POWERED TRAMPER: DESIGN AND EVALUATION

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Abstract

Properly constructed modules will prevent reduced lint value and increased ginning costs when significant rainfall occurs. Study of the compressive properties of seed cotton has shown that more cotton must be placed in the center of the module to produce a crowned shape that sheds water. The goal of this research was to design and test a device capable of moving cotton from the outer edges to the center of a module, while still compressing the seed cotton. A powered tramper, which uses an auger to convey cotton, was developed to replace the conventional tramper. The powered tramper operates automatically without affecting the operating speed or pressure of the tramper cylinder. Initial testing of the powered tramper occurred in 2007, and modules were built with a crowned shape. Design changes were made to prevent plugging of cotton in the housing for testing in 2008. The height was measured at multiple points on the top surface of modules built with the powered tramper and conventionally built modules. Preliminary data indicated that the modules built with the powered tramper did have a crowned shape, with few depressions that might collect water. However, the modules made with the power tramper did not have a better shape than the few conventional modules measured. All modules in this sample were generally crowned, with few depressions where water could collect. The powered tramper will continue to be evaluated.

Introduction

Preserving the quality of seed cotton stored in modules is an important goal of cotton producers and ginners. Building properly shaped modules is a key component of cotton quality preservation during storage. Modules should be constructed with a shape that will shed water. Previous work by Simpson and Searcy (2005) indicated that the loss in lint value of a poorly shaped module experiencing significant rain was over $200, regardless of cover quality. Additional losses are incurred in ginning wet cotton.

A study of the physical properties of seed cotton (Hardin IV and Searcy, 2008) concluded that more cotton must be placed in the center of the module to produce a convex top surface. Cotton needs to be moved both along the length and across the width of the module to result in the most desirable shape. Hardin IV and Searcy (2007) developed a feedback system that accurately displayed the module shape to the operator. This system allowed the operator to move cotton to the appropriate location along the length of the module builder.

A properly constructed module in a conventional module builder may still have significant areas on the top surface where water can collect. The cotton unloaded from a harvester or boll buggy is not generally distributed evenly across the width of the module, resulting in depressions in the top surface. The goal of this research is to design and test a modification to the module builder that will provide the capability to move cotton across the width of the module, producing a module that is higher in the center than at the sides.

The proposed modification needed to meet the following design objectives:

- Easily retrofit to existing module builders
- Operates automatically or with a minimum of operator control necessary
- Allows free movement of cotton at all times- plugged cotton that must be removed by an operator is unacceptable
- Does not affect the operating speed or tramping force of the module builder
- Cost should allow for reasonable economic payback period

Materials and Methods

Initial Design

Preliminary work in the laboratory using a compression testing apparatus and a 1/8-scale module builder indicated the suitability of using an auger to both move cotton along the auger axis and compress cotton. Other methods of moving cotton proved ineffective or resulted in cotton plugging in the moving components of the device. A full-scale prototype (Figure 1) was developed based on these testing results.

Figure 1. Full-scale prototype.

This powered tramper replaced the conventional tramper. Cotton was conveyed to the center of the module by opposite-handed auger flighting on each side of the shaft spanning the length of the module builder. The shaft was chain-driven by a hydraulic motor mounted at the bottom of one of the support columns. The housing surrounding the auger was designed to transmit the compressive force of the tramper, reducing stress on the auger shaft and providing the same area as a conventional tramper. The housing center section diverted cotton out of the bottom.

Operation of the powered tramper was controlled by the hydraulic circuit shown in Figure 2. The hydraulic motor is connected in series with the tramper cylinder; therefore, the cylinder travel speed remains the same. When the tramper cylinder extends, the powered tramper operates until the pressure in the cylinder head reaches the setpoint of the adjustable pressure switch. Closing the pressure switch opens the bypass line around the motor, allowing full pressure in tramping cylinder. Additionally, cotton under compression could not be moved effectively by the powered tramper. An in-cab switch is wired in parallel with the pressure switch so the module builder operator can disable the powered tramper if desired. The auger speed is controlled with the adjustable flow control valve. The check valve prevents the auger from turning in reverse when the tramper is retracted.

