A LABORATORY SYSTEM FOR MODELING HAY STORAGE

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Summary

A simple system is described that uses a hinged metal baling unit and a hydraulic press to make 4.0 × 4.3 × 5.3 inch wire-tied, laboratory-scale, hay bales. A comparison of densities of conventional, small, alfalfa bales (15 × 18 × 37 inches) and laboratory bales was made over a wide range of moisture levels (15 to 36%) and conventional bale densities (10 to 25 lb/ft^3). Laboratory bale densities were regressed against conventional bale densities and agreement was excellent. The system is inexpensive to build and easy to use and can be reproduced easily.

(Key Words: Hay, Bale, Laboratory-scale, Alfalfa.)

Introduction

Packaging and preserving forage as hay continue to be areas of intense interest. Being able to make small, laboratory-scale, hay packages that simulate conventional hay bales for characteristics such as heat generation, mold development, and quality changes in both hay stack and isolated environments would facilitate hay research. Our objective was to develop a simple system for making wire-tied, laboratory-scale, alfalfa hay bales that were comparable to conventional bales over a wide range of densities.

Experimental Procedures

Design and Description. The baling unit (Figure 1) was constructed of 3/16 in.-thick (10 gauge) black iron plate. All hardware attached to the bale chamber (hinges, fasteners, and bale chamber support) were welded into place. The corners of the bale chamber without hinges or fasteners were bent at right angles. Two 4 × 4 in., tight pin, plain steel hinges were used to hinge the unit. Three 4 in. barrel bolt latches were used to close the unit. Four slots were cut in the bale chamber to provide for wire ties. Slots were wider near the bottom to make tying easier.

The press block was a 3 1/2 × 3 1/2 × 1 1/2 in. wooden block fastened to a 3 1/2 × 3 1/2 × 3/16 in. metal plate with four 1 1/4 in. lag screws. An attachment was then welded to the metal plate to fasten the press block to the hydraulic press. Two grooves 3/8 in. wide and 1/4 in. deep were cut across the face of the press block to maintain wire spacing during bale formation.

The base of the baling unit was a 7 1/16 × 7 1/16 × 1/4 in. metal plate with four 3/4 × 3/4 × 1/8 in. angle base chamber supports welded in place to prevent the bale chamber from expanding during bale formation. Inside the square, a 3 1/2 × 3 1/2 × 3/4 in. wooden block was attached such that the bale chamber fit neatly between the base bale chamber supports and the block. Two grooves were cut across the face of the block to maintain the bale wires in the correct position during bale formation. The grooves in the press block, bale chamber, and base block were aligned and positioned such that the tie wires on the hay bale were approximately 2 in. apart and 1 in. from each edge of the bale. The tie wires

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were common baler wire and were bent prior to the baling. We have found that a simple 4 x 4 x 12 in. wooden block works well as a mold for bending the wires.

