GIN PROCESS MONITORING & CONTROL THE NEXT GENERATION

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Introduction

The US Cotton Ginning Laboratory (USCGL) in Stoneville, Mississippi has developed over the last 15 years the models, processes, and systems that have come to be known as Computerized Gin Process Control (CGPC or GPC). Stanley Anthony and his colleagues have reported on the concept and method at past Beltwide Cotton Conferences (Anthony, et al 1995; Byler and Anthony, 1995) and in other venues.

With this report, we would like to present a brief review of the history of Gin Process Control, provide some details regarding the events that have occurred in the evolution of the concept, and give a report on the experiences of the 1996 ginning season. We would also like take a look at the future of Gin Process Control ... *the next generation*.

Development of the GPC System and Method

The researchers at the Stoneville Lab (USCGL) have determined and documented the performance characteristics of each type of processing machinery within the cotton gin in terms of their effect on fiber quality as a function of moisture and trash levels. These determinations have been made for numerous cotton varieties. They have also developed a computer model of a ginning system which uses the performance characterizations to optimize farmer profits while achieving the most beneficial market value through minimizing machinery use.

In other words, they have developed a method of optimization in which we can clean, dry, and gin cotton based on the incoming harvest qualities, predicted and actual performance of cleaning and drying systems, and the grower's discount schedule.

Taking a brief look at the history of GPC shows us how the method and system have evolved:

1. The methods and systems were first conceived at the Stoneville Lab in the early 1980's

2. The techniques were first implemented in the Stoneville "micro-gin" with exceptional results.

3. Limited, full scale field trials were then initiated in two commercial gins in the early 1990's.

4. Servico Gin in Courtland, Alabama was fitted with the most complete computerized gin process monitoring and control system in 1994.

   For the first season, the system only made recommendations to the ginner (*monitoring*) who would, at his discretion, manually control the cleaning and drying systems.

5. In 1995, *control* of the lint cleaning system was turned over to the GPC computer and decision making algorithms.

6. 1996 -- Zellweger Uster licenses the GPC technology.

Zellweger Uster joins the USCGL as a partner in the development and realization of the full potential of the Gin Process Monitoring & Control technology. Zellweger has assume the responsibility for the system at Servico Gin. New technologies, methods, and systems have been incorporated into the existing installation at Servico. As a result of this partnership and upon future performance in the marketplace, royalties will be paid to the USDA.

Zellweger Uster's role in the evolution of the system will be to:

1. Modernize and update the technologies

2. Commercialize the system

3. Take the system beyond the research models to a manufacturably viable product for the ginning industry

4. Expand the systems and concepts to their full potential

Zellweger was brought in as a partner to further develop the GPC technologies based upon our expertise in fiber testing instrumentation and our experience in providing quality control and quality management systems for the textile industry.

Gin Process Monitoring & Control System

There are three measurement stations in the system: one at the feed control, one behind the gin stand, and one after the lint cleaners. Figure 1 shows the measurement station behind the gin stand at Servico Gin used in 1996. Cotton samples are collected by a "paddle" sampler and pressed against the "window" of the color/trash measurement "head". A moisture sensor located in the paddle itself measures the moisture content of the sample while the

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color/trash readings are made through the window. The sample is released and the system reset for the next sample. Readings may be taken as frequently as once every six seconds.

Figures 2 and 3 show the sampling technique of the measurement stations. Figure 2 shows the paddle sampler in its "closed" position with the color/trash measurement head moved away to show detail. Figure 3 shows a collected sample -- this sample would be pressed up to the color/trash window when the measurement station is in its normally closed position.

Three systems can be controlled within the gin:

(1) pre-cleaning -- are they "in" or "out"
(2) lint cleaning -- are 1 or 2 used
(3) drying -- how hot are the burners run

Pre-cleaner control is determined from the color, trash, and moisture readings at the feed control and behind the gin stand. Servico Gin is equipped with more seed cotton cleaning than most gins and is also equipped with by-pass valves to eliminate a set of stick machines and or impact cleaners.

