

Ian Cosden, Matt Dunson, Jeff Gordon, Doug Cook and James Glancey
University of Delaware

Richard Strosser
CNH America LLC

BACKGROUND HAY CONDITIONING

- Conditioning rolls induce bending failure of the plant stems.
- Failure zones accelerate moisture loss from the stems.
- Proper machine adjustment (i.e. the gap between the rolls) critical for effective conditioning.
- Survey of operators indicates improper machine setup a majority of the time.
- Current manual roll gap adjustments do not promote frequent adjustment.



Intermeshing counter-rotating conditioning rolls on a CNH disc mower.

OBJECTIVES

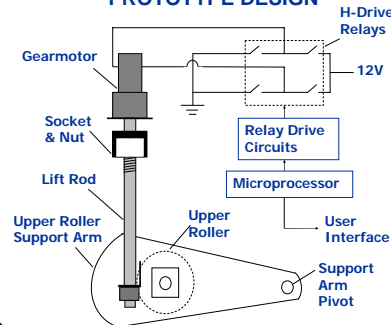
- Increase in-field drying rates by improving the adjustment of the conditioning rolls on mower-conditioners.
- Develop a system for automatic roll gap adjustment
- Compensate for roll wear over time.
- Improve operator safety.

METHODOLOGY

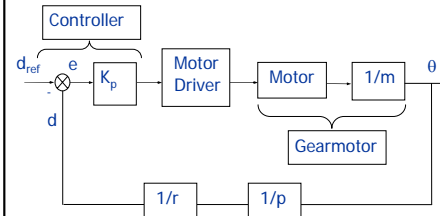
DESIGN REQUIREMENTS

- Accurate control of roll gap
- Repeatable adjustment
- Compensate for roll wear
- Integrate into existing mower conditioner header designs
- Minimize time required by the operator
- Increased safety/accommodate unplugging
- Low cost

PROTOTYPE DESIGN



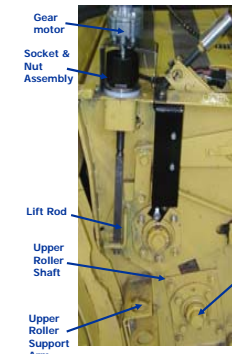
CONTROLLER DESIGN



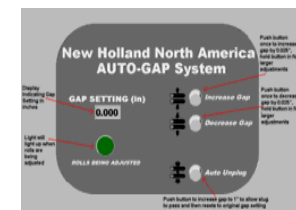
where:

- d_{ref} = roll gap set point
 - d = measured roll gap
 - m = gear ratio of the gearmotor
 - θ = angular displacement of the gearmotor
 - p = lift arm thread pitch
 - r = geometric factor
 - e = error between the measured gap and the gap setting
 - K_p = controller gain law
- $$= \begin{cases} 1, & \text{if } e > \delta \\ 0, & \text{if } -\delta < e < \delta \\ -1, & \text{if } e < -\delta \end{cases}$$
- δ = dead band gap

PROTOTYPE DEVELOPMENT



LEFT SIDE OF THE HW340 SELF-PROPELLED WINDROWER HEADER FITTED WITH THE AUTO GAP HARDWARE

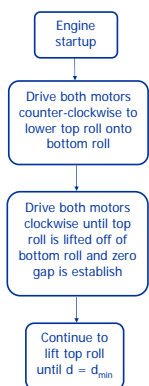


USER INTERFACE IN THE CAB OF THE WINDROWER

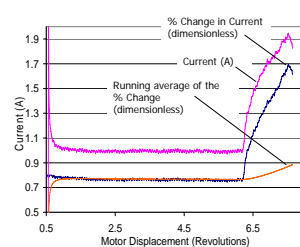
SYSTEM PERFORMANCE

FINDING ZERO GAP

STARTUP ALGORITHM



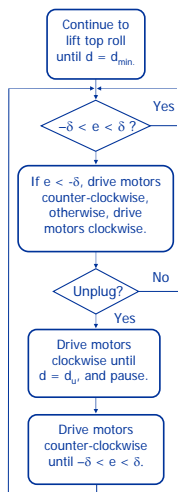
GEARMOTOR CURRENT AT STARTUP



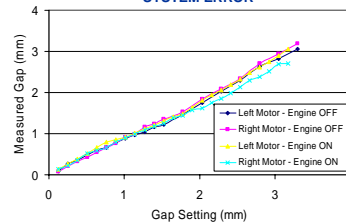
The sharp increase in motor current indicates the top roller is being lifted off the bottom roller. Percent change in current provides a robust indicator of zero gap that is less sensitive to friction and wear that occurs over time.

SYSTEM OPERATION

OPERATING ALGORITHM



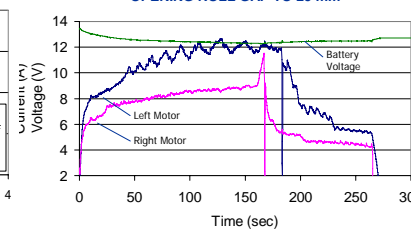
SYSTEM ERROR



Each data point in the above graph was generated by adjusting the roll gap from zero gap to the desired gap setting. The resulting gap was measured via LabView using additional displacement transducers mounted on each end of the upper roller. Maximum average error was 0.15 mm (0.006 inches) with the engine not running. Header and chassis vibration resulting from a running engine increased the average error to 0.25 mm (0.010 inches).

UNPLUGGING

OPENING ROLL GAP TO 25 mm



Data in the above graph was generated by first opening the roll gap to $d_u = 25$ mm from an initial gap setting of 0.25 mm, and then returning to the initial gap. As expected, motor current, voltage drop, and total cycle time were a function of roller spring pressure. For the maximum spring pressure setting, total cycle time for the unplug operation was 4.5 minutes. The corresponding peak power required by the left and right motors were 165 and 150 Watts, respectively. Cycle time decreased as roll pressure decreased.

CONCLUSIONS

- An automatic adjustment system was developed to control the conditioning roll gap on mower conditioners.
- The system provides a simple, cost effective solution for gap adjustment and maintenance, especially as the conditioning rolls wear over time.
- The control system improves operator safety by eliminating manual adjustments as well as the need for physically cleaning the rollers when plugged.
- Tests performed on a prototype system revealed that the effects of roll wear on roll gap could be eliminated with a feature that reset the rolls upon engine startup to establish zero gap.
- The system could effectively control roll gap within 0.25mm, and could also provide an unplugging feature that separate the rolls up to 25mm with the highest roll pressure setting.

ACKNOWLEDGEMENTS

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