Less gin cleaning for better fibre quality

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In today's highly competitive and diverse global textile market, product quality has become of paramount importance. For spinners to produce yarns that can be turned into high quality woven and knitted fabrics with little or no difficulty, emphasis needs to be placed on fibre quality and the maintenance of this quality through processes such as ginning.

The subjective classification of cotton according to established standards or grades — for example, USDA Grade Boxes — often forces the gins to over-clean the fibre since this results in a higher price for the cotton grower. But the over cleaning is often to the detriment of fibre quality, processing performance and ultimately the value of cotton as a raw material for textiles.

In fact, subjective grades are often such a poor indicator of the true spinning value of the fibre that some spinning mills offer price premiums for cotton that is harvested, ginned and shipped according to their strict specifications — that is, custom ginned. It is not known how much cotton is ginned in this way but indications are that large volumes of cotton are custom ginned world wide and that this practice is increasing.

Research in the US on the effects of ginning on fibre quality has shown that controlling moisture content during ginning, and reducing the number of lint cleaners, produces cotton with improved fibre properties, such as longer staple length, better length uniformity and fewer neps (two to five). In Australia, work conducted by the National Centre for Engineering in Agriculture (NCEA) has also shown that low heat and reducing the number of lint cleaners produces lint with better fibre properties. The work reported here builds on these results and aims to examine the subsequent effects of lint cleaning on yarn and fabric quality.

FIGURE 1: Textile processing routes for lint cleaner treatments

LINT CLEANING TREATMENTS

The results reported here come from two lint cleaning trials conducted during the 2002–03 season. Cotton for the lint cleaning trials was supplied by two growers — for the sake of anonymity, GA and GB.

Cotton from both growers was grown under irrigation in the Namoi Valley during the 2002–03 season. Both cottons were of a similar grade and had micronaire values of 4.8, which was out of the preferred range for fine count spinners, but typical of the 2002–03 crop.

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The lint cleaning trials were carried out at the Merah North gin (Namoi Cotton Co-operative) in Wee Waa under the supervision of CSIRO Textile and Fibre Technology (CTFT). Three cleaning treatments were used:

- Standard cleaning using two lint cleaners;
- Custom cleaning (ginning) using a single lint cleaner; and,
- Zero cleaning — that is, using no lint cleaners.

Cotton ginned under these treatments was subject to tight moisture control. Seed cotton moisture was kept between 6.5 per cent and 8.5 per cent during ginning by controlling dryer temperature to minimise effects of moisture variation on lint quality.

Initially trials were undertaken to test the effects of lint cleaner treatments on fibre quality using 12 modules of GA cotton. Two modules of GB cotton were then used to produce lint according to the three treatments for spinning and fabric trials at CTFT.

FIBRE TESTING

Each bale produced from the modules processed was HVI tested with further fibre and sliver samples being sent to the Schlafhorst Texlab in Mönchengladbach, Germany. At Schlafhorst, tests were carried out using the Advanced Fibre Information System (AFIS) and the Micro-Dust and Trash Analyser (MDTA) instruments, which are used to gain further insight into the fibre length, nep, trash and dust distributions within a sample.

TEXTILE PROCESSING

Three bales from each lint cleaner treatment (nine bales in total) of the GB cotton were then processed under identical conditions using machines set to industry standard settings and production speeds. Figure 1 summarises the steps taken at CTFT to convert raw fibre into

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TABLE 1: Important fibre properties

Importance rank	Ring spinning	Rotor spinning	Vortex spinning
1	Length	Strength	Length
2	Strength	Fineness	Cleanliness
3	Fineness	Length	Fineness
4		Cleanliness	Strength

TABLE 2: Effect of lint cleaner treatment on cotton grade

Lint cleaner treatment	GA cotton	GB cotton
Standard	21–3	21–2
Custom	31–3	31–3
Zero	31–4	31–4

TABLE 3: Per cent trash extracted in the blow room

Lint cleaner treatment	Mill cleaning	Carding	Total
Standard	0.80%	1.37%	2.17%
Custom	1.12%	1.39%	2.51%
Zero	1.35%	1.40%	2.75%

