IMPROVEMENTS IN HVI TRASH MEASUREMENT PROCEDURES

James L. Knowlton
Agricultural Engineer and Assistant Chief
Standardization and Quality Assurance Branch
USDA, AMS, Cotton Program
Memphis, TN

Abstract

Development of systematic procedures for setting up and calibrating the High Volume Instrument (HVI) trashmeter have resulted in improved operation and performance. New setup and calibration procedures implemented in 1998 provide a level of diagnostic thoroughness and calibration precision that greatly exceeds previous methods. The success of the current trash measurement system is a result of steady progress that began with development of trash measurement standards and continued with emphasis on instrument setup and calibration. Overall Cotton Program HVI trashmeter reproducibility for the 1998 classing season exceeded the previous high record by four percentage points.

Introduction

The video scan trashmeter has been an integral part of the HVI since the late 1980's. The development of the HVI trashmeter from analog scanning technology to modern digital image analysis has resulted in a measurement system capable of providing accurate and reliable cotton trash measurements. In addition to improvements in instrumentation, improved calibration standards and refined operating procedures have also contributed to improved measurement accuracy. The knowledge and technology behind today's cotton trash measurement has resulted from experience and study of the trash measurement as it has evolved over the years.

In 1998, the Cotton Program operated 242 HVI systems spread throughout the cotton belt in thirteen classing offices and the Quality Assurance Unit based in Memphis, Tennessee. One hundred and eighty Cotton Program HVI's are 900U (USDA production model) HVI systems manufactured by Zellweger Uster. The 900U was introduced in 1994 and with the purchase of 30 more systems this year the 900U will account for 210 of the 242 Cotton Program HVI systems. Since the 900U is the Cotton Program's principle HVI model, trash measurement improvement efforts have focused primarily on the 900U trashmeter. In 1998, the Cotton Program implemented new calibration and setup procedures for the 900U which also included a specialized set of tiles. Zellweger Uster engineers cooperated by providing software and hardware enhancements that were necessary for reaching trash measurement improvement goals.

Development of HVI Trashmeter Calibration Standards

The HVI trash calibration tile served as the only calibration standard during the early years of trashmeter usage. However, given the development changes from year to year, the inadequacy of the trash calibration tile as the only calibration standard became apparent. Difficulty was experienced in maintaining a constant percent area measurement level on cottons between trashmeters in spite of a constant percent area measurement level on tiles. In other words, the relationship between trash tile area measurements and actual cotton trash area measurements was different between different makes and models of trashmeters. As a result, in 1991 a cotton trashmeter calibration standard was developed (Randle, 1992). The cotton trash standard, which remains in use today, consists of a set of six cottons each placed inside a small plastic box with a clear optical quality glass over the cotton surface being measured. The enclosed samples are held tightly in place and protected from changes in trash content. The six cottons contain different trash contents representing classer leaf grades 2 through 7. The purpose of the "cottons-under-glass" trash standards is to serve as the absolute reference for cotton trash measurements. Following the development of the cottons-under-glass, the calibration tile no longer served as an absolute trashmeter calibration standard. Instead, the calibration tile would provide a trashmeter calibration relative to the level established by the cottons-under-glass.

Values for tile and cotton standards were first established by the Cotton Program in 1991 on a high resolution image analysis system at USDA's Agricultural Research Service in New Orleans, Louisiana. The decision to establish standards on an instrument other than the HVI trashmeter was due to the fact that in 1991 there were two HVI manufacturers. In fairness and in order to get the manufacturers to support the USDA standards, an image analysis system was selected because it was an independent system with no affiliation with either HVI manufacturer. In 1996, the Cotton Program established values on a new image analysis system that was set up in the Memphis office. In 1997, given that the Motion Control HVI was no longer being manufactured and the 900U had become the predominant trashmeter, the decision was made to designate the 900U trashmeter as the master value establishment system.

Although various instruments have served as designated master value estabishment systems through the years, the absolute standard for the trash measurement remains the cottons-under-glass. Two "master" cottons-under-glass sets, maintained by the Cotton Program in Memphis, Tennessee, serve as the ultimate reference for master

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:663-665 (1999)
National Cotton Council, Memphis TN

instrument calibration. Therefore, all trash calibration materials, whether tiles or cottons, are given values that are established at the level of the master "cottons-under-glass" sets.

