2002 BELTWIDE COTTON CONFERENCES, ATLANTA, GA – JANUARY 8-12

# THE AG LEADER TECHNOLOGY COTTON STRIPPER YIELD MONITORING SYSTEM

**Brent Busenlehner**
**Ag Leader Technology, Inc.**
**Ames, IA**

## Abstract

The Ag Leader Technology cotton yield monitor system for the John Deere cotton strippers utilizes multiple optical sensors to measure cotton volumetric flow rate in the exit side of the cleaner. The sensors utilize the same technology as the cotton picker yield monitor offered by Ag Leader Technology with some modifications to optimize its performance on a cotton stripper. Volumetric flow rates from the 3 flow sensors are communicated to a PF3000 yield monitor unit in the cab of the harvester over a serial communications bus. The PF3000 stores accumulated cotton volume for both fields and individual loads within fields, and combines these volumetric values with other information to calculate total weight and average yields for fields and loads. When the PF3000 is coupled with a GPS receiver, data can be stored on a PCMCIA memory card for producing yield maps with desktop PC software.

## Introduction

The Ag Leader Technology cotton yield monitoring system for the John Deere cotton stripper is the result of two years of testing on the cotton stripper, optimizing the system to achieve maximum performance on a cotton stripper. The optical sensing technology utilized is the result of 6 years testing with cotton pickers. The sensors were developed as a joint effort between The University of Tennessee, funded by Case IH and further development and commercialization continued with Ag Leader Technology.

## Discussion

### Sensor Design

The cotton yield monitor utilizes three pairs of optical emitter/detector units to measure the volumetric flow of cotton in the exit side of the cleaner. Figure 1 shows a pair of sensors. The emitter is slightly modified by having the wires exit the housing through the top of the unit instead of through the cover. The modification is to accommodate space constraints.

The sealed emitter unit consists of a circuit board, 5 infrared Light Emitting Diodes (LED's) and precisely positioned lenses that focus the LED point light source into cylindrical beams. The sealed detector unit is mounted directly across from the emitter unit. The detector unit consists of 5 lenses which focus's the light from the emitter unit onto individual light sensors that are mounted on a circuit board inside the detector unit. As the cotton flows between the pair of sensors, the light beam is interrupted and the detector senses the change in light intensity. The detector unit contains a microprocessor which reads the output of the light sensors hundreds of times per second, performs calculations on the varying signals, and transmits its readings to the yield monitor's display and data recording device in the harvesters cab, once per second, over an RS-485 serial communication bus.

The clear circles seen in Figure 2 are not the focusing lenses of the emitter and detector units, but are lens covers made of translucent plastic sheets, which are embossed so that their exposed surface is approximately flush with the inside edge of the mounting plate. The lens covers protect the focusing lenses from contamination and wear that could be caused by particles in the high velocity air stream. The lens covers are made from a fluoropolymer material which has very good non-stick characteristics, to prevent adhesion of moist soil or plant material. A soft gasket is clamped between the lens cover and the emitter or detector block to keep dust and moisture out of the space between the lenses and the lens covers.

### System Calibration

As is required with grain yield monitors and the cotton picker yield monitors, obtaining accurate measurement of cotton yield requires calibrating the measured weight of one or more loads that are recorded in the yield monitor against actual scales weights corresponding to those loads. These weights can be obtained by unloading the harvesters basket into a boll buggy that is equipped with scales, by weighing a trailer that has been filled by one harvester only, or by weighing a module that has been harvested by one harvester only. The harvester can continue harvesting other loads or fields before these actual weights are entered into the monitor. When the actual weights are available at a later time, they can be entered into the monitor for the corresponding loads, and the monitor can recalibrate previously recorded data to obtain the best match between the monitor's estimated weights and the actual scale weights.

