separated from the seed cotton in a cylinder cleaner.

A thermocouple-based temperature indicator was installed at the exhaust of the second cylinder cleaner to better monitor conditions. The thermocouple normally used to control the second stage burner was not used for temperature control but was connected to an additional indicator, and the indicated temperature recorded to produce additional data regarding the conditions. Control of the air temperature produced by the moisture-conditioning unit was based on a thermocouple located in the duct ahead of the mix point. Control of the stage one drying was based on a thermocouple located in the top of the tower drier.

Tests were run on two separate days with two moisture treatments each day. Each day six bales of cotton were ginned based on approximately 1450 pounds of seed cotton. Three of the bales were ginned while conditioning the seed cotton in the second tower dryer with warm dry air and three were ginned while conditioning the cotton in the second tower dryer with moist warm air. One trailer of cotton was used each day. The BXN47 cotton on the two trailers was believed to be uniform, because it was all planted on the same day, harvested on the same day (October 4, 1999), and grown in the same field at Stoneville, MS.

The two treatments were to use either heated air or humidified heated air in the stage two drying system. The stage 1 control was set to 160°F at all times. If the water temperature controller was used it was set at 92°F. For the dry air treatment the stage 2 pre mix set point was 140°F, and for the moist air treatment it was set at 98°F. The humidaire settings were lower than normally used in conditioning lint and the resulting air carried much less moisture than could be carried with higher settings.

Seed cotton samples were taken at the feed control. Lint samples were taken between the gin stand and the lint cleaner and also at the lint slide for determination of mc and fiber quality. The mc of the lint samples taken at the two locations were determined by the oven method (Shepherd, 1972).

The time to gin each bale was measured and the average was 10.05 minutes per bale. No differences were detected by ANOVA by day of test or treatment. The average ambient temperature during the first test day was 60°F and was 63°F the second day. The average ambient relative humidity was 77% the first test day and was 60% the second test day.

Results

Tests were run with a pitot tube and manometer to estimate the air flow in the system without cotton. The airflow in the seed cotton conveying system was measured to be from 3400 to 4900 ft/min, which was estimated to be adequate for running the test.

Table 1 shows the mean of the temperature readings taken while running the tests, separated by the day of the test and test treatment. The stage one after mix temperature average was within one degree F of the set point. The stage two average air temperature was within one degree F of the set point and the average water temperature was the same as the set point.

The lint mc data were analyzed by the SAS procedure MIXED (SAS Institute Inc., 1999) with the location of sampling, the test day, the treatment, the order of the sample in the series taken for each bale and all combinations used to predict the mc data. The individual variables as well as the location by day and location by treatment interactions were statistically significant. Table 2 shows a summary of the analysis of variance.

The overall mean lint mc was 5.6 for the first test day and 5.2 for the second test day. The mc mean was 4.7 for the low moisture treatment and 5.8 for the high moisture treatment for both days and both locations. The mean mc for the samples taken from behind the gin stand was 5.2 and the mean for those taken at the lint slide was 5.5. None of these mc means were as high as the minimum recommended mc, 6.0, but with the higher mc treatment on the second day the mc levels approached the minimum and

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with the higher mc treatments individual samples were above the minimum on both days.

The means of the mc readings from the eight sampling periods during each bale being tested is shown in Table 3. The standard error for these means was 0.08, therefore, some of the means were significantly different from others in a statistical sense. However, these differences were very small and were not considered to be significant in damage to fiber. A pattern in the means, such as consistently increasing or decreasing mc readings while the test was being run, would show that the conditions were not well controlled, but no such pattern was observed. An interaction between the sample order and the treatment would also be an indication of poorly controlled conditions, but this interaction was not statistically significant. Therefore, even though the means were different in a statistical sense, the differences were not important to the test. Of course, the sample order will be considered when examining the lint damage data to see if any significant differences were observed in those data.

The means of the mc readings showing the interaction between day of test and location of sampling are presented in Table 4. The mc readings were higher on the first day, with the higher RH, than on the second day. The mc was higher at the lint slide than between the gin stand and lint cleaners in all cases, but the difference was greater on the first day than the second test day.

