MEASUREMENT CONCEPTS IN A GIN PROCESS CONTROL SYSTEM, 1996

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Abstract

A computer-based system to control drying and cleaning machinery selection in commercial gins was installed at Servico Gin in Courtland, AL, in 1994. This system is now the most complete computerized gin process control system in the world. Directional valves for seed cotton diversion were added in 1995, and a new color/trash measurement system was installed in 1996. This gin has operated with some of the process control components for three ginning seasons, including 40,500 bales in 1996. This paper describes the measurement components of the system and how they relate to the process control.

Introduction

At the 1994 Beltwide Cotton Conference, Anthony and Byler (1994) and later Anthony et al. (1995) reported on the status of process control systems for use in gins. Since that time, a commercial version of the system was installed at Servico Gin in Courtland, AL. At this gin there were three major systems over which control was maintained, the drying system, the seed cotton cleaning system, and the lint cleaning system. The drying system control examined the moisture content of the seed cotton and lint and adjusted the burners to reduce variation in lint moisture content and to ensure acceptable moisture content at the gin stand. The cleaning control was mainly concerned with bypassing one of the two lint cleaners in the gin when appropriate, but seed cotton cleaner bypass was also included in the design and construction of the overall process control system.

Discussion

As explained by Anthony (1990) control of drying and control of cleaning are interactively linked, which means that controlling one affects the other. In addition, many of the sensors which are used in the two control systems were co-located. For example, the paddle sampler (Anthony, 1992) was used in several locations in the gin to obtain a sample. This sample then had color and trash content measured with a camera-type device, and moisture content measured electronically with a redesigned resistance-type device. The moisture content was primarily used by the dryer control system and the color and trash measurements were primarily used by the cleaner control system.

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Drying control

In Servico Gin, most of the cotton which was ginned was routed from a module feeder into a feed control. When ginning the small amount of cotton from trailers, the seed cotton was dropped into the same feed control. Two moisture sensors were located in the feed control, one was a commercially available system purchased from Samuel Jackson, Incorporated and the other was an experimental resistance moisture system constructed by the U. S. Cotton Ginning Lab (USCGL) based on a patent by Byler and Anthony (1995). The Samuel Jackson sensor was fixed on a small flat protrusion near the bottom of the feed control. The USCGL device was located in the end of a ram (Anthony, 1992). The ram was located in the back of the feed control and was periodically extended to press cotton against the opposite side of feed control. A color/trash camera similar to that used in the classing office was located on the side opposite to the ram and viewed the sample through a window.

This ram sampler station worked well when the cotton was high enough in the feed control to obtain a sample. However, the ginners preferred to use the module feeder to control the feed rate when ginning from modules and the gin could gin faster than cotton could be fed into the system when ginning from trailers so there frequently was not enough cotton in the feed control to obtain a sample. The Samuel Jackson sensor, which was located in such a manner as to contact the cotton as it passed through the feed control, was able to produce a usable measurement more often than the ram sampler moisture meter.

One burner heated the air used to pick up the seed cotton under the feed control which was immediately split into two streams. These two streams passed through parallel tower driers and seed cotton cleaning equipment. Each stream of cotton was then picked up by air heated by two additional burners and then passed through tower driers and further seed cotton cleaners before being fed into three gin stands. Warm, moist air was added in Samuel Jackson Double-Entry Conditioning Hoppers located between the conveyer distributor and the extractor-feeder for each gin stand to increase the moisture content of the cotton before ginning.

A second color/trash/moisture measurement station was located behind the second gin stand and before the lint cleaners for that gin stand. A paddle sampler was used to obtain a sample within the duct and an experimental resistance moisture sensor was built into the sampling paddle so that a moisture measurement was made on one side of the sample while the color and trash measurements were being made on the other side.

The cotton then passed through either one or two lint cleaners. The lint coming from the three sets of lint cleaners was combined into a single lint flue where another sampling station, essentially identical to that between the gin stand and lint cleaners, was located. Moisture restoration equipment added moisture to the cotton lint at

the battery condenser to increase the moisture content before the lint was baled. After the bale was packaged, the bale moisture content was measured by a microwave-based meter, model MMC-4000, manufactured by MALCAM Limited of Tel-Aviv, Israel. The bale moisture content was not used in the moisture control in this system, but the data was recorded by the data collection portion of the control system.

The basic moisture control system in the gin, installed in 1995 before this system was completed, included seven Honeywell 3000 controllers which controlled the temperature of the three hot air streams based on moisture measurements at the feed control. In the 1996 system, the moisture measurements of the fiber after the gin stand were used to send an additional analog signal to the Honeywell controller which sensed the moisture content in the feed control. The moisture measurement in the feed control was used to quickly respond to changes in the incoming cotton moisture content and the measurements after ginning were used to slowly adjust the system to maintain the desired moisture content.