Initial Testing- 2007

Optimal settings for the system parameters were determined. The pressure switch was set between 500-600 psi. This pressure setting was the highest value that would reliably ensure that the auger motor was bypassed before the maximum hydraulic system pressure (relief valve setting) was reached. The optimum auger speed was between 100 and 150 rpm. Faster speeds resulted in increased plugging of cotton in the housing.

The powered tramper was used to build 12 modules in 2007 and reliably produced crowned surfaces (Figure 3). The primary drawback of the powered tramper during initial testing was cotton plugging in the center of the housing. Design changes made during the cotton harvest lessened the plugging frequency.

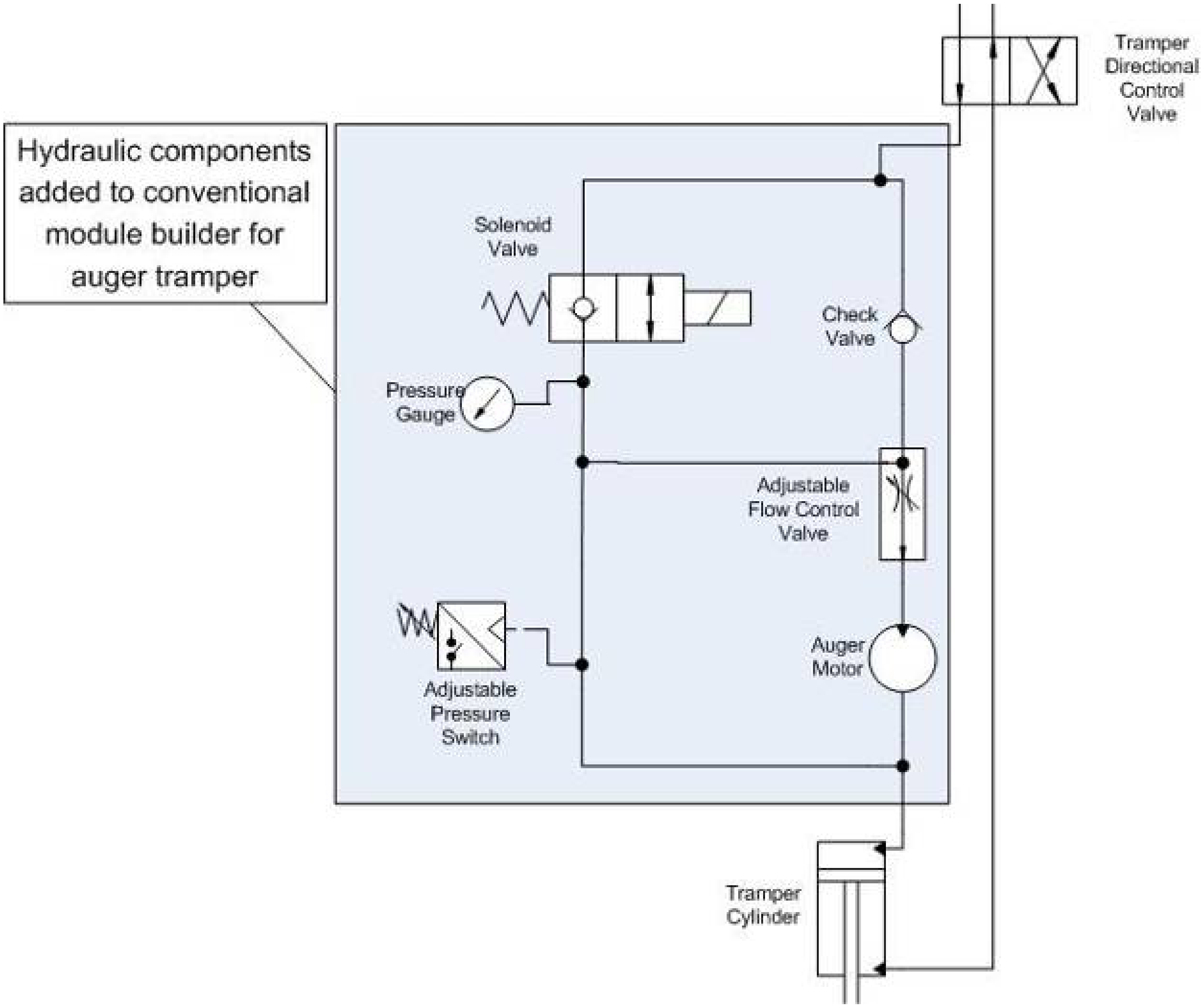

Figure 2. Hydraulic circuit to provide intermittent operation of the powered tramper auger.

Figure 3. Modules built in 2007 using powered tramper.

Design Modifications

