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EVALUATION OF HVI MOISTURE MEASUREMENTS

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Abstract

The Cotton Program has been investigating the possibility of measuring the moisture levels in the cotton fiber during the testing process over the past few years. An accurate moisture measurement is a key component in the development of a moisture correction for fiber qualities. This is a long-term goal of the Cotton Program and offers significant potential benefits, including more accurate measurements and cost savings related to Heating, Ventilation and Air Conditioning (HVAC). Currently, the Cotton Program has two moisture measuring instruments under evaluation. The first moisture measurement evaluated was an electrical resistance meter that was manufactured by Uster Technologies Ag. The other instrument is the Near Infrared Reflectance (NIR) moisture measurement device manufactured by the Aqua Measure Instrument Company. Data for this evaluation was obtained from cotton samples tested in the Memphis classing office during the 2003 crop year.

Background

The subject of cotton moisture content has been a source of great interest for many years in the cotton industry. The interest is even greater today with more and more gins using equipment to add water to ginned cotton lint. The fact that moisture levels in cotton have a significant impact on the quality measurements of cotton fiber is not a new concept. As early as the 1950's (Burley and Rouse 1953) studies were conducted that indicated an influence of moisture on fiber quality. Moisture has an impact on a variety of cotton processes in addition to fiber testing. The impact happens as early as the growing stage in the field where water has a direct impact on total yield in the field and fiber development that ultimately impacts fiber qualities. The moisture impacts the harvesting of the crop (Barker and Laird 1991). In wet or high humidity conditions, the stripper harvesting of cotton fiber can become difficult and cause equipment problems that will slow harvesting. The ginning industry has always recognized the benefit of adding and removing moisture at certain stages of the ginning process. Early in the ginning process, high moisture content can cause problems in getting the raw cotton to the gin stand. Gins use drying equipment to reduce the amount of moisture in the raw cotton in order to facilitate cleaning and seed removal. However, excessively dry conditions can result in increased static electricity, which can become a fire hazard in the gin. At the bale press, higher moisture contents are used to help in bale compaction. Moisture is also sometimes added just prior to baling in order to restore the moisture that was removed early in the ginning process.

The classification and grading process of the cotton fiber as indicated earlier is also impacted by moisture variations. The USDA Cotton Program adheres to the conditioning requirements established under the governing body of the American Society of Testing and Materials (ASTM) D-13 committee. Standard conditioning requirements of 70 degrees Fahrenheit and 65 percent relative humidity are set forth as proper fiber testing conditions (ASTM 1776). Large amounts of money are invested by testing laboratories on equipment and utilities in order to maintain an atmosphere conducive to fiber testing.

Since the inception of the micronaire measurement, cotton researchers have recognized that moisture has a significant affect on measurement results. A one percent change in moisture content can result in approximately a two percent change in the micronaire and length measurements. As moisture levels increase in the fiber, the fiber becomes longer. Fiber strength has the most significant reaction to the moisture content of all fiber properties. The strength of the fiber will change as much as five percent for a one percent change in moisture content. Increased moisture will result in higher levels of strength while decreased moisture will result in lower strength levels. Although these fiber property measurements are changing with respect to moisture, the fiber itself is still physically the same. The fiber is simply reacting to the moisture present in the fiber that makes it appear shorter, longer, coarser, finer, stronger or weaker.

The spinning industry is not immune to the influences of varying amounts of moisture content. Cotton fibers will behave differently in the spinning process due to the varying amounts of moisture content which could result in more or less waste in the spinning process in addition to affecting the production efficiencies due to breakage of the fibers in the spinning process which increases occurrences of "ends down".

Introduction

The USDA has investigated the possibility of measuring the moisture in the cotton fiber during the testing process over the past several years. Various instruments such as NIR, electrical resistance and radio frequency have been investigated. The driving force in finding a usable moisture measurement is the ability to correct moisture sensitive fiber measurements back to a standard moisture level. This would greatly reduce the expenses related to HVAC equipment and utilities in order to maintain a stringent testing environment. Near Infrared Reflectance as a moisture measuring device has been investigated previously and a correction equation was developed in some earlier work (Knowlton, 1995; and Knowlton and Grantham, 1995).

The purpose of this study was to evaluate the Uster instrument and the Aqua Measure moisture meter to determine if either instrument could be utilized parallel in the fiber testing process as a moisture correction tool. The Cotton Program was not able to perform an evaluation on the Uster moisture measurement due to complications in logistics that could potentially compromise the integrity of the sample on their system. Initially, there were concerns about testing times and the critical nature of the sample placement, which could have a detrimental impact on the accuracy of the moisture measurement. To do this, samples were tested for moisture and fiber qualities in both the preconditioned and conditioned states. The procedure and analysis for this study are presented below.

