RECOMPRESSION OF ROUND BALES OF BIOMASS FEEDSTOCKS

By

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Thesis submitted in partial fulfillment of

The requirement for the degree of

Master of Science

(Biological Systems Engineering)

at the

UNIVERSITY OF WISCONSIN – MADISON

2016

ABSTRACT

The production of ethanol from cellulosic feedstocks has been gaining market share in recent years in the United States in an effort to reduce the dependence on crude oil for transportation fuel. Cellulosic feedstocks, which include perennial grasses, corn stover, wood chips, and small grain straw, are in great abundance, however, the economical harvest, transport, and storage of these crops presents a substantial challenge with today's technologies.

To address this challenge, a new round baling system was investigated that produced a square cross-section bale with a density that would result in weight limited transport of over-the-road trucks. This system compressed large round bales (nominal diameter of 1.2 m) radially and strapped them so that they remained a square cross-section. This was achieved by modifying an industrial waste compactor and using hydraulic power to compress the bales. Several design iterations were completed, but ultimately bi-axially compression was found to create the most improved cross-section. A horizontal platen compressed the bale in the vertical direction, and then two vertical platens compressed the bale horizontally. Wheat straw, corn stover, switchgrass, and reed canarygrass were all evaluated.

The pressure-density relationship of the bi-axial compression was investigated and modeled for each crop. It was found that the compression cycle resulted in a three-stage process: (a) bale reshaping, (b) vertical compression and densification, (c) horizontal compression and densification. Bale reshaping does not increase the bale density but converts it from round to cuboid shape. Vertical compression and densification resulted in limited densification that occurred near the end of the horizontal platen stroke. The amount of densification was dependent on the initial bale diameter because the displacement of this platen was limited. The majority of

densification occurred during horizontal compression with the twin vertical platens. On average, wheat straw, corn stover, switchgrass, and reed canarygrass bales were compressed in the test fixture to a dry matter density of 233, 278, 225, and 250 kg/m^3, respectively.

The vertical compression process encompassed a moderate pressure range and was modeled using a linear regression model. The horizontal compression process encompassed higher pressures and was fitted with power, non-linear and linear models. Although a linear model best fit the data over the range of pressures applied, a power model best explained the process at higher applied pressures. Bales were restrained with polyester strapping, but expanded by 20 – 30% after removal from the fixture. Although compression forces were large, the pressure was applied over a relatively long time (~30 s), so specific energy requirements were less than would be expected with a plunger head baler. The pressure-density relationships and specific energy requirements found for round bale reshaping and compression were similar to other published work recompressing square bales.