Development of the 900U HVI Trashmeter Calibration Method

Original Calibration Method

In 1994, the first forty 900U HVI systems were obtained. From that time continuing through the 1996 classing season, 900U trashmeter calibration involved a manual calibration procedure to the cottons-under-glass. The procedure involved manipulating the threshold setting and area measurement calibration constants (cotton slope and cotton offset) until the particle counts and percent areas on the cottons-under-glass were measured within established tolerances. Although this method was effective, it was somewhat subjective and lengthy given the trial and error manipulative approach. Therefore, the cottons-under-glass calibration was only performed as a "setup" calibration. In order to maintain calibration between cottons-under-glass setups, a rapid and automatic trash tile calibration would maintain the setup level by providing daily routine calibrations.

After performing the cottons-under-glass setup calibration, a set of area measurement calibration constants (tile slope and tile offset) for the trash calibration tile would be manually manipulated until the measured tile area agreed with the standard area. During daily routine tile calibrations, deviations in the standard tile area from the measured area would result in equal adjustments in the cotton and tile slope constants.

1997 Calibration Procedure

In 1997, a tile calibration procedure was developed that would calibrate the 900U trashmeter to the cottons-under-glass measurement level. This new procedure replaced the lengthy cottons-under-glass setup calibration with a simple single tile setup. The HVI's routine calibration tile would be used to set the threshold. In order to improve the performance of the HVI's calibration tile, a new 196 dot count tile was designed and implemented. The old tile was a continuous pattern that did not end at the measurement boundaries. The dots of the new tile were all contained within the measurement boundaries to provide a calibration standard with an exact measurable dot count.

Instead of using cottons-under glass for setup calibration, the new procedure used them to provide only verification that the proper calibration level had been established. Another part of the new method involved setting the percent area calibration slope and offset to a standardized setting that was applied to all 900U trashmeters. The standardized slope and offset settings were applied to both cotton and tile measurements. The next step was to calibrate the percent area measurement by adjusting the threshold variable until the established percent area on the HVI calibration tile was accurately measured.

The main advantage of using the established calibration tile area to set the threshold is the precision provided by the area measurement. The original calibration method, as previously discussed, involved manipulating the threshold until the measured cottons-under-glass particle counts were in agreement with the established particle count values. The count measurement lacks the threshold sensitivity found in the area measurement. Considerable threshold change is required to observe a difference in the count measurement. In contrast, slight threshold changes are detectable by the area measurement.

In order for the 1997 method to work, the standard area values on the cotton standards and tile standards had to measure within calibration tolerances with only one slope and one offset applied. This is in contrast to the original 900U trashmeter setup method which required a different slope and offset for measuring cotton standards versus tile standards. The only way to ensure the use of only one slope and one offset for both cotton and tile measurements, was to establish standards on a 900U trashmeter (which was implemented during the development of this new procedure). In addition, the cotton to tile relationship had to be constant between all 900U trashmeters. Fortunately, this was found to be true as long as the trashmeters were in good operating condition.

New Setup and Calibration Methods for 1998

In 1998, a new 900U trashmeter calibration procedure was implemented. Unlike the procedure implemented in 1997, the new procedure required the design of new types of trash tiles and modifications in the 900U trashmeter software. A major difference in the new procedure was the integration of setup techniques into the calibration procedure. Previous calibration methods did not address or even detect many potential trashmeter problems. Trashmeter problems involving such things as camera focus, camera alignment, window size and foreign particles were addressed only during infrequent diagnostic checks. In many instances trashmeter problems would be masked by calibration.

The heart of the new procedure is a special trash tile set containing a total of thirteen tiles designed exclusively for the 900U trashmeter. The tile set is made up of a blank tile, an image area tile, a threshold calibration tile and ten area calibration tiles. The blank tile houses a white sheet of paper that contains no dots or any other markings. The image area tile is completely filled with a uniform pattern of approximately 1,500 laser printer printed dots. Each dot measures approximately 0.03 inches in diameter. The threshold calibration tile is identical to the 196 dot tile used by the HVI for routine calibration. The ten area calibration tiles have various sizes (0.015 to 0.10 inches in diameter) and numbers of dots. The dots are of uniform size on each tile and their count was determined by calculating the

number of dots required to give approximately a one percent area on each tile.

The first step of the new procedure is to clean all measurement surfaces and to check the camera focus. Camera focus is checked by observing the displayed camera image of typed text placed on the measurement window. The next step involves initializing all constants and setting the threshold using the threshold calibration tile. After placing the threshold calibration tile over the window, a new software routine gives the technician the option of a manual or a new automatic threshold calibration.