Procedure

A small lab within close proximity of the classing lab and the receiving room housed one HVI line for the purpose of obtaining the fiber measurement and moisture data in an environment controlled at 75 degrees Fahrenheit plus or minus 1 degree and a relative humidity of 47 percent plus or minus 2 percent. This was done in an effort to simulate the actual practices of a relaxed conditioning scenario in a proposed classing office operation. The cotton samples were tested in this environment in a preconditioned and conditioned state. In addition the samples were returned back to the classing lab for their original Form 1 classification.

The cotton samples were selected from the samples that were being delivered to the classing office for Form 1 testing. The samples were retrieved from the receiving room area prior to any conditioning and were transported in a sack into the small lab. The samples were removed from the sack and immediately tested on the NIR for moisture in a preconditioned state. Once the moisture was recorded, portions of the sample were placed in the HVI for testing according to standard operating procedures outlined in Cotton Program instructions. After the sample had been tested in its preconditioned state, it was returned back to the receiving room for routine conditioning on the Rapid Conditioning Unit (RCU). The sample was then placed in a plastic tray and transported back to the receiving room and placed on the RCU for conditioning. The samples were placed on the RCU with other samples that had been submitted for Form 1 testing. The same samples were retrieved from the exit point of the RCU and returned back to the small lab for further testing. The same procedures were used in testing the conditioned samples that was used in measuring the preconditioned samples. The NIR moisture data was recorded first and then the samples were placed in the instrument for HVI fiber testing.

Results

An analysis of the data was performed utilizing the t-test in order to determine if the moisture, strength, micronaire, and length measurements were detecting any differences due to the preconditioning and conditioning of the samples. The data was analyzed first utilizing the t-test and comparing the differences in the preconditioned and conditioned results for each of the measured properties. The results are shown below and the data does give evidence to the fact that each of the measurements are responding to differences in the state of conditioning. A T-test was utilized in the analysis and the results have been reported in Table 1.

A correlation was done on the data set in order to determine if the differences in the moisture measurement had any relation to the differences in the other quality factors. There is no correlation between the data with the moisture measurement and the fiber qualities measured by the HVI.

Conclusion

It appears that although the instrument measurements can detect differences, there is not enough precision or sensitivity in the measurements to relate them to each other. It is speculated that the variability that exists in the individual measurements is confounding any correlation within the data set. Although the NIR instrumentation under this evaluation appears to be adequate in detecting differences in moisture content, it does not appear to be useful for correcting fiber quality measurements for deviations in moisture experienced in classification.

References

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Table 1. T-test results for pre-conditioned and conditioned cotton

t-Test: Paired Two Sample for Means		
Moisture		
	Conditioned	***Preconditioned***
Mean	0.083832418	0.079299451
Variance	0.000159842	0.000162458
Observations	364	364
Pearson Correlation	0.572491649	
Hypothesized Mean Difference	0	
Df	363	
t Stat	7.367510779	
P(T<=t) one-tail	5.90656E-13	
t Critical one-tail	1.649061687	
P(T<=t) two-tail	1.18131E-12	
t Critical two-tail	1.966518539	
Strength		
	Conditioned	***Preconditioned***
Mean	286.0082418	283.3846154
Variance	368.0302349	317.6533164
Observations	364	364
Pearson Correlation	0.749020465	
Hypothesized Mean Difference	0	
Df	363	
t Stat	3.800382367	
P(T<=t) one-tail	8.46883E-05	
t Critical one-tail	1.649061687	
P(T<=t) two-tail	0.000169377	
t Critical two-tail	1.966518539	
Micronaire		
	Conditioned	***Preconditioned***
Mean	444.1868132	442.1153846
Variance	1583.937456	1547.248358
Observations	364	364
Pearson Correlation	0.989953641	
Hypothesized Mean Difference	0	
Df	363	
t Stat	7.022599328	
P(T<=t) one-tail	5.39534E-12	
t Critical one-tail	1.649061687	
P(T<=t) two-tail	1.07907E-11	
t Critical two-tail	1.966518539	
Length		
	Conditioned	***Preconditioned***
Mean	1101.667582	1095.252747
Variance	1058.922252	1343.814731
Observations	364	364
Pearson Correlation	0.680493528	
Hypothesized Mean Difference	0	
Df	363	
t Stat	4.384347777	
P(T<=t) one-tail	7.62846E-06	
t Critical one-tail	1.649061687	
P(T<=t) two-tail	1.52569E-05	
t Critical two-tail	1.966518539	