HIGH-CAPACITY CONTINUOUS SINGLE-PASS ROUND BALING SYSTEM FOR HARVESTING BIOMASS FEEDSTOCKS

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ABSTRACT

To accommodate high material other than grain (MOG) yields in crops like wheat, the feed system on a prototype single pass baler (SPB) produced by Hillco Technologies was modified and the hopper capacity increased by 100%. A two stage unloading system was developed with the addition of a secondary conveyor to more efficiently meter and unload the accumulated material in the hopper in two stages, producing the “lifting” and “rolling” action needed for fast unloading to more readily occur. Additionally, stalk cutoff knives were used on a 12 row ear snapper corn header to increase stover yields in corn. Stover yield was altered by the number of rotary knives on the header; fore-and-aft position of the rotary knives; and the header height.

The SPB system was tested in wheat, soybeans, and corn in the 2013 harvest season. The extended hopper capacity was sufficient to store material during a wrap and eject cycle of the baler in wheat, but the mass flow rate of the SPB was not sufficient to unload the hopper completely before the next wrap and eject event. Furthermore, feeding limitations were experienced when high moisture crop conditions were encountered in both wheat and corn. In soybeans, the SPB system functioned well and produced excellent bale shape. In corn, stover yield increased 100% but fuel use increased by 25% with the addition of six stalk cutoff knives compared to when no knives were used. The bale density decreased from 179 to 153 $kg \cdot m^{-3}$, cob content decreased 60% and the productivity of the combine harvester decreased 50% with the addition of six knives.

To address the feeding and mass flow rate deficiencies of the SPB, in 2014 a pinch conveyor was installed to control material between the metering system and baler; a third metering roll

added to the metering system; metering system feed throat clearance increased 33%; and the secondary conveyor integrated into the SPB automation system.

Continuous harvest of the combine harvester was possible in wheat with MOG mass flow rates from the combine up to 14 $Mg \cdot h^{-1}$ at a harvest speed of 4.8 $km \cdot hr^{-1}$ during the 2014 test season. Corresponding mass flow rate from the SPB was 21 $Mg \cdot h^{-1}$ and the duty cycle (period feed system operated relative to total harvesting time) was 70%. In soybeans, the duty cycle was reduced to 28% with the automation of the secondary conveyor and the SPB feed rate increased to 45 $Mg \cdot h^{-1}$ with a MOG mass flow rate of 9 $Mg \cdot h^{-1}$ at a harvest speed of 6.4 $km \cdot h^{-1}$. Four cutoff knives resulted in an increase in stover yield of 55% and an increase in fuel use of 25%. Corresponding bale densities decreased from 182 to 148 $kg \cdot m^{-3}$, stover cob content decreased from 71 to 43% and productivity of the combine harvester decreased 28%. SPB mass flow rate ranged from 29 to 37 $Mg \cdot h^{-1}$ with the metering system at its minimum clearance and a duty cycle of 32 to 39% with the addition of stalk cutoff knives.

The baler motor stalled when harvesting corn stover when the metering system was at its maximum clearance resulting in an instantaneous torque of 778 N·m and a corresponding power requirement of 61 kW. Mass flow rate of the baler averaged 54 $Mg \cdot h^{-1}$ and baler torque averaged 577 N·m before the baler motor stalled. Losses of stover from the SPB feed system was 5 – 7% of the total stover yield depending on MOG residue chopper settings.


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