THE NEW AUTOMATIC CLASSING SYSTEM

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Abstract

The USDA Cotton Program is embarking on a revolutionary concept in the area of High Volume Instrument (HVI) cotton classification with the inception of a new Automatic Classing System (ACS). The system's manufacturer, Zellweger Uster, is also the sole source for the Cotton Program's 240 other HVI stations currently used in its twelve classing facilities and the Quality Assurance Section. The ACS, located in the Memphis, TN Classing Office, includes ten HVI stations, six loading stations, one system controller, one unloading station, peripheral equipment, and is interconnected by an integrated conveyor system that moves the cotton through the system automatically. The ACS utilizes new technology to grade cotton samples via HVI without the need for human intervention. The system is presently undergoing extensive precision, accuracy and volume evaluations to satisfy strict USDA requirements before being declared production-ready. Once cleared for production, the system is expected to meet industry needs through improvements in reliability, accuracy and labor savings.

Background

History of HVI Measurements

To fully understand the concept of the new ACS, it is necessary to look at how it evolved. Cotton classification by HVI was first introduced for the growers in 1976 through a pilot project conducted in Lubbock, TX. After further study, the classing office in Lamesa, TX was the first office to provide 100 percent HVI testing in 1980. This was one of the most significant advancements in cotton classification as it officially introduced the cotton industry to the benefits of additional cotton fiber quality measurements previously unavailable.

HVI grading spread throughout the cotton industry due to the demand for instrument measurements for color, length, length uniformity and strength. The Cotton Program offered the new services to producers on a voluntary basis over the next few years as HVI technology continued to evolve. However, the push toward instrument grading culminated in 1991 when the USDA implemented 100% HVI testing as the official grades for the U.S. Upland cotton factors of length, length uniformity and strength. These HVI fiber quality measurements, in addition to grade and micronaire, provided better assessments of market value and improved end-user utilization to manufacturers.

Through the 1990s, the Cotton Program provided official HVI classification results for length, length uniformity, strength, and micronaire while still maintaining manual classification to determine the official grades for color, leaf and extraneous matter. The manual classers, trained by the Cotton Program, determined the color and leaf by visual comparison of cotton samples to the Universal Cotton Standards. Even though the classer grade was the official grade for color and leaf, the HVI has always been capable of measurements for both color and trash. The HVI color is measured in two components: Rd (reflectance or brightness) and +b (yellowness). The intersection of the Rd and +b measurements on the Nickerson-Hunter Color Diagram, the official chart used to correlate instrument measurements with the Universal Cotton Standards, determines the HVI color grade. The HVI measures trash content as a relation of percent area of trash particles detected by its camera.

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HVI Color Grade as the Official Color Grade

In 2000, the Cotton Program took another large step toward full instrument classification with the adoption of HVI color as the official U.S. color grade. With U.S. industry support, the HVI color was accepted as the official color grade effective July 1, 2000. With this progressive step, only the quality factors of leaf and extraneous matter remain as manual determinations (Earnest, 2000).

History of HVI Equipment

In the 1980s and early 1990s, two predominant manufacturers supplied all of the HVI equipment to the USDA. These were Spinlab Incorporated and Motion Control Incorporated (MCI). HVI equipment and components have undergone drastic changes and improvements over the years. With enhanced technology and increased emphasis on efficiency and ergonomics, the HVI evolved from a bulky three-operator station in the 1980s to a more refined one-operator machine by the mid-1990s. The Cotton Program embraced this new design not only for its improved technical capabilities but also for its efficiency in terms of space and labor utilization. The Cotton Program equipped all of its classing offices with one-operator instruments and continued to strive for better technology with each new version. Entering the 2000 cotton season, the Cotton Program operated approximately 240 one-operator HVI stations throughout its twelve classing offices and the Quality Assurance Section.

