STRIPPER COTTON YIELD SENSOR PRODUCES YIELD MAP

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Abstract

This paper describes the design and implementation of a Yield sensor for cotton strippers. The sensor is utilizing electro-optic technology. The sensor combines emitters and detectors mounted on the clean chute of the stripper. As the cotton passes through the chute, it is illuminated by the emitters. The detectors which are positioned across the chute detect the light pulses. The pulse count is relative to the volume and density of the cotton. It can then be used to estimate the mass of the cotton passing through the chute. The cotton weight is displayed on the cab indicator and also stored on a recording media, together with the GPS position of the stripper. The data can then be processed and displayed as a yield map. This technique enables growers of row cotton as well as of UNR cotton to monitor the yield of the crop for future improve of the field performance.

Definition of Terms

Cotton stripper - A cotton harvester which strips the fruit from the plant and further process the cotton by removing much of the plants residue using an on board cleaner.
Clean cotton chute - the chute on the harvester which conduit the processed cotton after it exit the cleaner.
Unprocessed cotton chute - the chute on the harvester wich conduit the raw cotton into the cleaner for processing.
GPS - Global Positioning System.
Sensor - emitter or detector unit containing the light emitting and detecting devices.
Detector - electrical circuit which performs the detection and signal conditioning (and discrimination from noise) of the Emitters light.
Emitter - circuits which illuminates cotton inside the chute for the purpose of detection and analysis.
Seed cotton - product of the cotton field picking with today's harvesters. The product contains the cotton lint, cotton seeds and other plant residues.
Yield map - a geographical map of a producing field showing in colors or contour lines the absolute yield, in kg or pound per acre, at each location.

Introduction

The ability to monitor cotton yield on the fly is a necessary component in the evaluation of the performance of a cotton field. The importance of the device has been recognized among growers in pursuit of precision farming technology. The sensing system enables one to record a momentary yield and associate it with the location in the field. The recent introduction of cotton yield monitors for cotton pickers have demonstrated their performance and accuracies. The transfer of such technology to cotton stripper is significant to the growers of UNR cotton, and those with strippers for standard row width cotton. The sensor when installed on the chute of the cotton stripper enables the grower to create a *yield map* showing the variations of the yield across the field. The first field tests performed during the 1998 harvest season in North Carolina have demonstrated that the sensor was responsive to yield variations. During the harvest season of 2000, thousands of additional acres were stripped in Texas. Basket weights were measured and compared to actual gin weight of the cotton. Yield maps were generated.

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System Description and Operation

The Yield Monitoring System, figure 1, consists of the following components: the Main Processing Computer (CPU), a data card (PCMCIA), a display device, a differentially corrected GPS receiver, all are mounted in the cab. Radio antennas, used by the GPS and the differential receiver, are mounted on the roof of the harvester. Mapping software, installed in the office PC is used to view and print yield maps. An array of flow sensors (emitters and detectors) are mounted across the clean cotton chute. During the harvest the CPU collects position data from the connected GPS receiver. It also collects flow data from the yield sensors. The data is then processed and stored in the removable data card memory.

Sensor Design and Operation

The sensor is composed of Infra Red (IR) emitters, detectors, signal conditioning and processing units; figure 2. The emitters are built of IR lamps which are driven by pulsing driver circuits. The sensors components are enclosed in weather sealed enclosures which are mounted on the surface of the chute. Openings are drilled on the chute to accommodate the sensors. Electrical cables connect the sensors assemblies to the CPU in the cab.

The emitters illuminate the chute. As cotton passes through the chute it blocks the IR light from reaching across to the detectors. The light blockage provides information about the size (volume) of the cotton passing through. The signals from all the detectors is being filtered, amplified and converted into digital format for further processing by the sensor's on board processor. The resulting measure of seed cotton mass is transmitted through the system bus to the CPU in the cab.

Yield Calculation

The system estimates the flow of seed cotton in one second intervals. The result is stored in the memory of the data card.

The total weight of cotton detected during a single recording interval can be calculated using the following equations:

$$W_i = c(a_n N^n + a_{n-1} N^{n-1} ... + a_0) \qquad (1)$$

where

- W_i - the total weight passing through during interval i
- a - is polynomial coefficient.
- c - is the weight coefficient
- N - pulse count calculated by the equation (2) below.

$$N = \sum_s (\int g_B v_B dt) \qquad (2)$$

where:

- N - mass count
- s - signal detectors
- v_B - detected signals from reflected and blocked light sources.
- g_B - gain coefficient for reflected and blocked signals

The total weight of a field W is the sum of all intervals i collected during the harvest period T :

$$W = \sum_i^T W_i \qquad (3)$$

Tests, Results and Discussion

The objective of the test conducted in Texas was to compare the system estimated weight of the harvested seed cotton to the actual cotton weight as measured by a scale. The estimated basket full of cotton was recorded for each dump. The dump actual weight was measured using boll buggy with load cells. The result of typical set of measurement taken on November 21st and 22nd are presented in table 1. The indicated Agriplan weight is the lint weight of the cotton calculated at 29% turn-out. One can notice that with the exception of couple of out lyres the estimated (Agriplan) weight fell within 3% of the actual weight. Accuracy considered sufficient for most precision farming practices.

The inaccuracies of some of the measurements has been attributed to the fact that only half the length of the chute was monitored. The left part was not equipped with sensors. The operator of the harvester has indicated that he could notice that "variation in yield on the left side of the harvested swath did not influence the monitor reading as much as did the right side of the swath". In the coming year the strippers will be equipped with additional sensors to include the entire width of the chute. It will then be possible to verify the above hypothesis and thus improve on weight and yield accuracies even further.

Summary

The design and implementation of electro-optic cotton yield monitor was presented. The sensor with the attached GPS system was built and operated on a number of installations for the purpose of test, evaluation and for the generation of yield maps. Accuracies in the range of 4% were reached in field operation where basket size amounts of cotton were measured and compared to standard scale reading.

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