Lint cleaner control is determined from color, trash, and moisture readings behind the gin stand and after the lint cleaners. The computer model can determine from these readings, in real time, if one or two lint cleaners are necessary to achieve the optimum benefit for the grower.

Automated directional control valves installed between the lint cleaners (Figure 4) mean the ginner does not have to slow down or stop the flow of cotton to change the sequence of lint cleaners. These valves were designed by the USCGL and the patents have been licensed to Zellweger Uster.

Drying control -- moisture is measured at the feed control and this measurement is used to quickly respond to changes in the incoming cotton moisture content. Moisture is also measured after the gin stand. This measurement is used to slowly adjust the system to maintain the desired moisture content. The system is designed to maintain a moisture content behind the gin stand as chosen by the ginner.

Using the full monitoring and control capabilities of the system the goals of the method include:

1. Maximize grower turnout

2. Optimize turnout versus grade to give the grower the maximum profit

3. To minimally process the cotton through only the necessary machinery to optimize the fiber characteristics -- this will lead to improved fiber quality

Research by the USCGL (Anthony, 1996) and others indicates the need and advantages to selectively processing cotton to optimize fiber quality:

Eliminating one stage of lint cleaning *can* produce the following positive results with respect to fiber quality --

- increase fiber length 2%
- reduce short fiber 22%
- increase seed coat fragment size 21%
- decrease neps 15%

Controlling fiber moisture *can* --

- increase length 4%
- reduce short fibers 47%
- increase seed coat fragment size 18%
- reduce the number of seed coat fragments 36%
- increase measured strength 5%

Actual results from the GPC system at Servico verify the possibilities of these research results. During the 1995 season, samples from bales ginned using the GPC system were collected at the press and sent to the Cotton Incorporated fiber testing laboratory for evaluation. The nep levels for the bales sampled averaged 189 per gram. The short fiber content of the bales sampled averaged 5.8%. The total number of bales tested was less than 100.

These are quite favorable when compared with the *Uster Fiber Statistics, 1997*. Zellweger Uster tests fibers from all parts of the world in its fiber laboratories. We collected results from tests conducted from 1994-1996 and have now published the first set of *Fiber Statistics* to complement the frequented published and well accepted standards for yarns, the *Uster Statistics.*

For neps, the *Uster 50% Standard* is 250 per gram. For short fiber content the *Uster 50% Standard* is 9.0%. The *50% standard* is derived from that set of worldwide samples tested by Zellweger Uster. The *50% Standard* indicates that of all the bale samples tested in the survey, 50% were higher than the quoted value and 50% were lower. The limited results at Servico are quite favorable when compared to world averages. See Figures 5 and 6.

New Additions/Accomplishments for the 1996 Gin Season

Zellweger Uster assumed responsibility for the Servico Gin "alpha" site for the 1996 season. The system had performed well during the previous two seasons and the basic mechanical components were in good condition. There were opportunities for numerous improvements in the measurement, electronic, and software areas.

Prior to, or during the 1996 gin season the following additions/ improvements were made at the Servico site:

- the latest HVI color/trash technologies were incorporated into the measurement stations

- the measurement stations were made autonomous by the addition of individual computer systems at each station

- a new calibration philosophy/method was implemented which improved the performance of the measurements and reduced the need for calibration

- *on-line control* of the drying system was established

- a new decision-making algorithm was implemented which made the system more flexible and more widely applicable

- off-line measurement of color/trash and micronaire was accomplished using the stand alone Colorimeter and Micronaire instruments of ZU

Using the data from the off-line instruments, Servico Gin was able to sort and warehouse cotton based on categories set up by their cotton merchant. This enabled direct shipment of bales to mills based on the specific fiber category desired. It also resulted in a estimated $6 per bale savings in warehouse costs.

1996 Results at Servico Gin

The final analysis of all results at Servico has not yet completed (as of January 1997) but the results that are available are quite impressive from the grower's point of view.