The measurement portion of the drier control system was functional during the 1995 ginning season but the control portion was not completed until the 1996 ginning season. The system was designed to maintain a moisture content behind the second gin stand chosen by the ginner. There has not been sufficient time for a comprehensive analysis of the control system. Based on observations of the operation, the system was capable of responding quickly to changes in the incoming moisture content, however, the burners and thermal lag of the metal portions of the system were limiting factors. The long term control worked well, when stable incoming moisture material was being processed the requested moisture content was maintained. Due to blowing heavy rain, some modules which contained basically dry cotton (below 7% wet basis fiber moisture content) had wet areas in them (above 9% fiber moisture content). The dryer control system was designed to rapidly raise the burner temperatures when higher moisture content seed cotton was detected, partially to compensate for the thermal lag due to the need to heat the metal in the tower driers. At times the wet portion of cotton was small and had passed through the system before it had responded completely to the higher moisture of the incoming cotton. Because of the heat stored in the tower driers, the system then over dried the cotton for a period of time. All of this resulted in more fluctuation in the burners and in the final moisture of the cotton than was desired. Despite this problem, it was observed that the automated system maintained the final moisture content of the cotton nearer the set point than when manual control was used.

Three of the Honeywell controllers were attached to thermocouples located in the tower dryers downstream from each of the three burners. The Honeywell controllers used this signal in the burner control scheme and also produced an analog output of the temperatures, which was recorded. These temperature readings were not used in the control system but will be helpful in the later analysis of the operation of the system.

Cleaning control

The basic approach to optimize the gin process control system was explained by Anthony, Wesley, and Brown (1982). They described how decisions can be made to bypass seed cotton cleaners and/or lint cleaners. Anthony (1990) implemented the approach in a small-scale gin system which also included automated directional valves. A computer implementing this approach, along with equipment to reroute the cotton while ginning, was installed in Servico Gin in 1994. This particular gin had more seed cotton cleaning equipment than most, and was capable of bypassing only one set of stick machines and/or one set of impact cleaners. In addition, it had two stages of lint cleaning with the capability of bypassing one or both stages of lint cleaning.

The control software used by Anthony (1990) used information from measurement stations located before cleaning to decide whether or not to use the cleaning. Because a reliable measurement of the trash level of the seed cotton could not be obtained in the feed control, at Servico Gin, this approach could not be used. Experience had shown that nearly always when data was available the decision was to bypass both sets of seed cotton cleaners and even with both sets of seed cotton cleaners bypassed the gin had as many seed cotton cleaning machines as recommended by Anthony, Hughs and Mayfield (1994). Therefore, these were bypassed the entire ginning season.

The color and trash measurements were made with a standard 750 color head fitted with a camera for video analysis, manufactured by Zellweger Uster. These units had the same hardware and software as that used in the Agricultural Marketing Service cotton classing offices for the determination of High Volume Instrument color and trash. If the second gin stand was operating, the trash and color readings made directly behind the second gin stand were used to decide whether to use one or two lint cleaners, much as described by Anthony (1990). In addition, the color and trash readings taken in the lint flue were used to validate the decision. If the second gin stand was not operating but one or both of the others gin stands were, the lint cleaner decision was based on the measurements at the lint flue. As a general rule, if the lint had a good color but was high in trash two lint cleaners were used, otherwise only one lint cleaner was used.

Software was written so that these decisions could be based on any pricing scheme which the owner of the cotton chose to use. The software was written to recognize the owner based on the module number, then determine if that owner chose to use automated control. If he did, the control was implemented, otherwise, the default cleaning machinery and

drying scheme was used. Before much cotton had been ginned, all of the growers who used this gin chose to use process control to decide how their cotton should be ginned. There is some financial risk in using this system. All measurements are subject to error and certain erroneous measurements will cause the system to make incorrect decisions. In addition, when ginning is done at higher moisture levels and when fewer lint cleaners are used there is an increased risk of a price discount due to preparation. Incorrect decisions by the process control system can cost the owner of the cotton from several cents to several dollars per bale. In the past, systems of this kind have made few incorrect decisions and the profit from the correct decisions has far more than outweighed the losses from incorrect decisions, (Anthony et al., 1995).

Summary

Implementation of a gin process control system at Servico Gin, Courtland, AL, was begun in 1994 with improvements added in 1995 and 1996. The current system includes the functional control system: drying, seed cotton cleaning, and lint cleaning. This paper describes the concepts used in controlling the machinery and drying level to optimize monetary return to the farmer. Over 100,000 bales were processed with this system during the three ginning seasons, 1994-1996.

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