NEW GINNING TECHNOLOGY FOR AUSTRALIAN COTTON

CRC109

July 2005 to June 2006

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CSIRO Textile and Fibre Technology

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Background

The ginning industry in Australia is relatively modern, with high throughput compared with the gins in other countries. Currently 37 gins operate in Australia each processing an average, over the last three years, of 70,000 bales[1]. Reduced production as a result of the drought of the last three years has seen some consolidation of gin owners and equipment.

The majority of gin machinery used in Australia is designed and manufactured in the USA by two manufacturers; Lummus Corporation and Continental Eagle. The average age of installations is currently 15 years old[1], with the oldest over 28 years old.

There is some opinion within the Australian ginning and merchant industry that the US designed gin machinery and systems, particularly the pre-cleaning and lint cleaning processes, is not optimised for Australian conditions. Evidence of this is that pre-cleaning systems are more often by-passed than used[1] and that Australian lint has a reputation for high nep and short fibre contents as a result of successive passages through two lint cleaners.

A large part of the research covered in CTFT9 and in the project preceding it; 'Improved Quality of Ginned Australian Cotton' (CTFT6), has been focussed on understanding and modifying the mechanical elements in the controlled-batt saw lint cleaner so that fibre damage is reduced.

Project CRC109 was a separately funded project with aims to examine the whole ginning process critically and focus on identifying new technology and systems in gin pre-cleaning, ginning itself, lint cleaning and/or baling appropriate for Australian cotton. To this end CRC109 has been an information gathering project partly extending on the knowledge gained through the CRDC project CTFT9 but also initiating new understanding of other areas in the gin. The outcome of CRC109 is represented in the second of the new CRDC and CCC CRC ginning projects, which has the objective of measuring fibre moisture accurately in the gin and providing a feedback system to driers and/or humidifiers in order to modulate moisture in the fibre.

A further objective, which emerged during the survey of gins, is the examination of the gin point between the saw and gin rib. New saw tooth and gin point profiles are proposed in order improve gin efficiency and reduce fibre damage – in particular to the seed coat.

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[1] CCC CRC CRC109 Australian Gin Survey 2006 – see PART A

Objectives

New ginning technology for Australian cotton – CRC109

July 2005 to June 2006

1. A review of literature and preliminary investigations of the gin and lint cleaning areas listed on page 3, including consultation with key manufacturers of ginning and cotton processing equipment, and ginners.
2. A review of sensing technologies, including current, moisture, image and load sensors, currently applied and available to industry, and initiate preliminary testing of their active application to ginning and lint cleaning systems.
3. Assess potential intellectual property.
4. Depending on the potential of areas identified in this study to be exploited by the Australian cotton industry and outcomes from CRDC project CTFT9, seek to appoint post-doctoral level scientist with view to initiating and progressing industrial trials in 2 or 3 of the five areas listed on page 3 (of the proposal) – see below.

Areas nominated for investigation

Areas in the gin that have good potential to be exploited in terms of providing improvements to fibre quality and productivity will be examined. These include but are not limited to:

1. The application of saw tooth and/or spiked beaters (in series) in the lint cleaner feed works to produce a more even and open batt prior to combing by the saw cylinder.
2. The application of an auto-leveling system between the lint cleaner feed bar and feed roller to ensure a constant combing ratio.
3. An investigation of saw wire profile and how this affects combing action at the feed bar and consequent fibre interaction at grid bars.
4. An investigation of doffing brush efficiency and whether or not this can be improved by increasing air supply via vents and or an air knife to the doffing zone.
5. The application of active or real time sensors in the gin, such that the position of mechanical cleaning elements such as the gin ribs, feed rollers, feed bar, grid bars etc etc. can be optimized immediately in terms of fibre quality.

EXTENT TO OBJECTIVES HAVE BEEN ACHIEVED

The objectives of project CRC109 were largely to collect and review information on the Australian ginning industry; in particular on its practices and requirements for advances in productivity and/or fibre quality control. CTFT believe that simple on-line feedback sensors and systems for process and quality control need to be implemented for better control and management of Australian gins.

