A self-adjusting seed finger system to improve gin turn-out

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AT A GLANCE…

Seed fingers are an important part of the gin stand and are used to control the seed roll load, which controls the level of seed damage, seed coat neps and turnout. The CSIRO Manufacturing Flagship has developed a new device that can self-adjust the angle of the seed fingers while seed-cotton is processed. Early trials have shown significant correlations between residual lint on the ginned seed and the angle of the seed finger shaft. Correlations were also observed between the angle of the seed finger shaft and gin motor power consumption.

Seed fingers are an important part of a gin stand and are used to control the density of the accumulated seed roll and the rate of seed drop during ginning. They are typically a pivoted array of evenly distributed prongs or flap (lambrequin) extending towards the gin saws from the top of the huller ribs.

They support the seed roll, which is the revolving mass of seed cotton that accumulates on top of the gin saws and seed fingers. The seed fingers support the seed roll and re-present any seed cotton that has not been fully ginned back onto the saws for ginning.

Yet from an operational point of view the seed fingers are undeveloped in terms of their ability to be controlled for the benefit of the ginner and grower. Currently the seed finger shaft is set manually by the ginner who fixes one of three or four pin settings available. The decision for this adjustment is based on the seed roll being able to turn unimpeded and without excessive drop of partially ginned seed. If the setting is ‘suitable’, it is subsequently often left for an entire ginning season in that position. That the setting is not routinely adjusted is because of the inconvenience in stopping the gin stand to make the adjustment. Moreover, there are no readings or dials to help reinforce the appropriateness of the load applied in this setting, just visual inspection of seed flow and gin motor amperages by the ginner.

Research by Kevin Bagshaw in 2011 showed seed roll density and the forces exerted on the roll box casing vary constantly across the length of the seed roll. The research showed seed roll density could change significantly many times over a one minute period as material in the seed roll is charged and discharged. Seed-cotton inflow was typically heaviest across the central part of the gin apron while the discharge of ginned seed was greatest at the outer edges of the seed roll. Similar patterns were observed across gin stands of different width and manufacture. These observations led to the conclusion the seed roll was filled from the middle and that ginned seed then travelled to less dense areas to be discharged at the outer edges of the seed roll. In terms of output, higher seed roll loading typically meant lower residual lint and longer fibre length, while low loadings gave poorer lint removal and shorter fibre length.

But the ginner does not typically alter the seed fingers for these changes in density because it is inconvenient to stop the gin stand to make adjustments. As a setting available to the ginner the seed fingers have received little attention in peer review and patent literature. According to the USDA’s Ginners Handbook, “seed fingers should be closed and then slowly opened as wide as necessary to allow cleaned seeds to fall out of the seed box.”

Increasing the pressure or density of the seed roll in order to make the seeds stay in the seed roll for a longer period tends to reduce ginning capacity. “But excessively loose adjustment of the seed finger results in too much lint left on the seed and seed-cotton escaping the roll without being properly ginned”. Opening the seed finger position allows for a decrease in the forces required to expel fuzzy seed and so increases the residual lint value. Conversely, closing the seed fingers results in greater forces required to expel the fuzzy seed and so reduces residual lint.

An automated seed finger system designed to self-adjust to improve the distribution of forces applied across the seed roll has been developed by the CSIRO Manufacturing Flagship. Increasing the pressure on the seed roll improved gin turn-out and reduced gin motor power consumption. The system can be retro-fitted to any saw gin stand.

Figure 1(a): Seed finger shaft with three partitions

Figure 1(b): Partitions are each controlled separately via a stepper motor and screw spindle connected via the mounting plate to the end of the seed finger shaft

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August–September 2015
Testing the system

The seed finger system was designed and built at CSIRO and fitted into the fifth stand of a five stand Golden Eagle Series 161 gin at Warren before the start of the 2014 Australian ginning season. Figures 1(a) and (b) show the mechanical components of the system.

Each screw spindle has a travel range between 0 and 40 mm with the 0 mm setting corresponding with a seed finger pivot angle of 0° – that is, the seed fingers are in their lowest position relative to the seed roll. The 40 mm setting corresponds with a 30° elevation of the seed fingers. At this location the load exerted by the seed roll onto the seed fingers is expected to be highest. A motor controller and signal/data processing unit with custom software connects load cell force measurements with movement of the stepper motor and the pivot angle of the seed fingers.