Further design changes were made for testing in 2008. The diverter section and auger shaft were modified to prevent plugging (Figure 4). This auger shaft had 18” lengths of 9”diameter flighting on the ends of the shaft, which transitioned to 6” lengths of 6” diameter flighting. 6” long cleanout paddles were mounted 90° behind the end of the auger flighting to push cotton out of the housing. The diverter section was also modified to minimize clearance with the cleanout paddles. These design changes eliminated problems with cotton plugging in the housing.

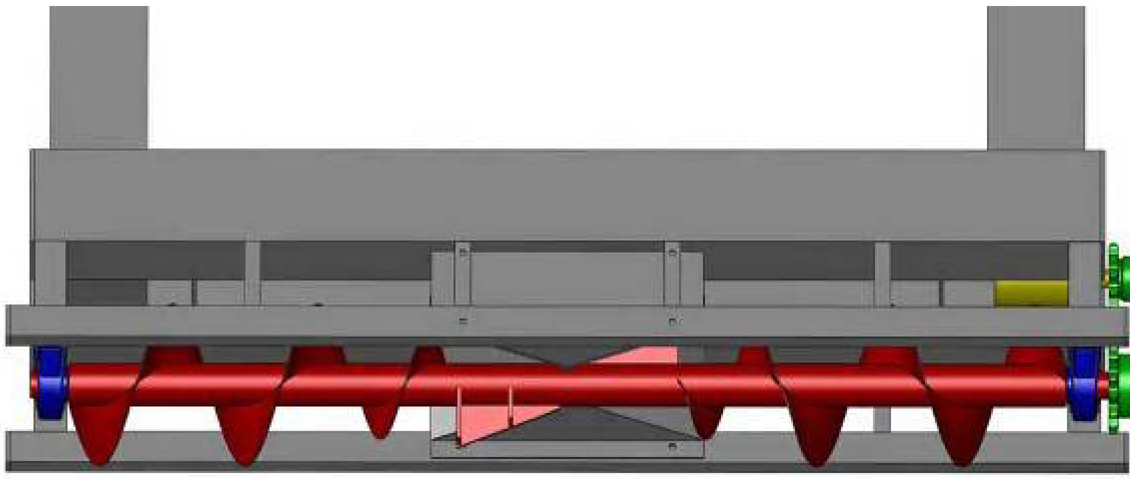

Figure 4. Drawing of design changes.

Module Measuring System

The powered tramper was tested in 2008 in several locations near Anson, TX. The powered tramper performance was evaluated by measuring the top surface profile, calculating the size of areas where water could collect, and comparing these results with conventionally constructed modules. A module measuring system was constructed to measure the top surface profile of modules (Figures 5 and 6). The system was mounted on a truck and driven alongside the module. Sensor data was collected in a datalogger to determine the heights at 13 locations across the top surface of the module, spaced 15 cm (6 in) across the width.

