A MACHINE FOR HARVEST FRACTIONATION OF BIOMASS GRASSES AND LEGUMES

By

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ABSTRACT

Significant efforts are being made nationally and worldwide to develop source of biologically based fuels from lignocellulosic feedstock, i.e. biomass. The harvest of perennial herbaceous crops is the main focus of this thesis because of the promise they show as a biomass feedstocks. Alfalfa, reed canarygrass, and switchgrass are perennial crops that are being studied for fuel production because the unique traits they possess and the wide range of climates they can inhabit.

An important concern in growing crops for fuel production is the effect on food production. Using forage cropland exclusively for fuel production diverts it from food production. It has been proposed to fractionate grasses and legumes and use the high-protein leaf fraction for food production and the high-fiber stem fraction as a biomass feedstock. This fractionation process has been carried out by processes known as wet or dry fractionation. Although both processes are feasible, they have significant technical or economic barriers. What is proposed in this research is a new process known as harvest fractionation where the protein rich leaves are stripped from the stems at instant the plant is harvested.

The research covered in this thesis investigates harvest fractionation, starting with the design, fabrication, and test of a harvesting attachment that stripped and gathered the leaf fraction while also cutting and windrowing the stem fraction in the field. This concept was to be tested to enhance the value of biomass grasses, reed canarygrass and switchgrass, as well as alfalfa by creating value stream of feed from their leaves as well as biomass feedstock from the stems.

A tined rotor was combined with a converging auger, to strip and gather the leaf fraction, while a disc cutterbar cut and windrowed the stem fraction. The harvesting attachment was powered and controlled with a self propelled forage harvester because of its available power and its processing and conveyance system. The harvesting attachment performed well in alfalfa at common field speeds, but the stripping rotor lacked power to adequately process bulky reed canarygrass and switchgrass. The hydraulic rotor drive system was changed to a variable speed belt and chain drive combination to increase the power available to the rotor. Rollers to pull cut crop off the cutterbar were also added. These changes improved the performance in reed canarygrass, but the redesigned system still could not fractionally harvest switchgrass at more than crawling pace.

The stripped fraction of alfalfa contained about twice the concentration of crude protein as the cut fraction, while the cut fraction contained twice the concentration of cellulose and hemicellulose as the stripped fraction. While the two fractions of reed canarygrass and switchgrass did not have substantial differences in fiber concentration, the stripped fraction did have over twice the crude protein concentration as the cut fraction. The stripped fractionation of the very mature grasses produced a feed quality similar to these grasses in pre-boot stage, while yielding a stem fraction with possible fuel or industrial value. Height of the stripping rotor relative to the crop height had a greater affect on quality and quantity than the ratio of rotor to ground speed.