The main purposes of the 2014 trials were to:

- Investigate the response of the seed finger prototype to pressures exerted by the seed roll on each partition during commercial ginning.
- Measure the effect of adjusting the seed fingers throughout their available range on residual lint and damaged seed count values.
- Measure changes in main gin-stand motor power consumption to determine the viability of using power draw, as well as pressure, as a means of auto-controlling the system.

Figures 2(a) to (c) show the location of the seed finger system and control panel fitted onto the commercial gin-stand for the trials. Seed-cotton (variety Sicot 74BRF) from irrigated and modern spindle harvested production was processed during the trials.

Discussion of results

Seed finger angle and force measurements

Figure 3 shows the average normal force applied with individual values for each partition. Both the left and right partitions applied less force than the centre partition of the seed roll which is typically denser than the outer (left and right) sections. The system’s software can be programmed to control the pressure applied to each partition within defined ranges with the pressure range determined by one or all of the following factors; residual lint on seed, pivot angle range and/or gin motor current (power).
Force and gin motor current

Interestingly and somewhat counter-intuitively, as the force applied by the seed fingers was increased, gin motor current draw at near full production (15 bales per hour) decreased linearly at a rate of nearly 12 amps per kilogram of force applied (Figure 4). This suggests that the seed roll produced by the increased force is more compact and therefore able to rotate cleanly without any impingement on top of the gin saws that drive the rotation of the seed roll. More experiments are needed to develop a more definite answer to this phenomenon and to determine whether seed discharge rates are affected. It is noted that in terms of production rates, the gin stand used in these trials was operated at the same rate as adjacent stands without any measurable change in throughput (bales per hour).

Residual lint

Figures 5 and 6 show the relationship between partition angle and residual lint values as seed finger partitions were lowered (Figure 5) and then raised (Figure 6). Except for the values associated with the left partition during lowering they show less residual lint on the seed as the seed finger angle increases. The diminished relationships in Figure 5 are associated with seed cotton accumulating under the seed finger retarding the lowering mechanism, particularly on the left hand side. The largest changes in residual lint were found on the right hand side as it was raised, after seed had been cleared underneath the seed finger flap. Residual lint values on this side were over 10 per cent at 0° which reduced to 8.6 per cent at 28°, a reduction of 1.4 per cent. For every one degree increase in angle, there was 0.05 per cent less residual lint on the seed – that is, greater turnout.

Across all three partitions, the residual lint value decreased an average of 0.7 per cent (from 9.9 per cent at 0° to 9.2 per cent at 28° – see Figure 7). The significance of this value is that the partitions in this trial were moved in unison with each increment/decrement and so larger reductions might be expected if the system was operated on an automatic basis, where compaction across the seed roll is automatically equalised using the partitions set to a standard ‘calibrated’ force.

Damaged seed

No trends were evident in the relationship between the average percent of seeds damaged measured for each step of seed finger elevation. And no difference in values was observed between the control gin stand (adjacent) and the active seed finger stand, although there were some significant variations in damage levels in all cases. Differences in the seed roll geometry between the control and treated (seed finger) stands is suspected as being the main cause of the differences in residual lint and damaged seed values.

Conclusions

This research provides evidence that the position of the seed fingers influences the amount of residual lint on ginned lint and lends weight to the idea that self-adjusting seed fingers could be used to extract more fibre (increase turn-out) for the grower.

As seed finger angle was increased, more residual lint was removed. Differences of up to 1.4 per cent less residual lint after the seed finger angle was increased to its maximum were recorded without any impact on seed damage. As well as reducing residual lint, incrementing the seed fingers also increased the force applied to the seed roll and surprisingly reduced gin motor power consumption.

We gratefully acknowledge financial support from the Australian Cotton Research and Development Corporation and the CSIRO Agriculture and Manufacturing Flagships. We would also like to thank Ausscott Limited, and in particular Wayne Towns, David Pratt and their team for hosting and helping with the trials described in this paper. We also gratefully acknowledge Neale Gibbons for his workmanship and Ian Redknap and Michel Givord from the CSIRO Manufacturing Flagship for their design work.