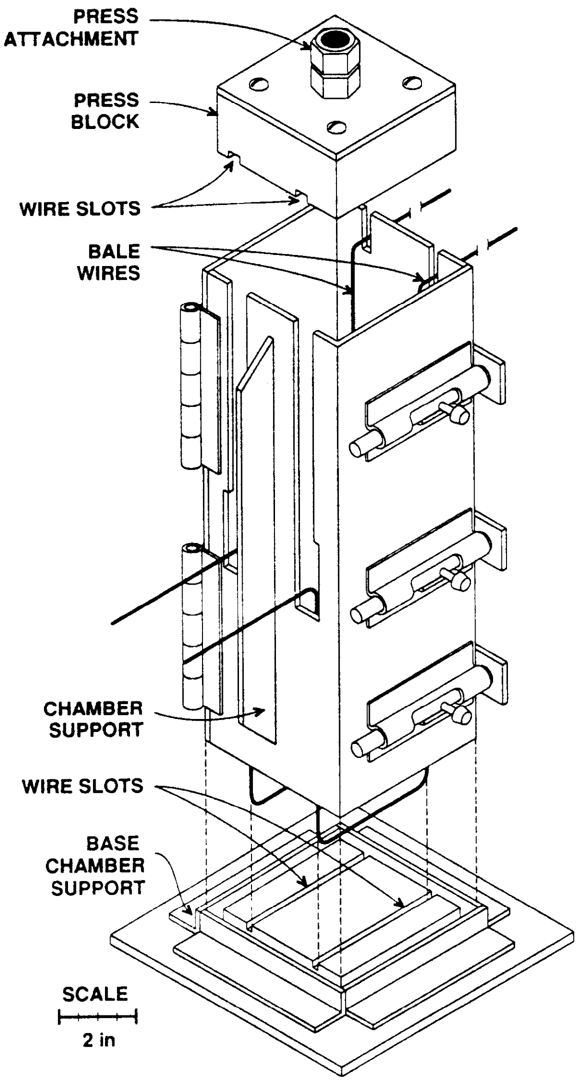

Figure 1. Scaled Drawing of the Laboratory Baling System

Bale Formation. To distribute forage evenly throughout the bale, forage is cut to approximately 4 inches, using a 24 x 24 in. paper cutter. We found it feasible to initially bale the hay in the field with a conventional, small, rectangular baler and then break down selected conventional bales to supply material to make the laboratory-scale bales. The paper cutter was large enough to handle an entire conventional bale flake at one time, eliminating the need to manually tear the flake apart and induce subsequent leaf shatter.

Prior to packing, tie wires are inserted into the bale chamber as shown in Figure 1. The forage is then packed into the bale chamber by hand and hydraulically pressed, so that it remains compressed in the chamber. For high density bales, the bale chamber needs to be hand-packed to capacity, hydraulically pressed, then hand-packed and hydraulically pressed again, until all the desired forage is in the bale chamber. The press block is then removed from the chamber, and the long ends of the tie wires are folded over the compressed forage. The forage is again compressed, this time down to the desired bale length. At this point, the pressure is released slightly so the slack can be pulled out of the tie wires. The forage is then compressed to the desired endpoint, where the long and short wire ends are tied with pliers. The bale chamber is removed from the base, and the chamber is opened, releasing the tied bale. Excess wire from the ties can be clipped as necessary.

Density Adjustment. Density is controlled by maintaining a constant bale volume and varying the amount of plant material placed into the bale chamber. Therefore, it was necessary to establish an average, laboratory-scale bale size. Preliminary studies were conducted on second-cutting alfalfa harvested at one-tenth bloom. Ninety bales with DM content between 65 and 80% averaged 4.05 ± .08 in. high and 4.27 ± .08 in. wide after they emerged from the bale chamber. The average area of the butt end of the bale was then calculated to be 17.24 $in.^2$. Bale length was controlled by marking a line on the bale chamber at the desired length, hydraulically compressing the plant material to that line, and then tying the bale. Our preliminary studies showed that bales averaged 5.27 ± .16 in. when the line was drawn 5.75 in. from the bottom of the bale chamber, resulting in an average bale volume of 91.0 ± 4.4 $in.^3$. The variability in bale length could undoubtedly be reduced by placing a stop in the pressing mechanism or by positioning the bale chamber such that the desired bale length is obtained when the press stroke is exhausted. These options would reduce reliance on the precision of the press operator, but would also limit flexibility in bale length. The upper density limit we achieved was about 50 lb/ft^3, but higher densities could be reached with a higher capacity press. The limit was not due to the strength of the bale chamber.

Results and Discussion

A comparison of densities of the conventional, small, rectangular, alfalfa bales (approximately 15 x 18 x 37 in.) and laboratory bales is shown in Figure 2. At each density, three conventional bales were made from the same windrow of alfalfa using a New Holland Hayliner 273 wire tie baler. These bales were weighed and measured to compute their average density. Then one conventional bale was opened so that laboratory-scale bales could be made from the same alfalfa source. At least two laboratory bales were made to correspond to the average density of the three conventional bales.