Evolution of the Automated Classing System

ACS Concept

In 1998, Zellweger Uster approached the USDA Cotton Program with the concept of manufacturing a new HVI that would perform without the need of human operators. This concept was immediately appealing from the standpoint of improved efficiency in operations and labor. The Cotton Program has always vigorously investigated any avenues that held potential for improved efficiency in operations. Pursuing such avenues has resulted in the implementation of new innovations in conditioning equipment, automation systems, technical equipment, and workstations for the classification process. Even with these new innovations, the problems affiliated with hiring and retaining skilled HVI operators escalated over the years in all of the Cotton Program's offices primarily due to low unemployment rates. The development of an improved HVI capable of operating without the need for human intervention was especially attractive because it could address labor difficulties while improving efficiency.

Another appealing concept of the ACS is its design as a system rather than a fragmented group of individual HVI stations within the laboratory. This design of multiple HVI stations interconnected by a programmable integrated conveyor operates in a continuous cycle and thus, does not require the manual labor affiliated with the current methods.

The Cotton Program's human classers will serve a dual role with the ACS. In addition to performing the visual determinations for leaf grade and extraneous matter, these individuals will also operate the loading stations. Effectively utilizing the classers to perform both duties will eliminate the need for additional personnel to operate the loaders, thus enhancing efficiency. The only additional tasks required of the classer will be to place the sample into a loading chamber and push a button to activate the loading station. Once activated, the loader will automatically load the sample into a specially designed plastic cassette for transport throughout the rest of the classification process.

The ACS concept also makes provisions for other important operations within the classification process previously performed manually by HVI operators or classers. Tasks such as the retesting of samples with initial HVI measurements outside instrument parameters, routing and holding of samples for specific purposes such as checklots or standards, and disposing

of samples after all classification is completed will now be handled automatically.

A main system controller, referred to as "SYSCON", will control and monitor all operations within the ACS and will alert Cotton Program personnel in the event of trouble or malfunction. All software for the system is written to be compatible with the Cotton Program's central computer system to ensure instantaneous capture of classification data.

The individual HVI stations will have modular components to provide easier service and minimal downtime. In the event of a component failure on a given HVI, the module containing the component can be removed quickly and replaced with an operational module. The HVI can then resume operation while a technician performs repair work to the faulty module off-line.

Phases of ACS

In early 1999, Zellweger Uster presented an "Alpha" model of the new HVI equipment to the Cotton Program. The Alpha model only consisted of a single instrument primarily focusing on the HVI measurement components. This conceptual instrument was demonstrated and both parties had an opportunity to evaluate its performance and potential.

Later in 1999, Zellweger Uster presented a "Beta" system model to the Cotton Program consisting of a revised HVI station, a loading station, unloading station, and a section of integrated conveyor connecting all of the various stations and components. The Beta system was demonstrated which provided the Cotton Program an opportunity to see first-hand, on a small scale, how the proposed system would operate. The Beta system was rigidly tested to evaluate strengths, weaknesses, logistics, and throughput potential. Afterward, both parties conducted numerous meetings to discuss the evaluations and discuss concerns.

Objectives of New Automated Classing System

While evaluating the Beta model of the ACS, the Cotton Program carefully considered the objectives that the new equipment must satisfy in order to justify contracting the system for official cotton classification. These objectives were discussed with Zellweger Uster. First and foremost to the Cotton Program was the assurance that the ACS would provide more reliable and efficient services than current HVI equipment. In order to accomplish this, the ACS would utilize the latest technologies available while addressing the challenges of a limited workforce. It was also imperative that the ACS provides flexibility in servicing individual components using limited resources such as personnel and tools.

Implementation of the ACS

Installation of the ACS began in June 2000 in the Memphis Classing Office. The integrated conveyor system and overall "skeleton" of the system were the first components installed. The layout of the individual components was crucial since the overall equipment configuration was designed to fit the existing dimensions of the Memphis laboratory. Once the skeleton was in place, installation continued for all of the primary machinery, utility services, and peripheral equipment.

ACS Attributes

The ACS consists of five primary sections. These are the loading stations [6], integrated conveyor system (ICS), High Volume Instruments (HVI) [10], System Controller (SYSCON), and the unloading station. Each of these sections provides a critical function in the classification process by providing transportation, testing, data transmission, and disposal of the samples.