Systems like the Uster Technologies ‘Intelligin’ and the Continental Eagle ‘Eagle Eye’ represent new on-line systems that enable the ginner to fine tune lint cleaning and moisture addition. The failure of the Australian gin industry to utilize these systems reflects their poor utility to Australian cotton in terms of price, applicability of data and consequently of return benefits to the ginner.

Wary of the failings of these systems this project has sought to define and detail systems that would be useful in improving the quality of Australian cotton; namely lint cleaner control, moisture sensing and control and contamination detection and removal.

The objectives detailed in the two new CRDC and CCC CRC ginning projects, which appear in this report, describe work to be done to realize systems capable of controlling these areas and thus improve Australian fibre quality.

A further objective, which emerged during the survey of gins, is the examination of the gin point between the saw and gin rib. New saw tooth and gin point profiles are proposed in order improve gin efficiency and reduce fibre damage – in particular to the seed coat.

Methods

There have been four broad areas of activity throughout CRC109. These include 'information gathering' and consultation with industry, engineering and ginning experts to gain feedback on proposed concepts; 'laboratory trials' where concepts have been tested in the laboratory before application to industry; 'industrial trials' where concepts are realised and fitted and tested in a working gin; and 'extension' where research results are extended to industry.

Formal and informal information gathering has been on-going throughout the course of both projects. Researchers made many trips to gins throughout both projects; to discuss gin operating practice; run trials or to modify gin machinery. The reports and subsequent project proposals put to the CRDC and CCC CRC this last year, found in this report in PART A, represent the distillation of these information gathering activities.

During visits to gins in early 2006 as part of the Australian Gin Survey the topic of gin saw wear, longevity and gin efficiency was often raised in discussion. Gin saw blades have a limited life and face a number of problems while in service. As a result CTFT set out to make preliminary examinations both Continental Eagle & Lummus Corporation gin saw blades in terms of wear, tooth profile and metal fatigue. Blades were subject to numerous tests and trials at CSIRO and at a cotton gin in NSW. New saw tooth and blade profiles were also explored – see PART B.

Reports on industrial trials are collected in PART C of this report. A trial to measure the effects of adding moisture pre-gin using Samuel Jackson Conditioning Hoppers over the gin-stand was also conducted at Brighann gin.

Formal presentations made to the Australian Cotton Grower Research Association (ACGRA), the Australian Cotton CRC and the CCC CRC. These presentations plus articles published in the Australian Cotton Grower and Australian Cotton Outlook are collated in PART D.

LIST OF DOCUMENTS INCLUDED IN THIS REPORT

Information gathering – PART A

1. Research and detailed plans for moisture replenishment and auto-levelling systems for lint cleaner 2005 to 2006
2. Survey of Australian gin plant and practice 2006
3. CRDC/CRC project application (MLC) 2006
4. CRDC/CRC project application (moisture and contamination) 2006

Laboratory trials – PART B

1. Gin saw wear and metal fatigue properties 2006

Industrial trials – PART C

1. Effect of moisture on fibre damage 2006
    a. Moisture effects on fibre

    b. Moisture measurements

Communication and extension – PART D

1. Presentation Australian Cotton CRC final research meeting – Aug 2005
2. Article Australian Cotton Outlook ‘Ginning for Quality’ – Dec 2005
3. Article Australian Cotton Grower ‘Inter-lock Wire’ – May 2006

REPORTS

PART A

PART B

PART C

PART D

CONCLUSION

The industry and technical information collected during this ‘project’ along with the results of the moisture trials (see PART C) conducted late this year is being used to initiate the new CRDC CCC CRC ginning project: New Ginning Technology for Australian Cotton: Part II (Moisture and Contamination).

Preliminary examinations of both Continental Eagle & Lummus Corporation gin saw blades in terms of wear, tooth profile and metal fatigue have resulted in the identification of new saw tooth and blade profiles that have potential to improve ginning efficiency and fibre damage control – see PART B – and which will be examined as part of the new CRDC CCC CRC ginning project New Ginning Technology for Australian Cotton: Part I (MLC).