This procedure was repeated 39 times over moisture levels from 15 to 36% and conventional bale densities from 10 to 25 lb/ft^3. Conventional bale densities were varied by changing the tension on the bale chamber. Laboratory bale densities were then regressed against conventional bale densities. Excellent agreement in density occurred between the two bale sizes; however, hay bales of any size are quite difficult to measure precisely, particularly in regard to length. The difficulty in making precise measurements undoubtedly contributed to the variability in the data. We have found that the most dense bales are the easiest to make. Lower density bales can be made, but some practice might be required to consistently do a satisfactory job.

This system provides a very simple way to simulate, on a small scale, a field-tied hay bale. The baler is both easy to use and relatively inexpensive. Materials for constructing the unit can be purchased for approximately $50.

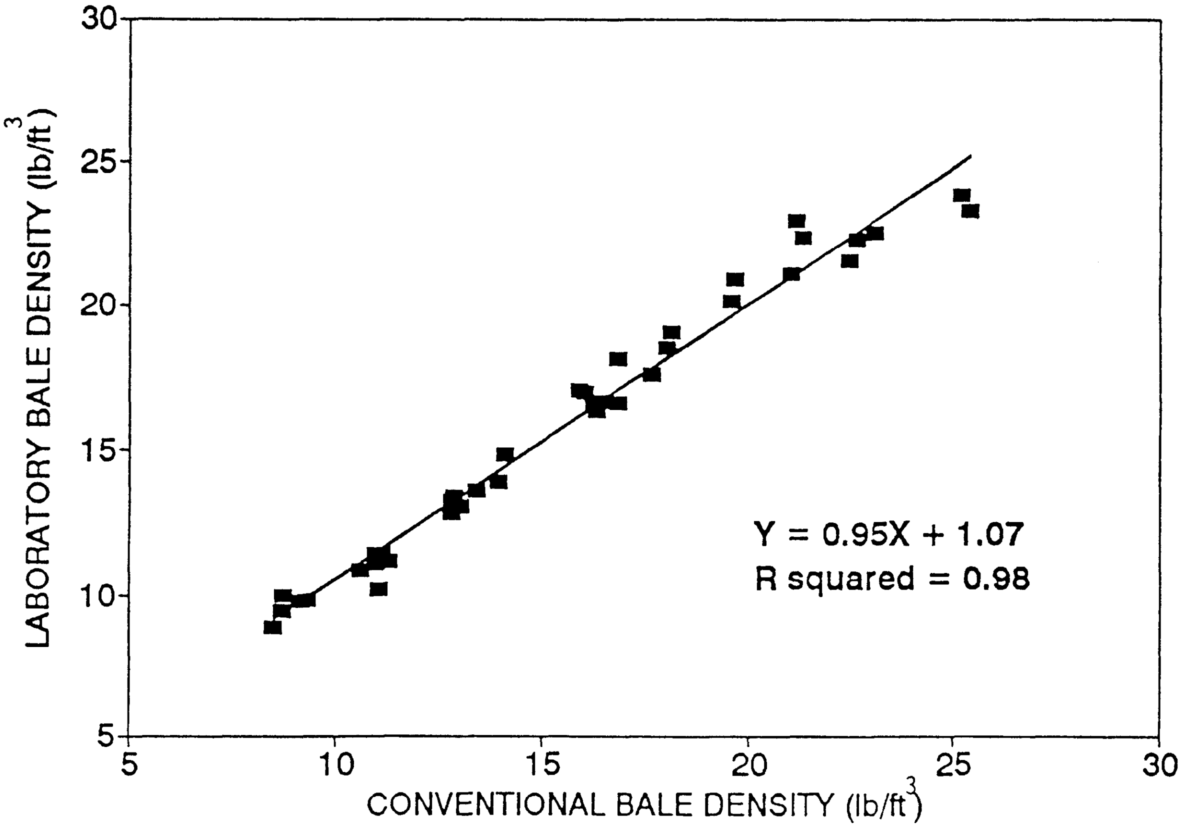

Figure 2. Relationship between Laboratory-scale and Conventional Alfalfa Bale Densities. The Standard Error of the Slope (s_b) = .024