ADVANCEMENTS IN USDA COTTON CLASSING FACILITIES

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Abstract

The U.S. Department of Agriculture, Agricultural Marketing Service, Cotton Division has made vast improvements in several areas of its operation over the course of the last three years. Advancements in Heating, Ventilation, and Air Conditioning systems and High Volume Instrument classification technology as well as the development and implementation of process flow automation, rapid conditioning of cotton samples, and operation mechanization have resulted in a more efficient process yielding the most accurate and timely classification results possible. The advancements made in the classification process reflect the Cotton Division's ongoing efforts to improve the services provided to its customers.

Introduction

The process of classifying cotton samples has virtually been revolutionized by the USDA, AMS, Cotton Division since the early 1990's with the inception of 100% classification by High Volume Instruments (HVI). The implementation of HVI classification in all USDA classing facilities introduced a more technical means of classing cotton samples. As HVI technology improved, the need grew for tighter control of the environmental conditions within classing facilities. Efforts also increased to develop more efficient methods of sample preparation and testing, sample flow through the classification process, removal of dust and lint particles from the work environment and labor utilization.

The Cotton Division continues its efforts each year to develop and implement new technology and equipment to increase productivity and efficiency in all facets of cotton classification. Of the fourteen classing facilities currently operating in the United States, only two were constructed prior to 1986. This reflects the Cotton Division's efforts to operate modern facilities designed to accommodate changing technologies. New or renovated facilities constructed since 1986 are in the following locations accompanied by their respective year of construction:

Abilene, Texas, 1991	Lubbock, Texas, 1987
Birmingham, Alabama, 1990	Macon, Georgia, 1996
Corpus Christi, Texas, 1989	Memphis, Tennessee, 1995
Dumas, Arkansas, 1994	Phoenix, Arizona, 1986
Florence, South Carolina, 1994	Rayville, Louisiana, 1992
Harlingen, Texas, 1987	Visalia, California, 1991

There are only two facilities currently in operation that were constructed prior to 1986. These are located in Hayti, Missouri, constructed in 1967, and Lamesa, Texas, constructed in 1980. These facilities have undergone several internal modifications over the years.

This paper will describe several of the most recent advancements that have been developed and implemented in many of the Cotton Division's classing facilities. In addition, it will discuss how these advancements work together to produce an efficient process of classifying samples. Improved Heating, Ventilation, and Air Conditioning (HVAC) systems installed in new and existing classing facilities maintain the strict atmospheric conditions that are imperative in laboratories and conditioning rooms for accurate HVI testing. These HVAC systems are the basis for the new Rapid Conditioning Units (RCU) and also provide the laboratories with a very effective method of removing cotton dust and lint from the work environment. The implementation of the RCU has reduced the time necessary to properly condition cotton samples for HVI testing to a fraction of what was required in the past. Progressive advancements in HVI technology have continued to enhance the accuracy and precision of fiber quality measurements while reducing the labor requirement for operation to one individual. Zero-pressure accumulating roller conveyor systems have automated the flow of cotton samples to and from work stations while minimizing the need to manually handle samples. The automation of specific operations performed manually in the past has also increased productivity by reducing the amount of physical labor needed to perform certain tasks.

Improved HVAC Systems

The implementation of HVI classification in all USDA cotton classing facilities necessitated the need for control of the moisture content within individual cotton samples. Prior to any HVI testing, the Cotton Division requires that cotton samples reach a moisture content equilibrium level between 6.75% and 8.25%. To control the moisture content within the individual cotton samples, the Cotton Division controls the atmospheric conditions surrounding the samples. The classing facilities maintain atmospheric conditions for sample conditioning and testing at a standard of 70 degrees Fahrenheit +/- one degree and 65 percent relative humidity +/- two percent. This standard was established in 1985 as a result of a detailed study funded by the USDA to determine the optimum level of control needed to ensure accurate and precise fiber measurements.

To maintain the required atmospheric conditions for HVI testing, the Cotton Division has implemented more sophisticated HVAC systems in its new classing facilities and upgraded equipment in its older facilities. Growing cotton production and the Cotton Division's dedication to

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improving customer service has resulted in the need for more HVI lines, better dust and lint removal, improved lighting, a more productive process flow, and the development of the RCU. These developments have increased the requirements for HVAC equipment capacity, durability, and reliability. These systems now carry much of the burden in the classing facility's ability to operate around the clock and provide accurate and timely results.

