Moisture Management at the Gin for Quality Preservation

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Introduction

The moisture content (mc) of upland cotton fiber substantially affects many of its physical properties and the mc of cotton fiber changes readily based on its exposure to moist or dry air. Excessive mc of cotton in the gin has been a problem, especially in the more humid production areas of the USA. During wet weather the seed cotton was difficult to gin and would sometimes spoil before it could be adequately dried. The U. S. Cotton Ginning Unit was established in Stoneville, MS, in 1930 and at first concentrated on the problems associated with excessive moisture in seed cotton which resulted in the vertical tower drier (Gerdes et al., 1941). Driers of several different designs were quickly accepted by the U. S. industry. According to Gerdes et al. (1941), 1.6% of the U.S. gins were equipped with driers in 1935, 6.6% by 1938 and by 1940 the proportion had increased to 11.5%. By 1951, 81% of the gins were reported to be equipped with driers (Griffin and Merkel, 1953). Many of the early driers used the low-pressure exhaust steam from the power plant for the gin through a heat exchanger as the source of heat; others used internal combustion engine waste heat and independent "furnaces" fired by coal, oil, or gas. All of these driers used heated air in contact with the seed cotton as the primary drying method and therefore are referred to as pneumatic driers.

These pneumatic driers helped solve the problem with high mc seed cotton which plagued farmers in certain years, especially in the Mississippi River Valley. Artificial drying of seed cotton resulted in faster, more trouble free gin operation
and facilitated removal of foreign matter. In addition, the resulting ginned lint had a “smoother” look for less grade penalty due to rough preparation. However, Gerdes et al. (1941) reported that some gins used more drying which resulted in reduced fiber length and strength. Gerdes (1950) found that gins used two or three driers in series with drying temperatures as high as 177 °C (350 °F). Gin managers found that the cleaning possible with lint dried as low as 3.9% resulted in better grades and prices despite the penalties from damage to the fiber length and strength resulting from ginning the dry cotton. Data collected by Gerdes (1950) showed that drying at temperatures up to 177 °C resulted in improvement of grade with a tendency for lower fiber length and fiber tensile strength. He also showed that the yarn spun from the more aggressively dried cotton had lower skein strength.

At first, high drying temperatures were blamed for the damage, but later it appeared that the fiber mc was the more important factor. Moore and Griffin (1964) presented data showing that single fiber breaking force increases with increasing mc in the range of 3 to 15%, while fiber-seed attachment forces remain constant from 3% to about 11% and then decreases up to 15% mc. These data provided an explanation for why ginning at higher mc improved fiber length quality.

A complete moisture control system would be able to monitor the lint mc and vary the lint mc level by either removing or adding moisture. Current
recommendations are to gin with the fiber mc in the rage 6% to 7% (wet basis) at the gin stand (Mayfield et al., 1994), which allows for sufficient cleaning with minimal fiber damage.

Byler (2006) reviewed the literature from the past 70 years regarding the moisture restoration of seed cotton and fiber quality. Several studies supported the practice of adding moisture to low moisture seed cotton, either as a vapor or liquid spray, before the gin stand in order to better preserve the fiber length quality. Reviewed literature consistently supported ginning at mc levels above 6% to best preserve fiber length quality. However, seed cotton cleaning is less efficient at higher mc levels and trash in cotton lint can easily be seen and measured, while lint mc and short fiber are relatively difficult to measure. Mangialardi and Griffin (1977) reviewed weather patterns for the humid US mid-south for the months of September and October. They concluded that in order to preserve fiber length quality there was a need for moisture restoration before the gin stand when cotton lint contained less than 6.5% mc between the hours of 10:00 AM and 7:00 PM. The need for moisture addition was particularly acute late in the season when it was not unusual for the ambient relative humidity to be as low as 20%.

**Drying**
The adoption of the modeling system has allowed farmers to harvest during the best weather and therefore the seed cotton is drier than ideal for ginning when harvested. However, there often is a need for considerable drying when module covers leak or when it has been necessary to harvest when the seed cotton is wetter than ideal for ginning. Without adequate drying in the gin the seed cotton is difficult to clean and often will have excessive trash content.

Several newer design drying systems have become available during the past 15 years including the Hi-Slip Dryer, Collider Dryer, and the Even Heat Tower Dryer. These have been developed as improvements on the traditional tower dryer which had originally been designed for ginning rates of approximately 4 bales per hour because of the substantial increase in gin through-put since the late 1930's.

Modern gin plants need to have substantial drying capacity to handle the potentially wet seed cotton flow rate. However, this drying equipment also has the capacity to over-dry seed cotton if drying is not needed. Many gins now have automated drying control based on incoming seed cotton mc measurements. These systems can rapidly respond to wetter seed cotton but also turn down the burner temperatures when the heat is not needed. This type of system will better preserve fiber quality while also preserving fuel. Many gins use non-automated control by staging dry modules to be ginned consecutively and shutting down the burners altogether when not needed.
Even more advanced ginning control can sense the trash levels of the cotton and reduce the drying when the lint is clean and allow somewhat more drying when the trash level are higher. This interaction between cleaning efficiency and fiber damage effects on bale price requires the most advanced sensing and control system for the modern cotton gin plant.

**Seed cotton moisture restoration**

Some gins have the equipment necessary to add moisture to the seed cotton before ginning. This equipment is usually installed after seed cotton cleaning to take advantage of the higher cleaning efficiency when the seed cotton is drier. USDA Agricultural Research Service data have shown that this added moisture will improve the lint quality with greater AFIS fiber length and length uniformity, HVI length and strength, and lower AFIS short fiber content (Byler and Boykin, 2006).

**Moisture measurement**

The key to properly controlling anything is the ability to accurately measure that property. Because of the modern ginning rates and the potential for rapid changes in incoming seed cotton mc, drying control needs to be automated and the seed cotton mc sensing also needs to be automated. Moisture sensors have
been available for gins for many years but the accuracy, repeatability, and drift of these meters continues to be of concern. Several physical properties can be used to measure mc. Meters based on electrical resistance, electrical capacitance, near-infrared light absorption, and radio-frequency absorption are available.

The lint in seed cotton dries quickly but the seed dry slowly. So when gins dry cotton they mostly dry only the lint portion of the seed cotton. Also the lint portion is the most susceptible to damage when ginning at lower mc. Drying control systems which measure the lint portion of the seed cotton are preferable to systems which measure the overall seed cotton mc when used after drying in a feed-back control scenario. Of the basic principles listed, the electrical resistance and near-infrared light absorption respond most significantly to changes in lint vs. the cotton seed.

**Summary**

Proper control of the lint mc in the cotton gin is crucial to maintaining the fiber quality. If the mc is too high the fiber will be damaged by microbial action and will result in poor color as well as poor spinning properties. At lower mc, but still higher than desirable, the cotton will be more difficult to clean and will tend to have excessive non-lint content which will reduce the value to the seller. At the other extreme seed cotton may be harvested dryer than ideal for ginning or may
be excessively dried in the gin. This overly dried lint will tend to be damaged during the vigorous ginning process which will result in lower fiber strength, lower fiber length and increased short fiber content. These fiber quality problems also lead to lower yarn quality. So, the production of optimum lint quality depends on the knowledge of the properties of the incoming seed cotton and an understanding of the results on fiber quality and non-lint quality of processing of that seed cotton. The ginner manages the drying system and cleaning equipment based on the seed cotton presented for ginning and the capabilities of the gin plant available. Automated control allows the manager to concentrate on the larger control issues while allowing the control system to manage the details.

References