The initiation of the new CRDC ‘Nep Survey’ project in 2006/07 will provide information that can be used to measure the effects of new gin technology on fibre quality.

EXTENSION (& COMMERCIAL) OPPORTUNITIES

As per CRDC CCC CRC project proposals

EXECUTIVE SUMMARY

The two new ginning projects sponsored by the CRDC and CCC CRC will examine two important factors that affect fibre quality in the Australian ginning process; lint cleaning and fibre moisture. Research in lint cleaning will continue on from CTFT9 and the development of the MLC.

Moisture in lint is a significant variable in determining whether fibre is damaged during ginning and lint cleaning. Dry cotton i.e., < 5% regain (moisture content by dry weight of fibre) is subject to more damage than cotton at a regain above 6%. Control of fibre moisture through Australian gins is critical in enabling the industry to produce high quality lint. The issue of measuring and replenishing moisture will be examined in the new CCC CRC ginning project (Part II).

A further objective, which emerged during the survey of gins, is the examination of the gin point between the saw and gin rib. New saw tooth and gin point profiles are proposed in order improve gin efficiency and reduce fibre damage – in particular to the seed coat. The issue of gin efficiency will be examined as part of the new CCC CRC ginning project (Part I).

AUSTRALIAN GIN SURVEY – 2006

OBJECTIVE

Understand how Australian gins manage the quality of fibre they process. In particular, the management of quality with regards to the use of lint cleaners and moisture in the ginning process.

METHOD

Survey questions (see Appendix A1) were answered in writing or verbally during interviews conducted in person or over the phone. Twenty one of 37 gins were approached to be surveyed. Of these 14 (or 38% of all gin (sites)) provided answers.

BACKGROUND

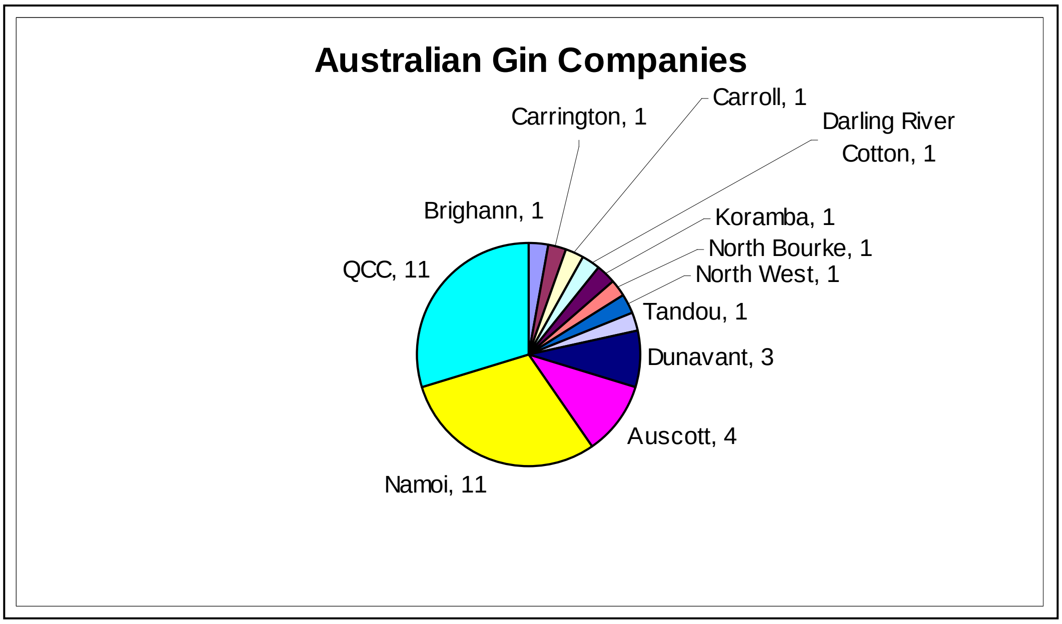

Figure 1 - Australian Ginning Companies - 2005

There are currently 37 gins in operation in Australia although some of these, particularly in the south and west have not been operated for the last three years (of this current drought).