The means of the mc readings showing the interaction between the treatment and the sampling location are shown in Table 5. The interaction is shown in the differences between the columns (or rows) not being approximately equal. The lint gained more moisture between the two sampling locations for the drier treatment than for the higher moisture treatment. Also when comparing the two sample locations, the samples obtained behind the gin stand had gained more moisture for the low mc treatment than for the higher mc treatment, compared to those obtained at the lint slide because of the greater moisture gradient relative to the air. Both of the interactions that were significant make sense, physically, but the differences in mc were not large. The mc levels were higher at both sampling locations with the high moisture treatment.

Table 6 shows the results of analysis of the AFIS data for the 192 samples for lint properties. Table 7 shows the results of analysis of the AFIS data for the 192 samples for non-lint properties. The location where the samples were obtained, the treatment, the day of the test, and the order the sample was taken per bale and all interactions were used to model each of the listed parameters with the SAS procedure MIXED. Tables 6 and 7 show the means of the data obtained at each of the two locations, and for each of the two treatments. These means are marked if they differed from each other with a probability greater than 0.05% or 0.01%. In addition, any of the other parameters or parameter interactions which were significant at the 0.05% level or lower are listed.

As can be learned from Tables 6 and 7, most of the parameter means differed by location of sampling, which we would expect because two lint cleaners in series were used between the sampling locations. For example, both the AFIS fiber length by weight and by number were decreased by the use of the two lint cleaners, regardless of the moisture treatment. The AFIS nep size and count were affected by the lint cleaners, but the seed coat nep size and count were not affected. The low/high moisture treatment also significantly affected the fiber length by weight and by number. Several of the trash parameters were not significantly affected by the treatment, but the total trash count was affected with more trash in the samples taken during the higher humidity treatment.

The day of the test was significant for almost every measurement, even for measurements for which the treatment was not significant. The mc of the fiber was different between the two days and the interaction between day of the test and the treatment was significant, so the mc of the fiber could account for much of the significance of the day in this data. However, because the trash measurements were significantly affected by the day of test, but many measurements were not affected by the treatment, it is likely that there were significant differences in the cotton itself in the two trailers of cotton ginned on the two days that caused the significant effect of day.

For the most part, the order that the samples were collected was not significant (labeled as sample in tables 6 and 7), so the fact that there were significant differences in the mc by sample collection order apparently did not affect the quality of the fiber. The treatment*sample interaction was significant only for short fiber content by weight and number. If this interaction had been significant it would have been an indication that conditions may not have been controlled as well as would be desired. The relatively few parameters for which sample and other interactions with sample was significant supported the conclusion that conditions had been adequately controlled.

When the data from the classing office was examined with ANOVA, no significant differences were observed in the data due to moisture treatment. The HVI color values of Rd and +b and the length values of uniformity and fiber length in 100ths of an inch were all significantly different between the two days of the test. These differences relating to the day of the test support the idea that the cotton tested on the two days was somewhat different. The fact that no statistically significant differences were detected in the classing office HVI data is explained by the relatively small differences caused by the mc treatment and the limited number of samples involved. In the AFIS data there were 120 cotton samples that were each measured three times resulting in 360 readings for the entire test. For the HVI data, 12 samples were sent to the classing office with one measurement available for each sample. The considerably greater number of measurements available from the AFIS testing allowed smaller differences to be detected as significantly different. As an example, the HVI length was estimated statistically from the 12 readings for the two treatments with an estimated least significant difference of 0.018 inches. A similar length measurement from the AFIS data would be the length by weight in inches that was estimated from the 360 readings with a least significant difference of 0.004 inches, or more than four times more accurately.

Research data over the years has shown that ginning at mc levels within the recommended range produces cotton of higher quality than ginning at lower mc. During some periods of time during certain years seed cotton drying is required, but much of the time lint is drier than the recommended level when it arrives at the gin. In the past equipment that would accurately measure and control the seed cotton fiber mc was generally not available. However, equipment is now available which would allow gins to control the mc of the fiber, not simply control the drying of the fiber. After additional work is completed to more completely describe the operational parameters of the system, gin managers should consider the benefit of ginning at higher mc. If economics allow, gins should then install moisture control equipment that will result in improved fiber quality.

Conclusions

The equipment was adequate to change the conditions of the air in the second tower drier, which allowed tests of moisture conditioning rather than only drying in this portion of the gin system.

The procedure produced lint of significantly different mc so that the effects of ginning at two levels of mc on fiber quality could be measured.

Although the moisture level differences in the samples were not great, the fiber quality measurements resulted in significantly better fiber length properties when the higher humidity air was used in conditioning. Trash levels were generally unaffected by the conditioning process although the trash levels tended to be higher with the higher moisture treatment.

