CAPSTONE EXPERIENCE 2012

Inexpensive Bale Wrapper

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Problem Statement

Countries that are less developed than the United States can struggle with challenges related to forage production. Farmers in countries such as Mexico, Costa Rica, and many others must deal with adverse weather and lack of capital for producing forage for livestock. Harvesting forage as baled silage basically solves the weather problem, but there is still the problem with capital. Since there currently is not a good, cheap option for storing forage in less developed countries, there is a need for an inexpensive method of wrapping bales. The objective of this project was to create a prototype of a bale wrapper that would be economically viable in third world countries.

Constraints

Cost was the most important constraint to this project. It was vital that the bale wrapping mechanism was affordable to farmers in third world counties but still functional. It also needed to be less expensive than any other alternatives that are currently available. It was also made clear that manual labor was available to assist in the bale wrapping process. The bale wrapping needed to use 20 inch bale wrap and needed to be portable. It also needed to be capable of wrapping bales with a maximum size of four feet by four feet.

Features

Direct drive from hydraulic wheel motor: Power is transmitted through a wheel hub to an adapter hooked to the shaft. This was used instead of a direct coupler for cost reasons.
Hydraulic system: Uses a pressure compensated adjustable flow control valve to cut back flow in order to slow the swinging arm down to about 30 rpm. Includes provisions for use on either an open or closed center hydraulic system.
Bale roller: Consists of a shaft with a pipe attached around it held at each end with bearings.
Adjustable height wrap: Adjustable by using two sizes of square tubing that one can slide snuggly inside of the other and a set of holes and bolts.
Wrap Tensioner: Tensioner has polyethylene for the roll of wrap to slide on at the top and bottom. The top piece of polyethylene is held down by a spring on threaded rod, which allows for adjustment of the level of tension to create stretch.
Counterweight: Balances out the weight of the wrap.

Operation

The tractor is backed up to a bale that is oriented to roll in the same direction as the tractor tires. The wrap is then be manually attached to the bale. The swinging arm is then be started to rotate and wrap the bale. As the arm is wrapping the bale, the tractor is slowly backed up to push the bale along the ground. Each area should be covered with two layers of plastic at one time and the bale should be rotated all the way around one time in order to end up with at least four layers of plastic covering the entire bale. The wrap can then be manually cut to release it from the bale.

Figure 1. Picture of the nearly completed bale wrapper.

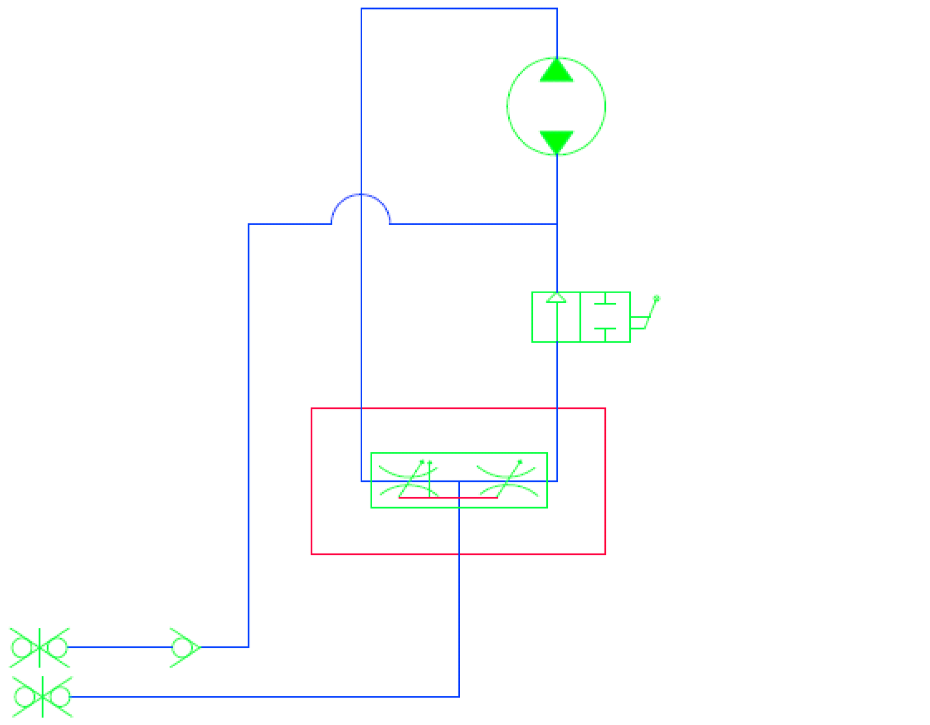

Figure 2. AutoCAD drawing showing a diagram of the hydraulic components of the bale wrapper.

Hydraulic Calculations:
Torque Needed=120lbs*50in=6000in-lbs+10% inefficiency=6600in-lbs
Pressure Needed=6600in-lbs*2π/28.3in^3=1465psi
Flow needed=30rpm*28.3in^3/231=3.68gpm

Budget

Item	Cost
Steel	470.82
Bale Wrap	89.99
Wheel Motor	169.99
Bearings	53.80
Hydraulic Fittings/Hoses	149.33
Hydraulic Flow Control Valve	86.95
Paint	19.95
Miscellaneous	87.90
Total	**$1128.73**