Loading Station

The loading station requires a human operator and consists of a work surface, loading chamber, computer terminal, keyboard, scanner, tray stand, and cotton waste chute. The terminal is connected to the USDA's central computer system (Tandem) that processes all of the classification data for the USDA. The loading station serves two purposes in the classification process. First, the classer uses it to grade each sample for leaf content and the existence of extraneous matter. This data, along with the sample's identification number, is entered into the Tandem computer system via the keyboard and scanner. Second, the classer places the sample into the loading chamber and activates the system with a push of a button located on the station. Once activated, the sample is automatically loaded into the specifically designed cassette already equipped with its own unique identification. This identification is automatically scanned and transmitted to the SYSCON to allow the sample to be tracked throughout the classification process. This provides a redundancy in the system whereby the SYSCON and the Tandem each have the necessary information to match the bale identification with the proper cassette identification.

Integrated Conveyor System (ICS)

The integrated conveyor system serves as the means of transporting the samples via cassette throughout the ACS. The ICS consists of two tiers of conveyors. The upper tier is primarily responsible for the conveyance of cassettes from the loading stations to the HVI stations. The lower tier serves to return the cassettes to an unloading station after they have been HVI tested. The unloading station also serves as a distribution station where a barcode reader scans the cassette identification to determine the next step in the process for the sample. The sample may require retesting, holding, or disposal. Once this decision is made, the ICS transports the sample to its destination.

Each of the two tiers is controlled by a Programmable Logic Controller (PLC) and contains sensors and diverters controlled through intelligence software to help avoid any obstruction, blockage, or to bypass any instrument(s) being repaired or maintained. The ICS runs continuously throughout the operation and numerous diverters are utilized throughout the system to stop or alter the path of a cassette. Several elevators are located throughout the conveyor and HVI stations to transport cassettes to and from the two tiers of the conveying system as necessary.

High Volume Instrument (HVI) Stations

The HVI is where the actual cotton fiber testing occurs. As with past models, this new HVI measures the fiber length, length uniformity, strength, micronaire, color reflectance of the cotton fibers (Rd), yellowness of the cotton fibers (+b), trash, short fiber content, and elongation. This instrument exceeds the technology of the previous generation of HVI by providing a measurement for moisture content and a new trash measurement capable of discerning leaf from extraneous matter. This trash measurement utilizes digital image analysis software to distinguish bark and grass from leaf.

The cassette containing each cotton sample pauses at four different points within the HVI to allow for fiber testing. At the entrance of the HVI, the cassette passes through a barcode scanner that transmits the sample identity to the HVI. The HVI allows the cassette to pass through while stopping it at various points to obtain specific fiber measurements.

Micronaire is a measurement of a cotton sample's fineness. Micronaire is obtained by applying pressure to the cotton sample and using mechanical "picking" devices to obtain the correct amount of cotton necessary for the measurement. Air is forced through the cotton fibers to measure resistance. The fibers are weighed on a scale and the HVI calculates the micronaire.

The color measurement is obtained by pressing the cotton sample in the cassette flush against a glass window. Xenon flash technology is used to

provide the lighting necessary for obtaining the Rd and +b readings from the sample. This Xenon flash technology is also new to the USDA and provides a more stable lighting than the previous lighting found on the 900-U models. This Rd and +b color data is compiled to determine the overall color grade of the cotton sample. The trash measurements are taken at the same location as the color and provides trash data related to particle count, a percentage of the total area occupied by trash, and the aforementioned feature discerning leaf from extraneous matter (bark and grass) in the cotton sample.

The measurements associated with fiber length and strength are obtained by applying pressure to the sample and retrieving necessary specimens using clamping combs. The combs are attached to a miniature belt conveyor that is controlled through the actuation of sensors to perform precise combing and brushing of the fibers prior to actual testing. Once the specimen combs are prepared, the measurements affiliated with length and strength are taken.

System Controller (SYSCON)

Once the HVI testing is completed, the ICS transports the samples out of the HVI. The SYSCON communicates with the HVI to verify if the sample's fiber measurements are complete and to determine the next path of each sample. The SYSCON and the Tandem also communicate to determine which samples will be diverted to a holding area for specific purposes such as checklots, training, or cotton standards creation. All of these decisions are made prior to the unloading process through the logic of the SYSCON and then relayed to the conveying system. If the sample is sent to the holding area for a specific purpose, a barcode reader will read the cassette identification and relay the information to a barcode printer located adjacent to the holding area. This printer will then print an official bale identification tag to match the identity of the sample as well as display any other information specific to that sample such as the reason for its retrieval. If no special requirements exist then the cotton sample in the cassette is removed via the unloading station and the empty cassette is sent back to the loading stations. A diverter exists just prior to the loading stations to determine which loading station will receive the next empty cassette. All loading stations are kept stocked with empty cassettes by the SYSCON to avoid any delays caused by waiting for cassettes.