Cotton Division HVAC systems operate under a "cycle" concept which begins with a supply of conditioned air delivered to a laboratory or conditioning room. Through a series of processes, this air is removed, cleaned, humidified, dehumidified, heated and cooled, as needed, before being delivered back into the same room again as conditioned air (See Figure 1). A new supply of conditioned air is delivered to a classing laboratory approximately every two minutes and to a sample conditioning room approximately every four minutes. This air exchange is what maintains the balance of atmospheric conditions within the rooms. A thorough description of the HVAC systems' components and operation can be found in a paper published last year (Earnest, 1995).

These advanced HVAC systems utilize a microprocessor based method for controlling specific operations. Direct Digital Control (DDC) technology directly controls the individual points of operation in the HVAC system through the use of various sensors, controllers, and electronic devices. These highly technical devices have the capability of instantaneously updating control data to ensure that the system makes the necessary adjustments to room conditions as they are required. This DDC technology also provides a monitoring capability whereby Cotton Division or maintenance personnel can continuously monitor the HVAC system's operation. This attribute aids in the maintenance and trouble-shooting of the HVAC system while providing valuable data about the system's components which can be used to prevent problems and track the system's performance. The implementation of the improved HVAC systems has allowed the Cotton Division to consistently maintain tight limits on atmospheric conditions in laboratories and conditioning rooms which, in turn, contributes to accurate classification of cotton samples.

Improved Dust and Lint Removal Systems

Another important byproduct of the more sophisticated HVAC systems is the built-in dust and lint removal system that is configured into the overall design. Air that is supplied to the laboratory must be removed and returned back to the HVAC system for reconditioning to ensure the balance of atmospheric conditions within the room. The most beneficial method of removing this air from the room is through intake boxes located at every work station in the laboratory. This design returns this air to the HVAC system while providing employees with an effective method of removing cotton dust and lint particles from their work areas. The dust and lint removal system is comprised of a series of underground air ducts installed throughout the laboratory and extending into the mechanical room. Individual duct ports are strategically located in recessed enclosures to allow easy connection to stationary dust intake boxes located at each employee work station. Large high velocity fans located downstream in the ductwork pull air through each work station intake box and deliver it to the air handling unit serving the laboratory. This air carries dust and lint particles away from the work stations. As the air arrives into the air handling unit, it is cleaned and reconditioned by the HVAC equipment before being supplied back into the room. The essential process of returning air to the HVAC system not only helps to maintain the strict atmospheric conditions within the laboratory but also provides a clean and healthy work environment for Cotton Division employees.

The standard for maximum allowable dust and lint particle content in a Cotton Division laboratory is 500 micrograms per cubic meter, mean concentration, averaged over an eight-hour period. The Cotton Division has consistently maintained levels considerably less than 500 micrograms per cubic meter in all of its classing facilities. Most classing facilities equipped with the built-in dust and lint removal systems described in this section consistently maintain a dust and lint particle level of less than 100 micrograms per cubic meter, mean concentration, averaged over an eight-hour period.

Rapid Conditioning Units

The Rapid Conditioning Unit (RCU) was introduced to cotton classification in 1993 as a means of rapidly conditioning cotton samples to an acceptable moisture content prior to testing on HVI equipment (See Figure 2). The RCU was designed by USDA Cotton Division personnel and has been implemented in seven classing facilities since its inception. The RCU works under the basic concept of drawing conditioned air through cotton samples to enable them to reach the proper moisture content level for HVI testing rather than storing them in stationary racks until they absorb the proper amount of moisture (Alldredge, Knowlton, 1994, 1995). The primary component of the RCU is a wire mesh belt conveyor located in the classing facility's conditioning room. This conveyor is equipped with a sheet metal plenum attached beneath its bed. This plenum is attached to a series of sheet metal ducts that eventually connect to the air handling unit that supplies conditioned air to the conditioning room. A high velocity fan is located within this series of ducts close to the air handling unit. This fan pulls surrounding air from the conditioning room and directs it through the cotton samples as they move along the length of the wire mesh conveyor. The RCU serves as the primary means for returning air back to the air handling unit to be reconditioned and re-supplied to the room as conditioned air. This is a vital part of the conditioning cycle of the HVAC system. The addition of the RCU to classing facility operations has increased the importance of the HVAC system in the overall classification process. The HVAC system is now required to supply enough conditioned air to the conditioning room to accommodate both the room itself and the requirements of the RCU. This supply of air is essential for proper conditioning on the RCU. Without the HVAC's effective operation, the RCU cannot perform to the Cotton Division's standards.

