Moisture Restoration of Cotton

Restoring moisture to cotton fibers is not an uncommon ginning practice. This publication offers guidance for ginners to ensure that methods of moisture restoration are used properly at the gin.

Moisture Management is Important

Moisture content is a major factor affecting the cotton ginning process from unloading through bale packaging. Moisture management is critical to cotton cleaning, handling, and fiber quality preservation at the gin. Cotton with too high a moisture content will not easily separate into single locks, but will form wads that may choke and damage gin machinery or entirely stop the ginning process. Cotton with too low a moisture content may stick to metal surfaces as a result of static electricity generated on the fibers and cause machinery to choke and stop. Fiber dried and processed at low moisture content is more brittle and easily damaged by the mechanical actions required for cleaning and ginning. When pressing and baling low moisture cotton, hydraulic pressure dramatically increases causing excessive equipment wear and problems with bale tie breakage escalate.

The effort required to measure and control moisture will pay dividends in gin operation efficiency and market value of the cotton. Research has shown moisture contents for seed cotton cleaning and ginning cotton is best at **6 to 7** percent moisture content (**wet basis**), which allows for sufficient cleaning with minimal fiber damage. Bale packaging at these moisture contents minimizes press force, static and bale-tie breakage. Bale storage at moisture contents greater than 8 percent can cause degradation to the fiber color during long term storage.

Although the optimum processing and storage moisture contents of cotton are well known, managing cotton moisture content during ginning is a difficult task. Ginners are constantly dealing with cotton coming into the gin that is too wet or too dry and must monitor moisture levels throughout the process. Too often, fiber is over dried and additional moisture is needed. Restoring moisture to cotton fibers improves processing and adds weight to the bale. This publication offers guidance for ginners to ensure that methods of moisture restoration are used properly at the gin.

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Restoration Methods

Many approaches have been used to restore moisture in cotton fiber using **humidified air**, **liquid water sprays**, and combinations of these systems. Moisture can be added during seed cotton processing by using moisture conditioning hoppers prior to the gin stand, however, most gins restore moisture at the battery condenser and/or the lint slide.

Humidified air systems depend on the ability of raw ginned cotton fiber to absorb water vapor from the surrounding air. The temperature and humidity of the air have a direct influence on the moisture content of the cotton fiber. The air is heated in order to increase its water vapor carrying capacity and to increase the water vapor pressure for more rapid uptake of moisture by the cotton fiber. Humidified air can be used in transporting lint to the battery condenser, blown/pulled through the batt at the battery condenser, and/or at the lint slide, providing a relatively uniform distribution of moisture. One of the common problems with humidified air systems is controlling the temperature difference between the fiber and the surrounding air and/or equipment causing poor moisture absorption or even liquid condensation on metal surfaces.

Many gins use **liquid water sprays** on top of the batt at the lint slide. This method allows for rapid application of liquid water, but does not encourage absorption of the liquid by the fiber; thus, the liquid water is not inherently bound with the fiber but is on the surface of the fiber. Raw ginned cotton has a deposit of natural wax and other substances, notably calcium and magnesium pectates, on or in the primary cell wall that make it water-repellent. As well, liquid water sprayed on the top of the fiber does not penetrate the depth of the batt, which will result in a sandwich of liquid water between layers of fiber. Moisture migrates very slowly in universal density bales, sometimes taking months to equilibrate. Non-uniform water distribution can cause wet spots in the bale, increasing the risk of microbial growth and fiber quality degradation.

There is a practical limit to the quantity of moisture that may be added to cotton and care must be taken to avoid over application of water. The amount of moisture that cotton can absorb is a function of its **equilibrium moisture content** (page 4). Over application of moisture or unexpected condensation within machinery and pipes must be prevented or choking will result. If liquid water is present on cotton during the ginning process, gin operation will become irregular and may cease altogether. Cotton with fiber moisture of 8 percent or more will not clean and/or smooth out properly when processed through the lint cleaners.

