Reshaping and Recompression of Round Bales into Cuboidal Shape

By

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ABSTRACT

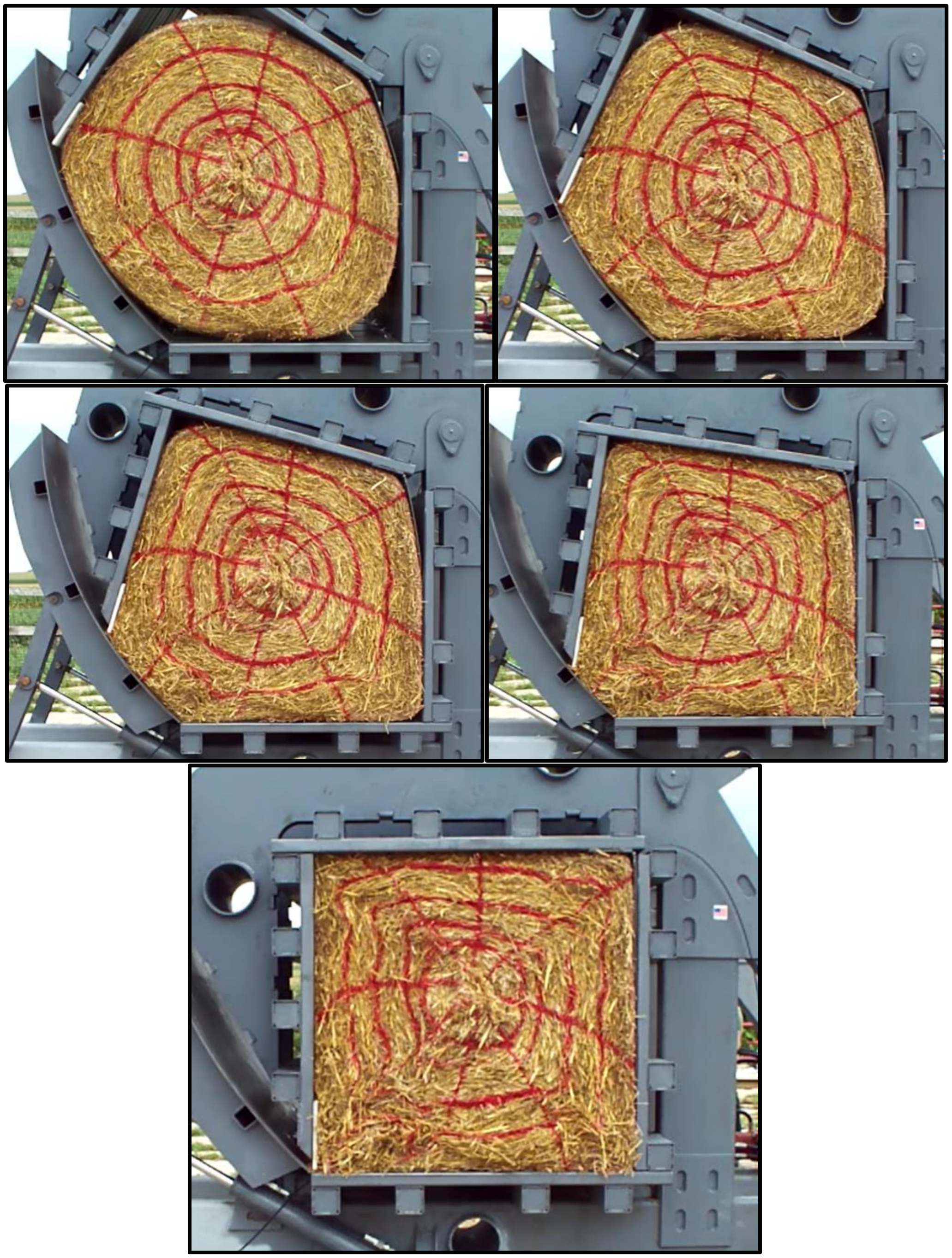
Current transportation systems of large round bales do not fully utilize the available volume and weight restrictions of the transporter. To address this problem, a new baling system (REPAC) was investigated that reshaped and repackaged large round bales into a cuboidal cross section with a bale density that would more fully utilize the volume and weight limits of transportation vehicle while maintaining the outdoor storage characteristics of a typical large round bale. To achieve this, a single stroke compression device was developed and designed using biomass compression characteristics. Considering specific design criteria, several design iterations were completed in conjunction with in-depth finite element analyses to arrive at the machine design used in this research. The design included a hinged two-part square compression chamber; one part fixed to the machine base and the other pivoting to compress the bale through the actuation of hydraulic cylinders. Corn stover, alfalfa, wheat straw, switchgrass, reed canarygrass, and fescue bales were all evaluated.

Regression analysis related force-bale density using linear, nonlinear, and power models suggested in past research, and the results of the modeling analysis were compared. During the compression event, initially there is some additional void reduction in the bale, so density increased at a greater rate than when recompression transitioned to the deformation stage where elastic and plastic deformation likely dominated. Alfalfa, fescue, and reed canarygrass required significantly less force to achieve similar densities compared to wheat straw, switchgrass, and corn stover. The power model consistently under predicted both initial and final bale density, the linear model over predicted both initial and final bale densities, and the nonlinear model performed the best by accurately predicting initial and

final bale densities with an absolute difference between predicted and actual initial and final densities of 2% and 1%, respectively. The specific energy requirements for the recompression process were similar to other published work on the recompression of large square bales and large round bales using a biaxial approach.

The compressed to initial density ratio showed that there was approximately an 80% increase in bale density. However, most of this increase was lost once expansion occurred after the bales were restrained with straps and then relieved of pressure. The expanded bale density was approximately only 25% greater than initial density. The expanded bales produced a squircle cross-section which exceeded desired dimensions. The squircle shaped bales could only safely be stacked on their flat face. The anticipated number of bales the REPAC system could transport per load was 48 bales at a 1.22 m square cross section. The average dimensions of the REPAC bales were approximately 1.37 m at the widest part of the cross section allowing only 40 bales to be transported per load.

REPAC bales were stored outdoors to qualitatively determine storage characteristics. Moisture distribution plots showed that moisture in the outer rind was typically greater than 40% which would likely cause spoilage losses. However, this is also typical of moisture distribution in large round bales. In many instances, moisture penetrated further into the top of the REPAC bale, compared to a typical round bale, due to the REPAC bale having a flatter top surface which likely slowed water movement off the bale. The moisture distribution plots and visual observations indicate that REPAC bales would likely have similar storage losses to large round bales, and certainly would have much lower losses than large square bales stored outdoors under similar conditions.



Progression of compression event of wheat straw bale in recompression machine.