Shortly after cotton samples arrive to a classing facility, they are removed from their delivery sacks and placed into plastic trays. The trays are then placed on the RCU where they will slowly travel the entire length of the conveyor and eventually pass onto another conveyor extending into the classing laboratory. These trays are fabricated with many openings throughout the bottom, and along with the configuration of the wire mesh conveyor, allow the conditioned air to readily pass through the samples and into the RCU's plenum. The time required for a tray of cotton samples to travel the length of the RCU and rapidly condition to an acceptable moisture equilibrium level is approximately five to ten minutes depending upon such variables as differences in cottons, sample size, incoming sample moisture content, air velocity, and the static pressure across the samples. This conditioning time is significantly less than the 48 hours required to condition cotton samples prior to the inception of the RCU.

Overall, the RCU serves two main functions in the cotton classification process: 1) it rapidly conditions cotton samples to a moisture content acceptable for HVI testing, and 2) it serves as a component in the automated flow of samples through the classification process. In addition, the RCU makes convenient use of the air that is already required for conditioning the room. It returns the room air back into the HVAC system to be reconditioned and re-supplied to the room, thus not affecting the primary concept behind the HVAC's design and purpose.

The implementation of the RCU has provided the Cotton Division with many benefits that were not possible before. Cotton samples can now be classified on the same day in which they are received at the classing facility. Storage requirements are much less than they were a few years ago due to the reduction in the number of bulky storage racks needed in a conditioning room for sample preparation. A much more efficient process flow has resulted from automating the conditioning process and connecting the RCU to other automated sample movement equipment. These advantages have resulted in reduced operating expenses, improved productivity per staff hour, reductions in day-to-day carryover of samples allowing for improved management of shift work requirements, and facilitation of accurate testing of cotton fiber properties.

Zero-pressure Accumulating Powered Roller Conveyors

The need to automate the cotton classification process as much as possible necessitated the implementation of powered conveyors in the laboratories of classing facilities. The utilization of plastic trays for transporting cotton samples across the RCU produced a need for a conveyor system that could easily move the trays without producing a great deal of forward pressure between them. Until recent years, cotton samples were transported through the classification process primarily by manual movements. The samples were manually unsacked, trayed, and moved to and from individual HVI lines and classing stations. Empty trays were then manually moved and stacked in the conditioning room where the process started over again.

The recent inception of the zero-pressure accumulating roller conveyors has eliminated much of this manual movement while providing an efficient means of delivering trays of cotton samples to the laboratory work stations and returning empty trays to the conditioning room. The zero-pressure conveyors are comprised of many individually powered zones of rollers driven by cables or narrow belts. Each zone works independently of the others. When a zone is activated, it moves all trays behind it forward until all of the zones are filled with trays. This ensures that all available zones have a supply of samples for the work station operators at all times, thus eliminating any lost time attributed to a lack of available trays. The zero-pressure system moves all of the trays up to available zones without allowing them to touch, eliminating pressure between them and making it easy for workers to remove the trays. The low maintenance zero-pressure conveyors have minimized the need for manual movement of trays and samples. This, in turn, has increased productivity and efficiency in the cotton classification process.

