Energy Performance Systems, Inc.

Project Title: Improving the Efficiency of Planting, Tending and Harvesting Farm Grown Trees for Energy

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Congressional District: 4 (Corporate office: Rogers, MN)
Congressional District: 7 (Project Farm location: Glencoe, MN)
Congressional District: 6 (Equipment Building Location: Big Lake, MN)

MILESTONE 4 - SUMMARY REPORT (PUBLIC)
Basic Planter Design and Fabrication

Executive Summary:
Design drawings for the six-row tree slip planter have been completed. The planter is designed to mechanically inject individual tree slips into no-till farm soil at a rate of 6 slips per second as the planter, which is pulled by a tractor, moves along at up to 5 mph. The planter consists of the following components: 1) support frame with a 3 point tractor hitch, 2) tree slip injection system, 3) tree slip feeder, 4) ram impact absorber, and 5) injection cycle control system. All component parts have been fabricated or purchased and the assembly of the six-row planter is complete. The planter design is aligned with the expectations expressed in the proposal.

Technical Progress:
The six-row tree slip planter, which has been designed and fabricated, is 11.5 ft high by 33 ft wide and 11 ft front to back, and weighs approximately 10,000 lb (see Figure 1 below). The tree slips are specified to be 10 in. long by 5/16 in. to 7/8 in. diameter. The planter support frame is built around a 10 in. by 33 ft long steel box beam, which is attached to the tractor’s three-point hitch by means of steel clamping plates welded around the box beam. To preserve the integrity of the box beam and to allow for row spacing adjustments, no welding was allowed on the beam itself with the exception of the end cap angles. The box beam is supported by a set of adjustable 15 in. gauge wheels at each end of the box beam (see Figure 2) that sets the height of box beam and thus the planter injection tube above the soil. The vertical attachment of each gauge wheel pair assembly, which is located near the center of gravity of the planter, is rated at 5000 lb load. The gauge wheels are designed to swivel 90 degrees so that the planter may be moved in a direction parallel to the box beam for easy handling as well as perpendicular to the box beam in the planting mode. The vertical support structure for each of the six planter assemblies is attached to the box beam using adjustable clamps so that the distance between rows is adjustable from 5 ft to 8 ft. The vertical support structure was welded primarily using 1.5 in.
square structural tubing. The horizontal support structure was built using 1.5 in. by 3 in. rectangular tubing clad with cold rolled 3/16 in. x 1 in. flats and 2 in. square structural tubing with various steel gussets and steel connection plates.

The planter injection system consists of a 4340 hardened steel crossbar fitted with aluminum impact pads, a ram 1.005 in. o.d. by 24 in. long, a vertical ram reset hydraulic cylinder (1.5 in. i.d. by 30 in. stroke), a mechanical trigger mechanism, an injection tube (1.015 in. i.d. by 2 in. o.d. by 59 in. long) and a number of injection springs. Two slots in the injection tube are milled such that the 13 in. long ram crossbar slides freely within the injection tube slots. One end of the springs is attached to the outer end of the crossbar, and the other end of the springs is attached to a stationary support rod such that at the fully extended ram position there is only a slight preload in the springs. In the fully retracted ram position the rubber springs provide the maximum accelerating force on the ram.

The tree slip feeder consists of the horizontal slip loading hydraulic cylinder (1.5 in. i.d. by 30 in. stroke), slip feeder head piece, slip storage box, slip feed hopper, and operator seat shown in Figure 3. For safety the operator seat (and operator) is shielded from the injection system by vertical steel plates attached to the frame as shown. At the end of the stroke two aluminum shoes attached to the ram crossbar impact the rubber wheels such that the ram is abruptly disengaged from the slip.

The planter operating cycle is controlled by 24 inductive proximity pickup switches, four for each row. The proximity switches are connected to an Idec Smart Relay programmable logic controller that in turn switches the 12 volt hydraulic solenoid valves on and off. A laptop computer was used to program the Idec unit. The tractor 12 volt, 30 amp power supply was used for the controls and solenoid valves. The operating cycle starts when the crossbar of the injection ram is at the bottom in contact with the impact wheels, the vertical piston is fully extended so that the trigger mechanism, which is attached to the end of the piston, is closed around the top end of ram, and the horizontal piston is fully retracted. Then the vertical piston retracts and lifts the ram to the upper set position, and the horizontal piston fully retracts. The operator loads the slip into the hopper and waits for a trigger signal. When triggered the horizontal piston moves forward placing the slip into the injection tube. Then the vertical piston moves upward to release the trigger mechanism which allows the ram to accelerate downward striking the slip and injecting the slip into the soil as the ram crossbar is stopped by impacting the shock absorbing wheels.

The proximity switches set positioning and timing of the cycle. The horizontal piston retracts to the first proximity switch such that the operator feed hopper is sealed at the bottom; the solenoid valve closes, and the operator places a slip in the hopper. The horizontal piston retracts to the second proximity switch such that the slip falls into place in the feeder during a 1/4 s delay, whereupon to horizontal piston fully extends placing slip in the injection tube. The third proximity switch is located at the trigger mechanism reset position of the vertical injection ram. When the trigger signal is given by the check wire switch, the high pressure valve is opened and the ram moves slightly higher thereby releasing the trigger mechanism. The ram lift mechanism moves downward, and just before the ram crossbar reaches the impact wheel the fourth proximity switch fires and closes the high pressure return valve on the vertical cylinder.
Figure 1. EPS six-row tree slip planter

Figure 2. EPS six-row slip planter attached to EPS owned tractor
Figure 3. Slip feed hopper, feed hydraulic cylinder, slip holding box, and operator seat.

Additional Milestones:

M1 – Annual Land Rental (first year); report completed, payment made.
M2 – Design & Test Planter Injection system; report completed, payment made.
M3 – Tree Slip Purchase & Tractor Purchase; report completed, payment made.
M5 – Test Planter; report submitted 12/7/06
M6 – First 80 acre Planting; revised report submitted 12/6/06.
M7 - Tree Harvester Testing; work on completing the harvester has been delayed.
M8 – Post Planting Tending and Monitoring; work completed, report in progress.
M9 - Annual Land Rental (second year); in progress.

Project Status:

The project is on target with respect to components that impact the ability to meet future year milestones, i.e. the land was rented, the cuttings were obtained, and planting was completed at a scale sufficiently large for economic evaluations of planting, tending, and harvest costs. Tree growth during the first growing season was normal.

The delay of completion of the planter is due primarily to institutional constraints including the lack of available overload personnel and design changes that have been necessary to compliment the fabrication capabilities of the area machine shops. Many machine shops with CNC capability had long lead times. As a result, parts were produced on manual machines and often were delivered out of spec requiring re-machining that was time consuming. Meeting the
deadline for getting the new planter fully designed, tested and time has been very challenging
given the late date of contract finalization.

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