The grower's received an average of 25 pounds more lint yield per bale for cotton that was processed on the GPC system and that was determined by the system should be minimally cleaned and dried. These grower's realized an increase in income of $24 per acre. For the 1996 season, this translated into in increase in farmer income of over $550,000 as a result of the GPC technology (Greene, 1996).

The gin received an estimated $6 per bale reduction in warehousing costs as a result of "block" storage of bales based upon there fiber characteristics (color, grade, micronaire). Bales fitting the desired category could be shipped from the "block" resulting in less handling of the bales and eliminated the need to search for particular bales based upon bale ID.

The cost savings of the reduced drying requirements as a result of the system were not available at the time this was written.

We are still evaluating and analyzing the some 600,000 data points that were generated on the 40,000 plus bales that were ginned. The correlations to USDA HVI and the anticipated improvements in data variation are not yet available.

Plans for the 1997 Ginning Season

Zellweger Uster, in cooperation with its USDA partners, plans to initiate a 2nd "beta" site for the 1997 ginning season. The "alpha" site at Servico will be improved and upgraded with additional technologies.

Among plans/improvements for 1997 will be a new "flash" style colorimeter which uses a strobing light source for the illumination of the sample. This new technique provides a more stable light source and will reduce the need for calibration of the sensor even further than was achieved in 1996.

For 1997, we will integrate the color, trash, and moisture readings into a single sensor. Previous versions of the moisture measurement device had the sensor located in the paddle portion of the sampler. This caused a few problems will acquiring the sample due to the thickness of the paddle necessary to accommodate the moisture sensor. Incorporating the moisture sensor next to the color window will allow for a more streamlined design of the paddle and thus a more reliable device.

A graphical user interface using gin "icons" and schematics will be introduced in 1997 along with a touch-screen monitor for ease of operator use.

Wire-less communication between the measurement stations and the host computer and between the host computer and the gin's main or network computer will be established in 1997. This will eliminate the need for the installation of electrical conduit and its associated cost. Modem communication between the host computer and Zellweger service personnel will also be established. This will allow service from an off-site location and minimize any potential downtimes.

IntelliGin System -- The Next Generation

This new system has been given the name USTER *IntelliGin System.* It will be commercially available beginning in 1998 and will be installed in numerous locations for the 1998 ginning season.

What is USTER *IntelliGin* ? It will consist of on-line measurement of color grade, trash, and moisture at a minimum of 3 locations in the gin. Measurements of these parameters will be made up to every 6 seconds. These on-line sensors will consist of patented paddle sampling devices and state-of-the-art technologies. There will be available either automatic or semi-automatic bypass valves for seed cotton and/or lint cleaners as required or desired. The system will have the capability of integrated control of the burners/drying system.

The system is being designed and developed to be a completely modular system -- it may be configured as a full monitoring and control system automatically directing the flow of material through the gin or it may be a simple monitoring/recommendation providing system or any combination in-between. The multiple configuration possibilities are designed to suit the particular needs of the individual gin.

Future developments of the system are already being considered. These could include a procedure and software program for the development of bale mixes directly at the gin according to specific textile mill specifications and the direct shipment of those mixes to the textile mill.

Measurement of additional fiber properties at the gin is a distinct possibility. Plans are being made to evaluate the measurement of length, strength, micronaire, and fiber neps directly on-line at the gin.

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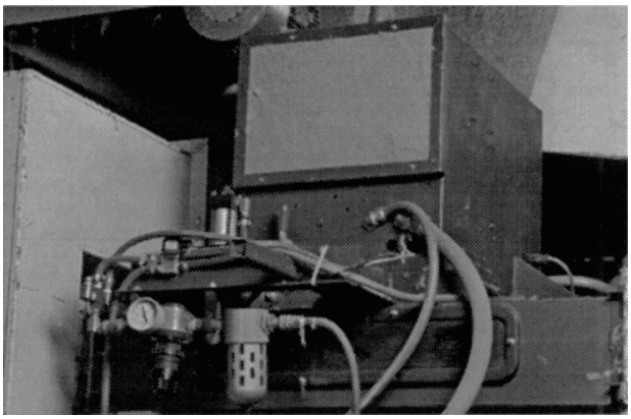

Figure 1. Measurement station behind the gin stand at Servico Gin used in 1996.