Improved High Volume Instruments (HVI)

The HVI itself has played an integral part in the Cotton Division's increase in efficiency and productivity. Improved technology has brought the HVI from a large, three-operator instrument to a smaller, more ergonomic one-operator design while still improving the operation capabilities and accuracy of the instrument's test results. The various components of the instrument have been strategically located to minimize operator movement while decreasing the time needed to process a cotton sample. The most recent HVI lines are capable of processing a cotton sample for seven quality factors in approximately thirty seconds. These factors are fiber strength, fiber length, fiber length uniformity, micronaire, color (Rd), color (+b), and trash content. As each sample is tested, these quality measurements are recorded on a computer record for that sample in the classing facility's computer system. This type of HVI line maximizes the amount of cotton samples that can be tested in a day of operation while not sacrificing the accuracy of the fiber quality measurements.

Individually Automated Operations

Through efforts to maximize efficiency in the cotton classification process, the Cotton Division has automated some operations previously performed manually. One such operation is the removal of cotton samples from delivery sacks. On the surface, this may appear to be a somewhat trivial exercise with little benefit. However, cotton samples are packed very tightly in sacks prior to being delivered to the classing facilities. Manually removing these samples from the sack tends to be a strenuous process and often requires a significant amount of time. A device was developed by Cotton Division personnel prior to the 1994 season that automates the process of “unsacking” samples. This device, known as an “unsacking machine”, is composed of a pneumatic ram mounted behind a frame that holds a full sack of cotton. The sack sits firmly in place with its mouth open and tied off while the pneumatic ram pushes the samples out from behind. The samples are pushed out onto a table that is used for traying the samples. The support frame for the unsacking machine is constructed of steel and is equipped with casters to allow the machine to be mobile. The ram is controlled by push button controls located on the machine’s support frame. During the 1995 cotton classing season, the unsacking machine was implemented in several classing facilities and reduced the physical labor and time required to unsack samples. It also fit in well with the automated flow concept implemented in the classing facilities due to its work station design and location in relation to other automation equipment.

Another type of equipment that has improved the automated process flow in many classing facilities is the gravity conveyor. This often overlooked piece of equipment is used to connect some of the other process flow components together. These conveyors are often used to transport plastic trays from the traying table to the RCU and from the RCU to the zero-pressure conveyors. These lightweight and durable conveyors are capable of being assembled almost anywhere and serve as a reliable part of the Cotton Division’s automated classification process.

The Cotton Classification Process Flow

Thus far, this paper has discussed the function of individual devices or equipment systems that contribute to the overall classification process. Each one of these components serves a vital purpose in the accurate and timely classification of cotton samples. However, it is the interaction between components that increases efficiency in the classing facilities. The effectiveness of the flow from one component to the next oftentimes contributes to the overall efficiency as much as the individual processes themselves. The following section of this paper will describe how the classification process evolves once the cotton samples are delivered to a classing facility.

When the sacks of samples are delivered to a classing facility, they are brought into the conditioning room through an air lock. This air lock prevents outside air from interacting with the conditioned air inside. Once inside, the sacks are stored in groups based on their time of delivery. This produces a first-in-first-out procedure for processing the samples. When the time comes, a sack of cotton is carried to the unsacking machine either by a gravity conveyor or on a mobile buggy capable of carrying many sacks. At the machine, the samples are removed from the sack onto a traying table. Workers then place the samples into plastic trays and load the trays onto the RCU either manually or via gravity conveyor depending on the traying table’s location in relation to the RCU. The trayed samples now begin the rapid conditioning process.

As the trays move along the wire mesh belt, the conditioned air generated by the HVAC system is drawn through the samples by the RCU fan. This air returns through the RCU plenum to the air handler for reconditioning. After the tray completes its five to ten minute journey down the RCU, a worker takes moisture readings of the tray’s samples with a hand-held moisture monitor. If the readings are acceptable, the tray is allowed to continue the process. If the readings are not acceptable, the tray is removed and taken back to the loading end of the RCU to be conditioned again.