FIGURE 2: Total trash and dust in cotton lint as tested by the MDTA

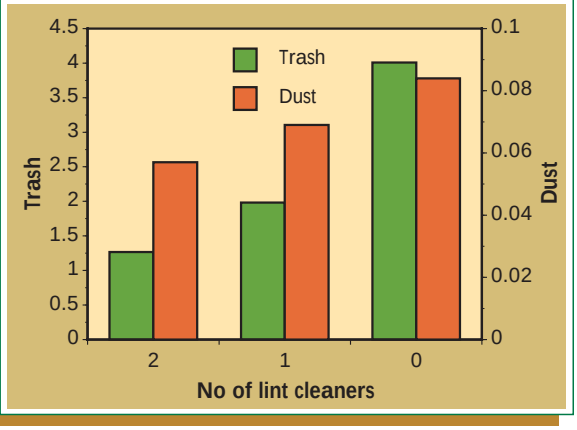

TABLE 4: Single jersey (Griege) fabric test results

		Ring			Rotor			MVS		
Fabric property ↓	Lint cleaner →	2	1	0	2	1	0	2	1	0
Bursting pressure (KPa)		385	409	420	398	403	357	398	427	458
Pilling (1 = poor, 5 = good)		1–2	1–2	2	1–2	2	2–3	2	2	2

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yarn. Spinning trials were conducted using the three main short staple spinning systems used by the cotton spinning industry today — ring (RF), rotor (OE) and vortex (MVS) spinning. Each lint cleaner treatment was subject to spinning trials over a range of yarn counts — ranging from medium count yarn through to the finest count that could be spun on each spinning system. Three spinning systems were used because each requires different fibre properties to achieve satisfactory quality and production (Table 1).

Yarns were knitted into single jersey fabric using a commercial circular 24-gauge knitting machine. Fabric was dyed using a reactive dye in a jet dyeing machine and finished on a stenter. For each yarn count spinning performance, yarn quality and fabric quality was measured. For brevity, this article will only list data for yarn count Ne 30/1 (20 tex).

WHAT HAPPENED?

Fibre quality

As with previous lint cleaning studies by the NCEA a reduction in the number of lint cleaners had a significant effect on the grade of cotton. Classing grades fell with the reduction in lint cleaners due to the uneven appearance of the cotton and increased levels of trash and dust (Figure 2), which affected colour assessment.

Standard cleaned cotton (two lint cleaners) was classed as Strict Middling with the custom and zero cleaned cotton (with one and zero lint cleaners) classed as Middling largely on the basis of increased trash levels — and in the case of zero cleaned cotton, poor preparation.

On the positive side, the results for staple length, length uniformity, short fibre content, strength and neps (Figures 3 to 7) show that the fibre properties of custom ginned cotton were generally superior to the cotton ginned under standard conditions (two lint cleaners). On

FIGURE 3: Staple length of cotton lint as tested by HVI

FIGURE 4: Uniformity ratio of cotton lint as tested by HVI

average, staple length increased by 0.5 mm, short fibre content decreased by 0.4 per cent, nep content decreased by 48 neps/gram (with no difference in nep size) and strength improved by one gram per tex when cotton was treated with one instead of two lint cleaners.

Further improvements of a similar magnitude occurred when no lint cleaning was used. Elongation remained constant and, as expected, fibre properties such as micronaire and maturity were not affected by ginning.

Gin production data also showed that gin turn-out or the cotton lint yield improved by approximately 0.4 per cent (around one additional bale per three modules ginned) as the number of lint cleaners were decreased.

FIBRE QUALITY — TRASH

Over the years there has been much debate regarding the possibility of moving lint cleaning into the textile mill rather than the gin in order to better preserve fibre quality. Studies have shown that if minimum cleaning is done at the gin, the modern mill blow-room — that is, opening through to carding — is able to cope. Table 3 lists the amount of waste extracted from the major cleaning and carding points for each lint cleaner treatment.

