Methods and Processes to Densify Corn Stover for Transportation

by

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Abstract

In the future, it is likely that the production of ethanol using cellulosic feedstocks will become common in the United States. An available source of cellulose material in the Midwest is corn stover. Low bulk density associated with corn stover causes inefficiencies during transportation and storage. The primary objective of this research was to increase the density of corn stover during harvest for more efficient handling. Currently most stover is harvested dried and baled, which is less efficient than wet harvesting due to additional field operations and drying time.

Harvesting stover in a wet form during grain harvest was accomplished by modifying a grain combine to harvest the whole corn plant. The combine was modified through the addition of a flail chopper, blower, and spout, which provided the ability to collect discharged material from the rear of the combine. To harvest the entire corn plant two different heads were attached to the combine; a whole-plant head from a SPFH, which passed the entire plant through the combine, and a stalk-gathering head, which harvested the entire corn plant but discharged the stalk and leaf fractions through a spout on head. The discharged material was collected into wagons pulled alongside the combine.

Increasing the density of stover discharged from the combine was attempted by using load compressing wagons. The load compressing wagons consisted of a modified Anco forage wagon that the compressed the stover with a plunger, and an OMC stacker. Data were collected from the Anco wagon using the whole-plant and stalk-gathering heads.

During this research the stover was compressed using one of three methods: no compression, multiple compressions, and continuous compression. The final experiment consisted of comparing the density of stover in the Anco wagon and OMC stacker.

The results from the Anco wagon compression tests revealed that no increase in density was achieved through compaction. The density of stover in a full wagon was very similar whether the load had been compressed or not. This result was thought to be from the stover pushing upward during compression, as no restraint was present in the wagon to stop the stover from rising during compression. The results were similar with the whole-plant and stalk-gathering heads, with higher stover densities reached using the whole-plant head. A comparison between the Anco wagon and OMC stacker revealed that the OMC stacker achieved higher stover densities even though a smaller pressure was applied to the load. This result supported the idea that stover was pushed upward during compaction in the Anco wagon; because unlike the Anco wagon, the OMC stacker able to constrain the stover on all sides during compaction.

To perform additional densification tests in the lab a small scale compression test stand was designed. The test stand provided the ability to compress small samples of stover in the lab. The test stand was built with a LVDT, which allowed for calculation of volume in the chamber, and a pressure transducer, which was used to determine the pressure applied to the stover. The data from these instruments were recorded by a data logger. The data from the test stand were used to create a compression model from a power equation. This equation could be used to predict density when a specific pressure was

applied to the stover. The coefficients from the compression model were statistically analyzed using an ANOVA test.

The first experiment utilizing the test stand was compression of ensiled corn stover harvested using the whole-plant and stalk-gathering heads. The goal of this experiment was to determine if changing particle size of the stover had a significant effect on compaction characteristics. Particle size reduction was carried out by a hammer mill and forage harvester. The results showed that processing reduced the pressure required for densification. All processing methods used in this research produced statistically similar compression characteristics.

Processing fresh stover during harvest was carried out by installing crop processing rolls in the combine. The processing rolls were design to weaken the structure of the stover as it passed through the combine. The ability of the processing rolls to change the compaction characteristics of the stover was tested by compressing stover treatments in the test stand. From this experiment it was determined that processing rolls did not have a significant effect on the compaction characteristics of the stover.

The results from this research show that stover should be processed to reduce the pressure required for densification; and that during densification the stover should be constrained on all sides. Additional research processing and compressing fresh stover would be beneficial to determine the most efficient method of handling stover during harvest.