Once a tray completes the rapid conditioning process, it rolls onto the zero-pressure conveyors which transports it to the area of the laboratory containing HVI lines. The tray moves up along the conveyor until an operator removes it for HVI testing. When the tray is removed from the conveyor, it is placed on a stand. The samples are then removed from the tray, HVI tested, and placed into another plastic tray. As the samples are HVI tested, the measurements are collected in the computer system and stored. When the receiving tray is full, it is placed onto another zero-pressure conveyor (located directly above the one previously mentioned) and carried to the manual classing stations located in another area of the laboratory. When the tray arrives in this area, it is removed by a classer and the samples are manually classified for color, leaf content, and any extraneous matter that may be present. After each sample is classed and the information is entered into a computer, the sample is discarded into an underground trench equipped with a sample removal system that transports the cotton samples to the rear of the building to be pressed into bales. The empty trays are placed on yet another conveyor located directly above the other two and transported back to the loading end of the RCU. The trays are removed from this point and stacked next to the traying table where the process starts all over again. This point marks the completion of a cycle in the classification process.

Collection and Dissemination of Classing Data

Another important aspect of the classification process involves the collection of information from each sample of cotton as it is classified on the HVI line and by a manual classer. As the quality factors are measured on the HVI lines, the data is sent via computer network to the classing facility's computer system. This is a mini computer system capable of handling vast amounts of classing data. When the samples are manually classified for color, trash content, and extraneous matter, the information is sent to the computer system and matched with the HVI information for that particular sample. Once this information is collected and compiled, it becomes available to customers through various means such as telecommunications, diskette, tapes, and punch cards (Morris, 1995).

Conclusions

Recent advancements in design, development, and implementation of new equipment and technology have allowed the USDA, AMS, Cotton Division to significantly improve its overall cotton classification process. Several classing facilities now have the capability of classifying samples on the same day in which they are received through the implementation of the Rapid Conditioning Unit. Sophisticated HVAC systems successfully maintain strict atmospheric conditions for sample preparation and testing while providing an efficient method for removing dust and lint particles from the work environment. Manual movement of cotton samples has been greatly reduced and efficiency increased with the inception of zero-pressure accumulating conveyors and other types of automated equipment. Recent improvements in the design and operation of the HVI has maintained the accuracy of test results while reducing the time and labor required to process a sample. Smaller components such as the unsacking machine and connection gravity conveyors have contributed to improved process flow. All of the advancements discussed in this paper have increased the Cotton Division's productivity and efficiency levels while improving the accuracy and timeliness of service given to its customers. The USDA, AMS, Cotton Division is continuously working to improve upon current innovations as well as investigating new equipment and technologies.

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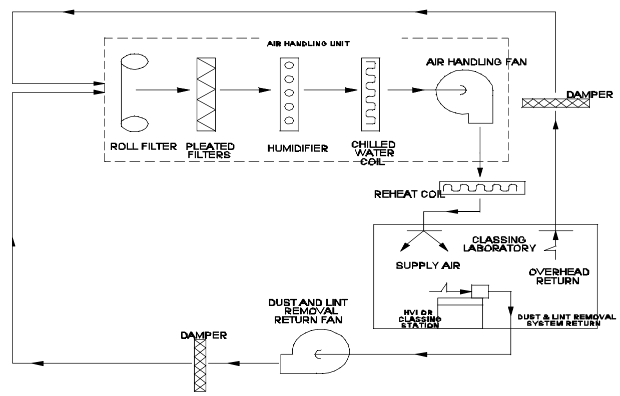

Figure 1. Various stages of the Heating, Ventilation, and Air Conditioning (HVAC) Cycle.

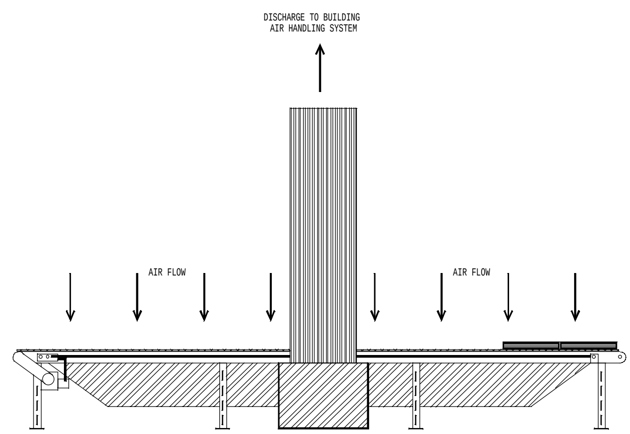

Figure 2. Rapid Conditioning Unit (RCU).