The fingers shown in Figure 5 were free to rotate as they move along the surface of the module, with their a measured by a rotary potentiometer. An inclinometer measured the angle from the horizontal of the arm where the fingers are mounted. The arm and fingers were raised or lowered with a winch to maintain contact with the module. The height of the arm was determined with a string potentiometer. The rotary potentiometer, inclinometer, and string potentiometer values were used to calculate the height at points where the fingers contacted the module.

The position along the length of the module was determined using star-shaped distance measuring wheels that contacted the module and rotated as the system moves along the length of the module (Figure 6). Rotation of the wheels was measured with rotary encoders. Actual position was determined from the two encoders and the rotation of the fingers. Spring-loaded parallel linkages kept the measuring system in the proper position against the module.

Figure 5. Module measuring system- height measurement.

Figure 6. Module measuring system- position sensing.

Data Collection and Analysis

Using this module measuring system, data was collected on 10 modules built using the powered tramper and 5 conventionally built modules. The data was first processed to determine module height and position along the length of the module. The resulting output has approximately 1.2 cm (1/2 in) resolution along the length of the module; however, the data points are not evenly spaced due to the rotation of the fingers. Therefore, the height data for each module was interpolated to a 15 cm (6 in) grid using MATLAB.

Using this interpolated data, cross-sections across the width could be examined. This was the only dimension affected by the powered tramper, so slopes along the length of the module were ignored. The area where water could collect was calculated using these cross-sections, as demonstrated in Figure 7.

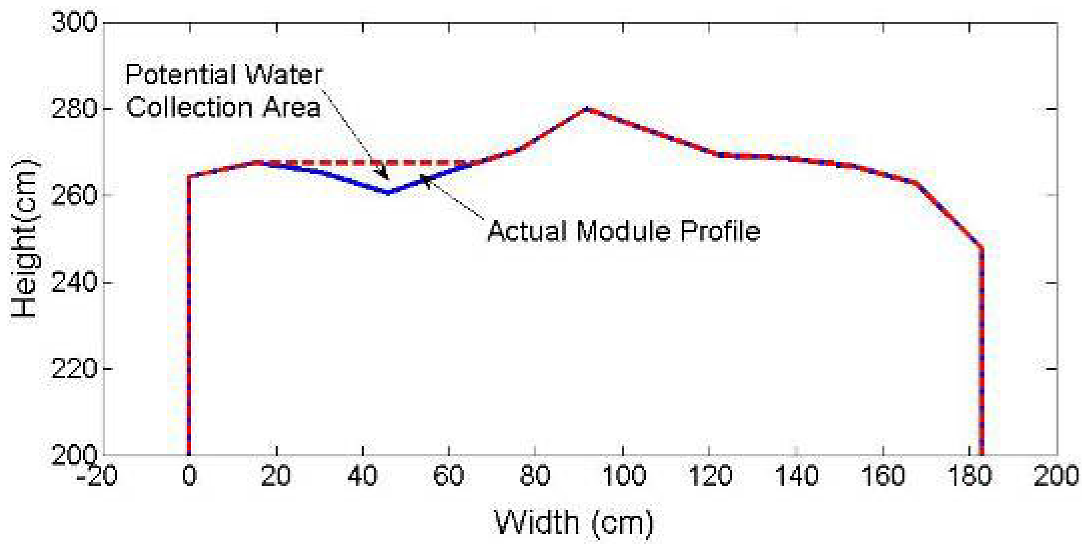

Figure 7. Calculation of potential water collection areas.

An analysis of variance was performed on the water collection area data using the generalized linear models procedure in SAS. The tramper used, powered or conventional, was the main effect, while the module was a nested effect in the experimental design. The difference in mean water collection area between the powered and conventional tramper was compared.

Results and Discussion

Module surface profiles were obtained using the interpolated data for the modules studied. One module built using the powered tramper is shown in Figure 8. Higher areas are displayed red, while the lower areas are shown in blue.