Unloading Station

The unloading station serves as the point where the decision is carried out as to the next destination of each sample. Each sample will take one of three routes upon arrival at the unloading station: 1) return to the HVI stations for retesting; 2) transport to the holding area for a specific purpose; or 3) be unloaded at the station into the cotton removal system. If a sample requires a retest, the ICS will automatically route the cassette back through the HVI stations where a retest will occur. Once the retest is complete, the cassette will travel back through the unloading station where the decision process will again take place.

If the sample has been earmarked for a specific purpose, i.e. checklot, training, standards, etc., it is routed to the holding area where it is given proper identification and handled accordingly by a Cotton Program employee. If no further testing or handling is required for the sample, it is automatically removed from the cassette and disposed into the sample removal system for transport underground to the bale press in the rear of the Classing Office. Once unloaded, the empty cassettes are transported by the ICS back to the loading stations where the classification process begins again with a new sample.

Evaluation of ACS

Evaluation Criteria

In order to be declared production-ready, the ACS must pass a series of performance evaluations first for precision and accuracy, and then for production volume. Zellweger Uster conducts its own internal evaluations throughout the installation and testing phases of the ACS implementation. These are separate from those mandated in the contract between Zellweger Uster and the Cotton Program. Once the ACS is completely installed, a series of rigorous performance evaluations are conducted by the Cotton Program to ensure absolute adherence to contract specifications and requirements. Each HVI measurement is tested individually using several known-value cottons to test precision and accuracy. Once all HVI components have passed these evaluations, a production volume test is conducted on the ACS. This evaluation will test the speed of the system with respect to the contract specifications.

Evaluation Results

Preliminary evaluations for precision and accuracy were performed on all individual HVI components throughout the ACS. All HVI components passed these preliminary evaluations. Preliminary tests were conducted on the ICS and loading stations using empty cassettes to verify proper routing and controls. Production volume testing was scheduled to begin shortly thereafter but was postponed due to delays affiliated with the ICS, system controllers, and communications between the SYSCON, Tandem, and ACS equipment. Individual testing of components has continued as well as additional conveyor tests using empty cassettes. Corrective procedures are underway to alleviate operational problems.

Once the problems are alleviated, the evaluation procedures will continue. Further HVI component tests for precision and accuracy will take place followed by production volume testing. USDA Cotton Program personnel will supervise all evaluation procedures and results to ensure absolute integrity. Results will be checked and verified by Cotton Program management prior to any approval. Meetings will be conducted between Zellweger Uster and the Cotton Program to verify concurrence on all evaluation results. The ACS will not be certified as "production ready" until it passes all evaluation criteria according to contract specifications.

Conclusions

As of December 31, 2000, final evaluations and production volume testing for the Automated Classing System in the USDA Cotton Program's Memphis, TN Classing Office were incomplete. Performance evaluations were postponed pending further testing and modifications to operational and communications software. These modifications are underway and evaluations will resume once they are completed and tested.

The development and implementation of the ACS is a bold and innovative step forward for the Cotton Program and for cotton classification as a whole. The Cotton Program is convinced that this type of technology is the direction of the future for HVI classification. The ACS holds great potential in terms of increased efficiency, accuracy, timeliness, and labor savings. Once realized, the Cotton Program can pass along these benefits to the cotton industry through improved classification services. As part of its mission, the Cotton Program is committed to providing the most reliable, accurate, timely, and cost-effective data possible to its customers. The advanced technology and efficiency potential of the Automated Classing System is one means of assisting the Cotton Program in this mission.

References

Earnest, D. W. 2000, HVI Color and Other Cotton Program Issues, 2000 Engineered Fiber Selection System Conference, Proceedings in press.