At the end of 2005 QCC bought the Twynam Agriculture ginning operations (3 gins) for $AUD25M. The exchange was mutually beneficial; QCC broadens its market reach into NSW whilst Twynam divests itself of a non-core activity.

QCC and Namoi are the largest ginning/merchant operations. Together they gin and ship over 50% of Australia's cotton. Auscott, whilst not as widespread in its operations dominates gin-market share in the valleys it operates in; namely the Macquarie, Namoi and Gwydir. Dunavant run three gins one each in the Gwydir and Condamine Valleys and one in the Fairburn Dam area.

There are a number of smaller independent gin companies – these can be divided into those that are solely custom gin operations e.g., North-

West, and those that are owned by large cotton grower(s) for the benefit of those growers almost solely e.g., Brighann. Two Namoi gins are co-owned by large growers as joint-ventures to benefit those growers.

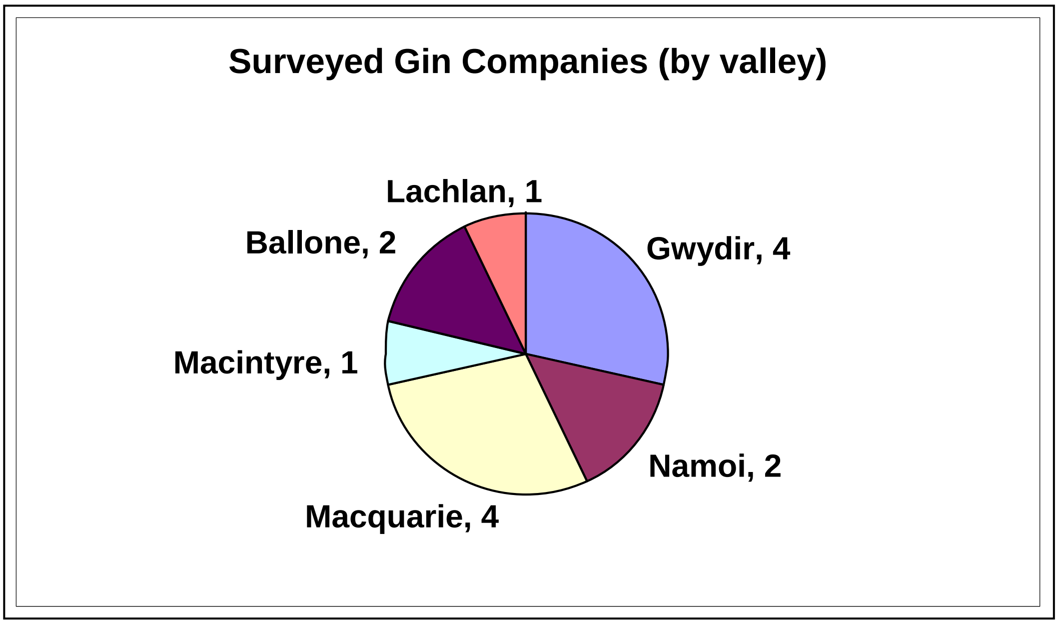

Figure 2

Figure 2 shows the number of gins in each valley/irrigation area surveyed.

What type of ginning system (make & model)?