Once the threshold is calibrated, the blank tile is measured to ensure that no foreign particles are in the trashmeter. If one or more particles are measured, then the trashmeter must be cleaned. Another cause of foreign particle measurement is camera misalignment which results in the trashmeter measuring a window edge as particles. A misaligned camera can be corrected in two ways. Before explaining these corrective actions, it is important to understand that the correct image area is rectangular and measures nine square inches. In addition, the image provided by the camera is larger than nine square inches and therefore must be trimmed by the trashmeter software. Sometimes the coordinates defining the image area can be adjusted to exclude a camera edge and therefore obtain a clear measured image. If readjusting the coordinates cannot be done without reducing the image area below nine square inches, then the camera must be physically realigned.

Once a clear background is achieved, the correct image area is verified and adjusted if needed. The image area tile is used to check and reset, if necessary, the image size. If the image area is correctly set to nine square inches, the trashmeter should produce an average count of 930 dots when measuring the image area tile. If 930 dots are not measured, then the coordinates used to outline the image area must be adjusted until the proper count is obtained. The image area is decreased if the count is higher than 930 or increased if the count is lower than 930. In addition, maintaining the proper rectangular proportions of the image area is important.

Proper image area is required for accurate threshold calibration. The reason is due to the threshold tile calibration which is based on the percent area measurement rather than particle count. Since the percent area measurement is the ratio of cotton trash area to total image area, any change in image area will affect the percent area measurement. Image area adjustment can also reveal a camera alignment problem or foreign particle problem. This occurs when the image area size must be increased and the increase results in the inclusion of a trashmeter edge or other foreign particles. As a result of this interdependence between the threshold, image area and blank tiles, the setup procedure requires repeating each tile setup until each tile setup procedure is passed.

After successful completion of the threshold, image area and blank tile setup, calibration of the percent area measurement is performed with the ten area calibration tiles. The established area values on the area calibration tiles were established by visually measuring the tile particles using a precision ruler under magnification and then calculating the percent area. The percent area calibration derives a correction based on the effect of particle size (Knowlton, 1997). The relationship between the 900U trashmeter area measurement and the visually determined area is quadratic over a range of particle sizes. Therefore, following the ten-tile calibration, two quadratic constants are determined that will bring the trashmeter area measurement to the level of the visual measurements. This procedure has proven effective in improving area measurement agreement between trashmeters as well as providing a solid calibration reference to the area measurement.

Since the cottons-under-glass must remain the absolute trash measurement standard, following the ten-tile calibration, a universally applied slope and offset factor are still required to maintain the level of the established standard. However, the magnitude of the slope and offset factors is greatly reduced with the ten-tile procedure versus the 1997 and prior methods.

As with all setup procedures since the introduction of the cottons-under-glass, the HVI calibration tile in this procedure is used to provide a reference to the setup calibration. If any drift is detected by the HVI calibration tile during daily routine calibrations, a small slope adjustment will be allowed. If the drift is excessive, a slope adjustment will not be made and a new setup procedure will be required.

As in the 1997 setup procedure, the cottons-under-glass are used in the procedure as a final calibration verification. The established values of the cottons-under-glass must be measured within set tolerances.

Results

The efforts to improve the cotton trash measurement have been reflected in yearly increases in measurement reproducibility. Reproducibility, as defined here, is the percentage of percent area trash measurements that agree between the classing office and the Quality Assurance Unit within ±0.1% for measurements less than 0.6% and within ±0.2% for measurements greater than 0.5%. Approximately one percent of all samples tested in classing offices are retested by the Quality Assurance Unit in Memphis, Tennessee. Overall reproducibility of these samples has steadily increased from 76% in 1994; to 78% in 1995; to 80% in 1996 and 1997; and to 84% in 1998.

Conclusion

The HVI cotton trash measurement has experienced changes in technology, calibration standards and calibration procedures. Development efforts have continued to result in improved measurement accuracy. Percent area trash measurement reproducibility has steadily improved from year to year since the introduction of the first 900U's in 1994. The implementation of major changes in setup and calibration procedures in 1998 resulted in the highest overall trash reproducibility ever achieved between classing offices and Quality Assurance. The 1998 record of 84% surpasses the previous record of 80% held in 1996 and 1997. Future efforts will continue toward the goal of making the HVI trash measurement even better.

References

Knowlton, J.L. 1997. Evaluation of HVI Trashmeter Calibration. Proceedings of the 1997 Beltwide Cotton Conference. pp. 526-531.

Randle, J.A. 1985. Cotton Trashmeter Evaluation and Calibration. 1992 ASAE Winter Meeting, Paper # 92-1539.