Moisture Measurement

Moisture meters commonly used in cotton gins primarily measure lint moisture, not seed cotton moisture. Lint moisture reaches equilibrium with the humidity in the air within a few minutes. However, seed cotton moisture takes hours or days to equilibrate, due to the influence of the seed. Meter readings are influenced by cotton type, contaminants such as trash, sample and ambient temperature, and sample density.

Current portable moisture sensors available include resistance sensors such as the Delmhorst, AquaBoy and Granberry units. Resistance sensors provide a good indication of relative moisture contents, but can vary from the true reading by ±1 percent moisture content. For cotton that has been flash conditioned with a moisture restoration system, a resistance sensor is only accurate to ±1.5 percent moisture content (Pelletier, 2003). When moisture readings are taken, five or more readings should be taken at different locations. These readings should be averaged because wide differences can occur within the bale, especially with liquid water sprays.

When any type of portable moisture meter is used, readings can be improved by the following procedures:

1. Follow manufacturer's recommendations.
2. Use uniform, homogeneous samples of about the same weight.
3. Wear gloves to prevent moisture transfer from hand to sample.
4. Place each sample in the measuring cup immediately to minimize moisture change in each sample.
5. Compress each sample uniformly with the same amount of pressure each time.
6. Check instrument calibration and replace the battery when needed.

Some gins have automated moisture sensors that take continuous reading during gin processing and can be used to control dryer temperature and moisture restoration systems. Most gins use resistance-type sensors, however, microwave and infrared moisture sensors are commercially available. Inaccurate readings can occur on cotton with surface water or high trash contents. Calibration and maintenance is critical to ensure accurate measurements for all types of sensors.

Safe Storage Moisture Content

Studies conducted at the USDA-ARS Cotton Ginning Research Unit in Stoneville, MS, since the 1950's, have shown that moisture content over 8 percent leads to color degradation of the fiber during storage. In a recent study, bales stored for 116 days at over 8 percent lint moisture with an initial color grade of 31 (Middling), resulted in a color grade of 41 (Strict Low Middling) after storage. Bales stored at moistures greater than 10 percent, resulted in a 43 color grade. In addition, sections of the bale stored at over 10 percent moisture had obvious dark discolorations due to microbial growth.

Textile mills can also have a difficult time in processing high moisture bales. Too much moisture can reduce the bloom height of the bale at opening and cause the fibers to matt, making separation and blending difficult. The change in fiber color occurs during storage, after the official classification, and leaves the textile mill with a bale that is not accurately represented by USDA-AMS color classing. If a history of suspected bales occurs, very likely the reputation of the gin and possible the U.S. cotton industry would be tarnished.

The National Cotton Council recommends 7.5 percent (wet basis) as the maximum moisture level for cotton bales, until such time as more research further refines this number.

Moisture Restoration at Gins

To help document how gins were restoring lint moisture, a study was conducted at 18 Mid-South gins to identify moisture restoration methods and measure before and after lint moisture contents (Anthony, 2003). The types of moisture restoration systems used at the gins studied were; (1) lint slide grid humid air system, (2) battery condenser humid air, (3) direct water spray at the lint slide, and (4) a combination of humid air and direct spray. Initial moisture contents, just prior to restoration, ranged from 3.7 to 6.2 percent for all gins.

The averaged restored moisture of the bales tested was 6.2 percent and ranged from 3.2 to 15.6 percent. The data showed that 8.6 percent of the bales were above 8 percent moisture content and 10 of the 18 gins tested produced bales greater than 8 percent moisture content. Those gins producing the largest percentage of high moisture bales were using the direct spray or combination systems (**See table below**).

The humid air system rarely adds more than 2 percent moisture to a bale, but the direct spray approach can add far more. Although the percentages of bales leaving the gin above 8 percent moisture was small, gin managers must be careful that moisture restoration systems are properly calibrated and maintained.