The ANOVA model was significant, with highly significant main and nested effects. The results of the means comparison (t-test) for the tramper type are shown in Table 1. The difference in mean water collection areas was statistically significant at the 5% level.

Table 1. Comparison of powered and conventional tramper.

Tramper Type	Powered	Conventional
Modules	10	5
Observations	610	313
Mean Water Collection Area (cm^2)	194	110

While there was a statistically significant difference in the mean water collection areas, the potential regions where water could collect was small for both the conventional and power tramped modules. The conventional modules examined were generally well crowned across the width. Those five modules were measured on the gin yard, and no information was available about the procedures used in forming them or their exposure time. It was suspected that the conventional modules had been subjected to high winds while covered. The force of the wind on the cover

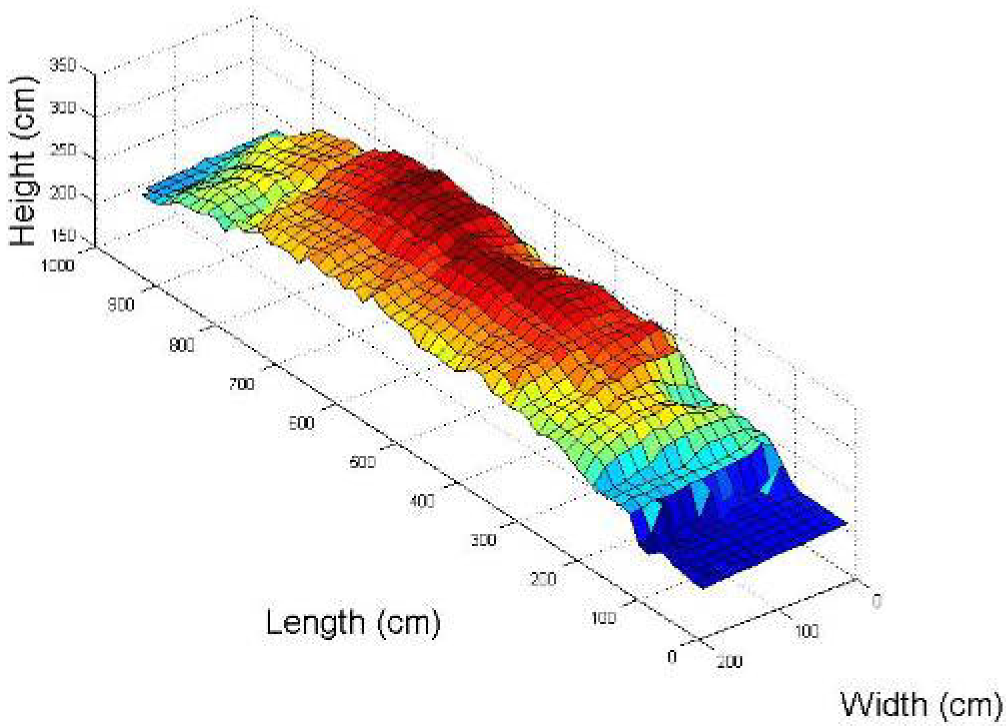

Figure 8. Surface of module built using powered tramper.

compressed, and possibly moved, cotton on the top surface of the module. No loose cotton was observed on the top of the conventionally built modules. Given the desirable shape of the five modules measured, the only result that can be obtained from this comparison is that both sets had a desirable shape, with minimal areas where water could collect.

Conclusions

The powered tramper automatically moved cotton from the sides of the module to the center, and the current design functions without plugging. The cost of the additional components used with the powered tramper was approximately $1500. Since the potential loss of lint value in a poorly shaped module experiencing significant rainfall is over $200, return on the investment in a powered tramper system would be rapid. Although the preliminary data did not show an improvement in desired shape over the conventional modules that were measured, this result was due to the unusually good shape of the conventional modules. The powered tramping system did perform as desired in moving seed cotton to the center line of the module without plugging. Further data on the performance of the powered tramper will be collected.

References

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