Figure 2. Paddle sampler in closed position with the color/trash measurement head moved away to show detail.

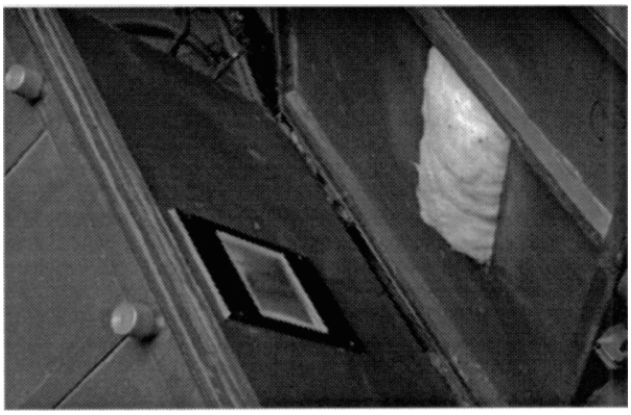

Figure 3. A collected sample.

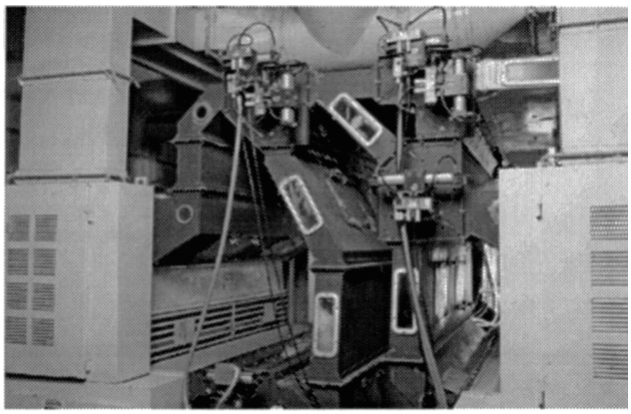

Figure 4. Automated directional control valves installed between the lint cleaners.

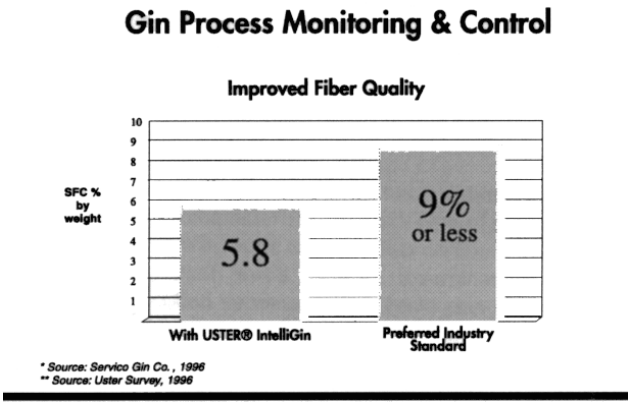

Figure 5. Gin Process Control -- Improved Fiber Quality -- Neps.

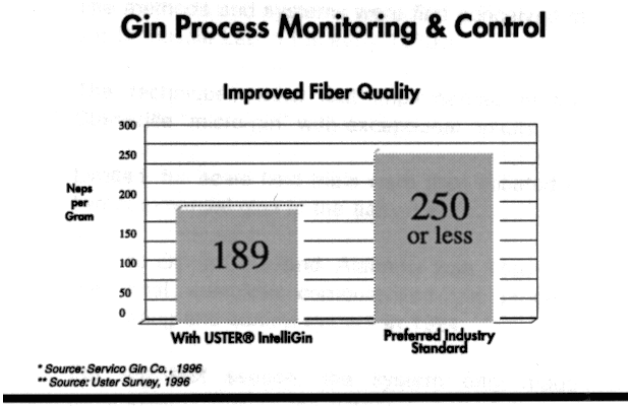

Figure 6. Gin Process Control -- Improved Fiber Quality -- Short Fiber Content.