Alternative Solutions

Spinning Reels: Two parallel, cylindrical rollers would be put horizontal to the ground at the base for the bale to sit on. A vertical portion containing the bale wrap would then have been able to spin freely around the bale in order to get the bale wrapped. This idea was not used due to higher costs and increased future maintenance.
Railroad Line: This design would have involved two parallel rails horizontal with the ground for a bale to roll along. There would also have been a vertical portion that held the bale wrap and freely spun around the rails. Size, cost , and portability caused this idea to not be used.
Pallet Wrapper: This would have consisted of a spinning table at the base that the bale would be sat on. It would also have had a vertical pole beside that on which the bale wrap would have been able to move up and down. Problems with this design were how to get the bale onto the spinning table and the necessity to flip the bale in order to wrap all sides of the bale.
Powering the spinning arm: The search for hydraulic motors started with looking at high torque, low speed motors, but none were adequate. This led to looking at ways to increase the torque while slowing down the speed. Belt and chain drives were looked into to solve this issue, but it was realized that it would take two step-downs to achieve the necessary speeds and torques. Gearboxes were too expensive to fit the budget.
Bale Roller: Originally, the idea was to just use the abundance of labor to roll the bale by hand. Then a roller was designed simply as a free wheeling round tube spinning around a fixed smaller tube. This design was eliminated because of fears that debris would get between the two tubes and cause the outside tube to no longer be able to spin.
Wrap Tensioner: Originally the plan was to use two small rollers to snake the wrap around in order to create tension. It also required a set of bearings to allow the roll of wrap to spin freely. That idea was scrapped to cut down the cost and make the mechanism simpler. The final product instead will use ultra-high-molecular-weight polyethylene and pressure to control the tension on the roll as it unrolls.

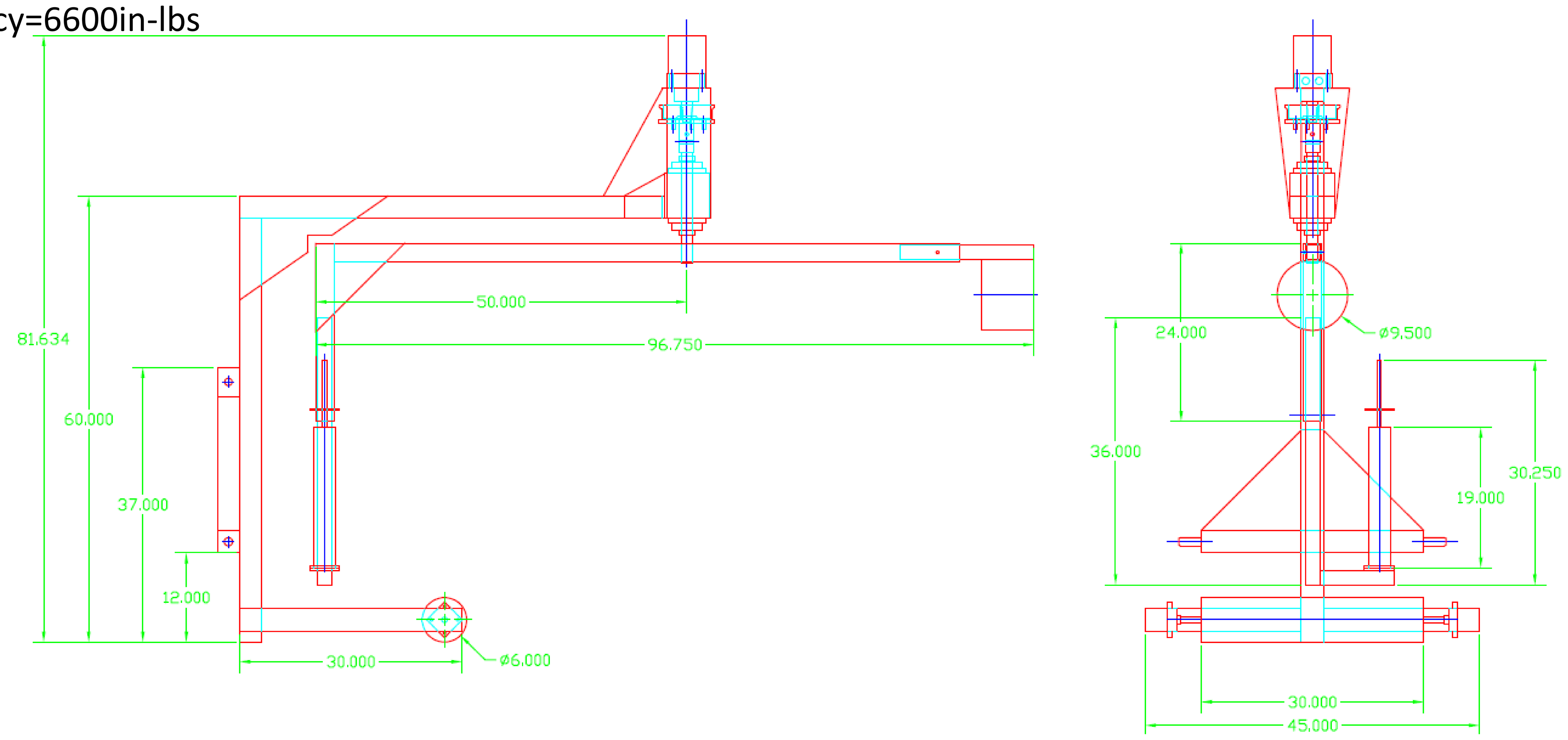

Figure 3. AutoCAD drawing showing side and front views of the bale wrapper with basic dimensions.

Project Sponsor: Dr. Dennis Buckmaster, Associate Professor of Agricultural & Biological Engineering
Technical Advisor: Dr. Patrick Murphy, Assistant Professor of Agricultural & Biological Engineering

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