The PF3000 monitor allows individual loads recorded in the monitor to be set as any number of different cotton "cal types" which can each be calibrated individually. Although it is desirable for a cotton grower to be able to harvest an entire cotton crop with only one calibration, this is often not possible, due to agronomic or environmental factors that require different calibrations to obtain good yield accuracy. For example, varieties with significantly different seed or staple characteristics may require different calibrations for optimum accuracy. Although the default names for the cotton varieties are COTTON1, COTTON2, etc, the monitor allows the operator to enter a name for each "cal type". The actual or estimated lint percentage can also be set individually for each cotton "cal type". If obtaining such weights are not possible each time the cottons' characteristics significantly change, it is possible to scale the loads using Ag Leader's SMS desktop PC software. Scaling allows a producer to compare the totals from the gin with what the yield monitor calculated.

**Sensor Installation**

The cotton stripper system has 3 emitter/detector sets that monitor the cotton that is being conveyed from the doffer brushes to the basket. The emitters are mounted on the basket side of the cleaner and the detectors are mounted on the inside of the cleaner where the unclean cotton enters the cleaner. There are two different mounting brackets that mount to the surfaces of the cleaner. Both the emitter units and detector units are mounted to identical metal mounting plates which pivot on quick release mechanisms, and are retained to the chute by two captive knurled nuts which engage studs mounted in the mounting brackets that are mounted to the cleaner. This unique hinging design allows for the sensors to be removed quickly by simply lifting the sensor from the mounting bracket after tilting the sensor out far enough to clear the studs which mate with the captive knurled nuts. Figure 3 shows the emitters mounted on the outside of the cleaner and Figure 4 shows a transparent side view of the cleaner with the emitter and detector in position. In Figure 4 the detector is mounted on the left (inside of the cleaner) and the emitter is mounted on the right (outside of the cleaner).

A section of the back side of the cleaner is removed to mount the emitter mounting bracket and to allow access to the smaller region of the inside surface of the chute where the detector mounting bracket is fastened. Templates are provided in the kit that makes alignment of the two sides and the marking of the holes very easy.

**Performance Results**

The cotton stripper yield monitor operated very well in the South Texas area it was tested. See Table 1, South Texas. All results in the table include all loads collected for the specified days under the specified test location and all loads under each test was calibrated once at the beginning of its test period. Calibration did not occur after all the loads were collected. The non-irrigated South Texas cotton yield ranged from approximately ½ to 2 bale cotton. The harvester used for testing was a 6 row John Deere 7455 and a small buggy equipped with scales was used to acquire weights throughout the day.

Results from each day show that the error range across a complete day of testing could be as low as 5% (± 2.5%). It was noticed there was a clear shift in the error when the seed variety of the cotton was changed to a select variety. This shift was quantified on at least 2 different fields. There is visually a noticeable difference between the two varieties and it comes as no surprise that the optical sensors will detect this change in the cross-sectional profile. The system once again performed consistent within each variety or characteristic difference. The results in Table 1, South Texas, shows that other varieties have an average error of 0.93% while the select variety has an average error of 10.04%. The 10% average error for the select variety would shift to zero if the system were re-calibrated for that variety.

Under the test conditions at the South Texas location, it is observed that 100% of all the 30 loads of "other varieties" collected were within ±5% error. The select variety under the South Texas test has similar results with 98% of all 55 loads within ±5% error (since the shift in the error, this is referenced from the average error).

Testing was also performed in the Lubbock area of West Texas. See Table 1, West Texas. The cotton harvested was all irrigated under center pivots with yields from 1 bale up to 4 bales in small areas. The three 8-row machines used for testing includes a 7455 and 2 – 7450s and a full size boll buggy equipped with scales was used to collect weights throughout the day. The 3 machines equipped with the yield monitors were highly modified by the farmer to maximize the machine performance. The results from these three machines indicate that approximately 90% of all loads collected are within ±10% error. A range of 46% to 59% of all the loads are within ±5% error.