It is clear that a modern spinning mill is able to cope with trashy cotton with minimal fibre damage and loss. This is further highlighted by the yarn trash results for the

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FIGURE 5: Short fibre content of cotton lint as tested by AFIS

FIGURE 6: Fibre strength of cotton lint as tested by HVI

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yarns produced on the three spinning systems, which show that the trash count/gram is similar irrespective of the lint cleaner treatment used. This confirms previous studies showing that if minimum cleaning is done at the gin, the opening and cleaning line in a modern spinning mill is more than able to cope with additional trash.

Neps

In the spinning mill, the opening and cleaning processes tend to create neps. It is then left to the carding machine, which is the heart of a spinning mill, to significantly reduce the level of neps with a further slight reduction taking place during drawing. There is also a decrease in short fibre content. The change in the number of lint cleaners did not appear to have any affect on the evenness of the card and drawframe sliver.

Yarn quality

In general, the improvements in fibre properties such as fibre length, length uniformity and SFC with reduced lint cleaning were reflected in improvements in yarn properties — that is, yarn evenness, the number of yarn imperfections and yarn strength — although these improvements were slight because of the effect of the high micronaire cotton used in the trial. A comparison of the yarn test results to the current Uster Statistics shows that, in general, the quality of the yarn produced in these trials was considered on par with the average quality produced worldwide.

In general, the most even yarns were produced from cotton ginned with zero lint cleaning although the differences between lint cleaner treatments were small. The reduction in lint cleaners also had a small influence on total yarn imperfections in ring spun (RF) yarn.

For MVS and OE yarns there was a substantial reduction in total imperfections — that is, the number of thin and thick places and neps for cotton treated with one lint cleaner. The reduction in lint cleaners also had minimal influence on yarn hairiness — that is, the number of fibre ends protruding from the yarn structure.

The reduction in the number of lint cleaners also only had a slight effect on yarn tenacity — with the strongest effect in ring spun yarns. All three yarn types had less variation in yarn strength.

Fabric quality

Knitted fabric was produced from the yarn and subject to standard bursting pressure and pilling resistance tests. Fabric burst pressure results typically follow yarn tenacity results. The results show that fabrics constructed from

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FIGURE 7: Neps in cotton bales as tested by AFIS

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ring and MVS spun yarns became stronger with a reduction in the number of lint cleaners, whereas the fabrics constructed from OE yarn showed an increase in strength with single lint cleaner followed by a slight decrease in strength for zero lint cleaners.

With the exception of fabric produced from MVS yarns, pilling performance improved with the reduction in the number of lint cleaners.

This is consistent with the current understanding of pilling — that is, yarn constructed from fibre with a high proportion of short broken fibres tends to produce more pills (unsightly entanglements on the fabric surface) during the course of the test.

Dyed appearance

The white speck count for each lint cleaner treatment was also measured. White specks are small neps made up of very immature or sometimes 'dead' fibre. These neps appear as white specks on dyed fabric as the fibres do not take up or hold dye. They are particularly prominent on smooth lightweight fabrics dyed darker shades.

FIGURE 8: Effects of lint cleaner treatments on white speck counts in dyed fabric (manual count/five square inches of fabric)

On fabric constructed from ring spun yarns, white speck counts decreased slightly with a decrease in the number of lint cleaners (Figure 8).

CONCLUSIONS

The custom ginning trial shows that reducing the number of lint cleaners to one, or even zero, results in cotton with more trash and a lower classing grade. But arguably more important fibre properties from a textile perspective such as staple length, length uniformity, SFC and nep content are improved.

Moreover, the textile processing trials demonstrated that the textile mill can adequately cope with the higher trash content with no detrimental effects on processing performance, yarn and fabric quality. Indeed, yarn and fabric test results improved with this approach.

These positive outcomes for custom ginned 4.8 micronaire cotton indicates that further work with finer cotton, more typical of normal Australian growths, is warranted. Custom ginning of finer cotton is expected to exhibit even greater benefits — that is, finer cotton is likely to be more susceptible to mechanical damage during lint cleaning.

This would confirm the general level of improvement that is achievable by reducing the level of lint cleaning in Australian gins.

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