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. Means of measured temperatures (°F) at specified locations and periods of the test.

	First test day		Second test day	
	Dry air	Moist air	Dry air	Moist air
Stage 1 pre mix	194	195	191	193
Stage 1 after mix	159	159	159	159
Stage 2 water	-	92	-	92
Stage 2 pre mix	141	98	141	98
Stage 2 after mix	125	101	127	101
Stage 2 exit	96	88	98	90

Table 2. Analysis of variance of the measured moisture content data for the lint.

Source of variation	F value	Probability of larger F
Day	5.87	0.0417§
Treatment	33.63	0.0004†
Location	64.47	<0.0001†
Sample	2.61	0.0158§
Treatment*day	0.04	0.8486
Location*day	10.37	0.0126§
Treatment*location	13.71	0.0062†
Sample*day	0.24	0.9750
Treatment*sample	0.17	0.9907
Location*sample	1.67	0.1248
Treatment*location*day	0.75	0.4119
Treatment*sample*day	0.35	0.9293
Location*sample*day	0.46	0.8582
Treatment*location*sample	0.30	0.9515
Treatment*location*sample*day	0.60	0.7534

§ Probability of greater F less than 0.05% but greater than 0.01%
† Probability of greater F less than or equal to 0.01%

Table 3. Means of mc measurements based on the order that the sample was taken.

Sample order	1	2	3	4	5	6	7	8
Moisture content	5.5	5.5	5.4	5.3	5.4	5.5	5.3	5.4

Table 4. Means of moisture data by day and location of sampling.

	First test day	Second test day
Sample from behind gin stand	5.3	5.1
Sample from lint slide	5.8	5.3

Table 5. Means of moisture data by treatment and location of sampling.

	Low moisture treatment	High moisture treatment
Sample from behind gin stand	4.7	5.7
Sample from lint slide	5.2	5.9

Table 6. Variations in fiber quality measurements from AFIS data.

	Location		Treatment		
	Between gin stand and lint cleaner	At lint slide	Low mc	High mc	All other significant effects and cross effects
Fiber length by weight (in)	1.00†	0.98†	0.98†	1.00†	Day†, sample§
Fiber length by weight (%CV)	30.8†	31.7†	31.5§	30.9§	Day†, treatment* sample*day §
Upper quartile length by weight (in)	1.187†	1.171†	1.173†	1.185†	Day†
Short fiber content by weight	6.7†	7.7†	7.5†	6.9†	Day†, treatment* sample§, treatment* sample*day §
Fiber length by number (in)	0.826†	0.797†	0.801†	0.821†	Day†
Fiber length by number (%CV)	46.0†	47.8†	47.5§	46.4§	Day†
Short fiber content by number	21.9†	24.2†	23.8†	22.3†	Day†, trt*sample§
5.0% length (in)	1.33†	1.31†	1.31†	1.33†	Day†
2.5% length (in)	1.41†	1.39†	1.39†	1.41†	Day†
Fineness (mTex)	193.0†	190.4†	191.2§	192.3§	
Immature fiber content (%)	3.95†	4.26†	4.15§	4.05§	
Maturity ratio	0.926†	0.947†	0.951†	0.959†	Day§

§ Probability of greater F less than 0.05% but greater than 0.01%
† Probability of greater F less than or equal to 0.01%

Table 7. Variations in non-fiber quality measurements from AFIS data.

	Location		Treatment		
	Between gin stand and lint cleaner	At lint slide	Low mc	High mc	All other significant effects and cross effects
Nep size (UM)	729†	707†	713†	723†	Day§, location*day§
Nep count (per g)	140†	205†	176§	169§	Day†
Seed coat nep size (um)	1149	1143	1152	1139	Day†, treatment*location*day§
Seed coat nep count (per g)	18.9	20.4	18.3§	21.1§	Day†, location*day§
Total trash count (per g)	895†	324†	572†	647†	Day†
Trash, mean size	333†	368†	351	349	Day§
Dust count	740†	259†	469	530	Day†
Trash count (per g)	156†	65†	103	118	Day†
Visible foreign matter (%)	2.94†	1.27†	2.00§	2.21§	Day†, location*day†

§ Probability of greater F less than 0.05% but greater than 0.01%
† Probability of greater F less than or equal to 0.01%