It is believed that the difference in performance between the test in South Texas and the test in West Texas can be largely contributed to the fact that many of the fields harvested during the 14 to 16 days at the West Texas location includes multiple varieties, varied levels of dryness, and an extreme mix of all conditions that will likely be seen throughout a harvest season. In addition, the machines were highly modified which could induce additional variables. The 8-row machines were harvesting at peak efficiency, maximizing the loading on the cleaner and thus the capacity of the machine. The South Texas machine was likely not operated at peak loading.

The test in West Texas was conducted for an extended period of time, much longer than was reported. The selected days were reported because they were all sequential days under the same calibration. Other calibrations occurred during the 32 day testing period because of mechanical changes made to the harvester that affected the yield monitor. The 3 machines at the this location, during which all three machines were equipped with the yield monitor and GPS, harvested a total of 3500 acres of cotton. During this harvest period the sensors lens covers of only one machine was cleaned only once. The particular field that caused the lenses to become dirty beyond an acceptable level was a very silty soil and the machine was ingesting a large amount of the silty soil. Under most conditions, tests suggest that regular cleaning of the sensors is not necessary.

## Summary

The Ag Leader Technology cotton stripper yield monitor system will offer cotton growers a tool, which will provide valuable management information through accurate characterization of yield variations within fields.

This yield monitor system has demonstrated that when calibrated against scales weights, it is capable of consistently measuring load weights within about +/- 5% average error under some conditions, with errors contained within +/- 10% under usually 90% of all conditions. It is observed that there is some shift in the error from select varieties of cotton. This shift in the error can easily be re-calibrated and shifted to zero. In addition, this system does not require the cleaning of the optical sensors under normal operating conditions.

This yield monitor has demonstrated that it is capable of generating accurate yield maps from data gathered by multiple harvesters operating in the same field.

## References

Myers, A. 2000. The Ag Leader Technology Cotton Yield Monitor System. Proceedings Beltwide Cotton Conference 2000.

Table 1. Accuracy results from two testing locations.

| | South Texas | | West Texas | | |
|---|---|---|---|---|---|
| | Machine 1 | | Machine 1 | Machine 2 | Machine 3 |
| | Other Varieties | Select Variety | Other Varieties | Other Varieties | Other Varieties |
| Average % Error | 0.93 | 10.04 | 3.75 | -1.69 | 0.22 |
| Standard Deviation | 1.69 | 2.20 | 6.42 | 4.86 | 6.21 |
| # of Loads | 30 | 55 | 158 | 94 | 256 |
| # of Days | 4 | 4 | 16 | 14 | 16 |
| % of loads within ±10% error | 100 | 100* | 87 | 92 | 90 |
| % of loads within ±5% error | 100 | 98* | 46 | 68 | 59 |

* % of loads from the average.

Figure 1. Cotton flow sensor detector unit (left) and stripper emitter unit (right).

Figure 2.  Sensor hinged open showing the clear lens covers.

Figure 3.  Emitters mounted on the outside (basket side) of the cleaner.

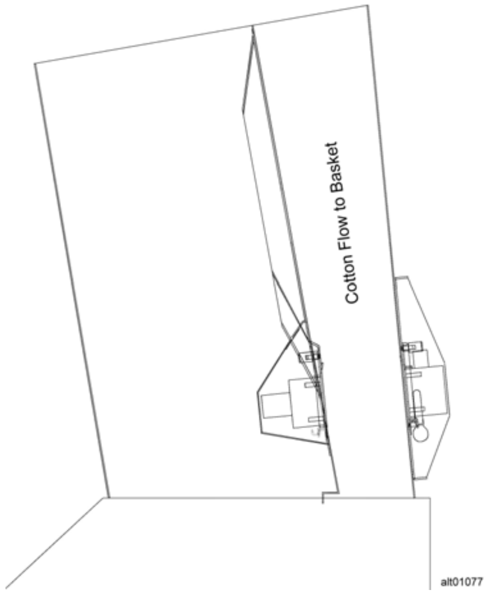

Figure 4.  Transparent side view of cleaner with emitter and detector.