Bale Moisture Contents (wet basis) of Different Moisture Restoration Systems

Moisture Restoration System	Average, Pounds of Water Added	Average Final Moisture (%)	Bales with Moisture > 8%
Grid (1)	2.7	5.5	0.2
Humid (2)	4.0	5.3	2.4
Spray (3)	7.6	6.7	11.7
Combination (4)	5.8	6.8	13.1

Moisture Reference Basis -- Dry and Wet

There are two moisture reference basis for describing percent moisture content, dry and wet. Moisture content dry basis (db) is calculated by:

%MC (db) = ((wet weight – dry weight) / dry weight) x 100

Moisture content wet basis (wb) is calculated by:

%MC (wb) = ((wet weight – dry weight) / wet weight) x 100

Dry weight, is the weight of lint with no moisture after being dried by the oven method (ASTM, 2001). Wet weight, is the initial weight of the lint before drying.

Dry basis moisture content is always higher than wet basis moisture. Most commercial moisture measurement devices are calibrated on a wet basis, however, some are calibrated on a dry basis. If the method of moisture content measurement is not referenced, it is generally assumed wet basis.

References

American Society for Testing and Materials, 2001. Standard Test Method for Moisture in Cotton by Oven-drying, D2495 -01. ASTM Standards, West Conshohocken, PA.

Anthony, W.S., 2003. Survey of Moisture Restoration at Mid-South Gins in 2002. The Cotton Gin and Oil Mill Press, Vol. 104 (6): pp 8-12.

Cotton Ginners Handbook, 1994. Agriculture Handbook No. 503, Agriculture Research Service, USDA, 337 pages.

Pelletier, M.G. 2003. Calibrating a Free Space Measurement of the Dielectric Properties of Lint Cotton. ASAE paper #03-1149.

Additional Information

USDA-ARS-CTTE, P.O. Box 40, Stoneville, MS 38776 (662) 686-5255 Cotton Ginning Technology Web Site: **http://msa.ars.usda.gov/gintech**

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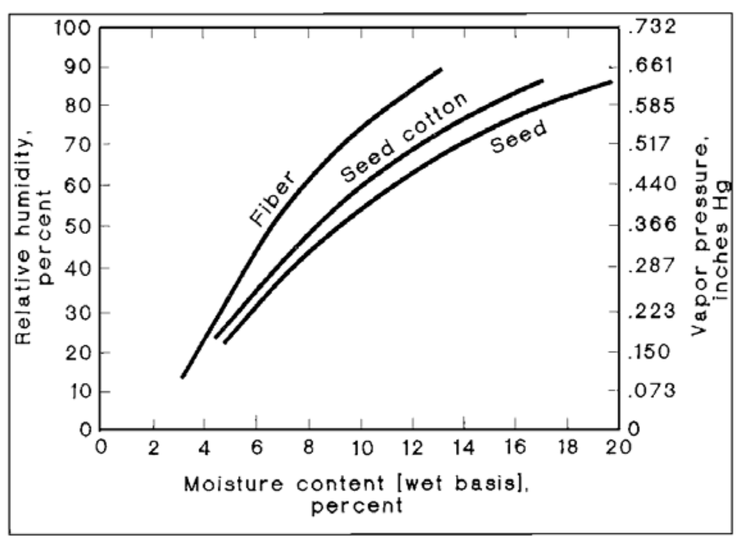
Equilibrium Moisture Contents

Cotton is hygroscopic and will gain or lose moisture based on the environmental condition at which it is contained. Dry cotton placed in damp air will gain moisture and wet cotton placed in dry air will loose moisture. For every combination of ambient air temperature and relative humidity, there is a corresponding equilibrium moisture content for the cotton. The figure to the right, shows the estimated moisture contents for fiber, seed and seed cotton. For example, if samples of seed cotton and fiber are placed in air of 50 percent relative humidity and 70°F, the equilibrium moisture content fibers will be approximately 6 percent and the seed cotton will be approximately 8 percent.



Moisture occurs not only in fibers and seed (absorbed moisture) but also sometimes on the exterior surfaces (surface moisture). The combination of absorbed and surface moisture can cause errors in common moisture measurement devices.