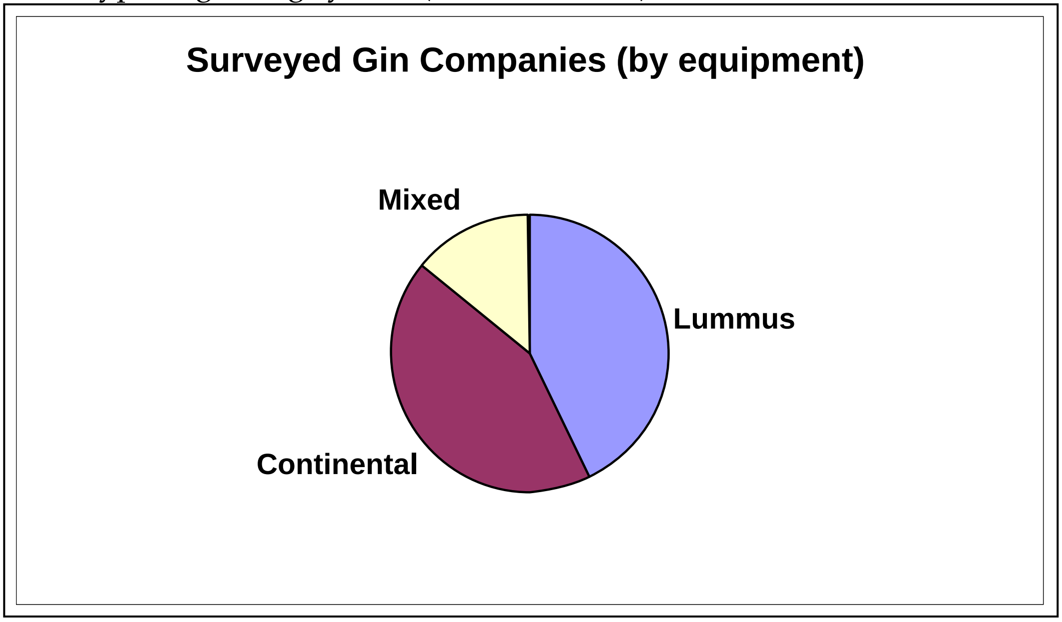

Figure 3 – Percent gin machinery by manufacturer

Figure 3 illustrates the mix of machinery used by ginners. By and large gin machinery utilized is split equally between two gin manufacturers; Lummus Ginning Corporation from Savannah Georgia and Continental Eagle from Prattville Alabama. There are various opinions about the quality and productivity of each manufacturer.

What is the annual production (bales per year) – last three years?

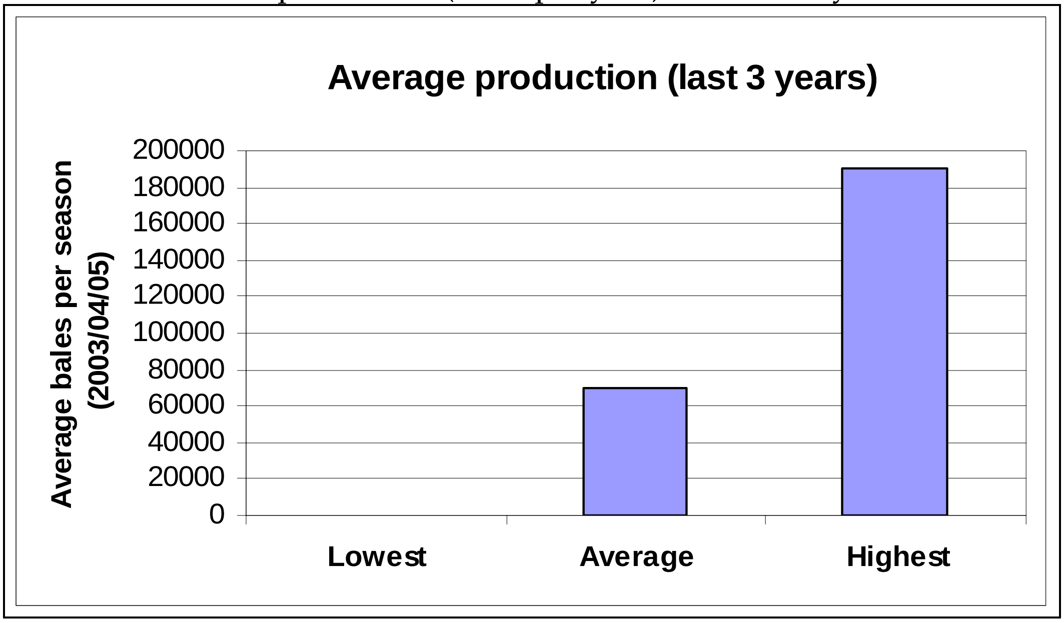

Figure 4 – Average production 2003, 2004 & 2005

Figure 4 shows the current average production of surveyed gins over the last three years. The average number of bales was a little over 70,000 bales with the highest being 190,000 bales and the lowest being zero bales (in the Macquarie Valley).

Age of plant (stage of re-build/re-investment)?

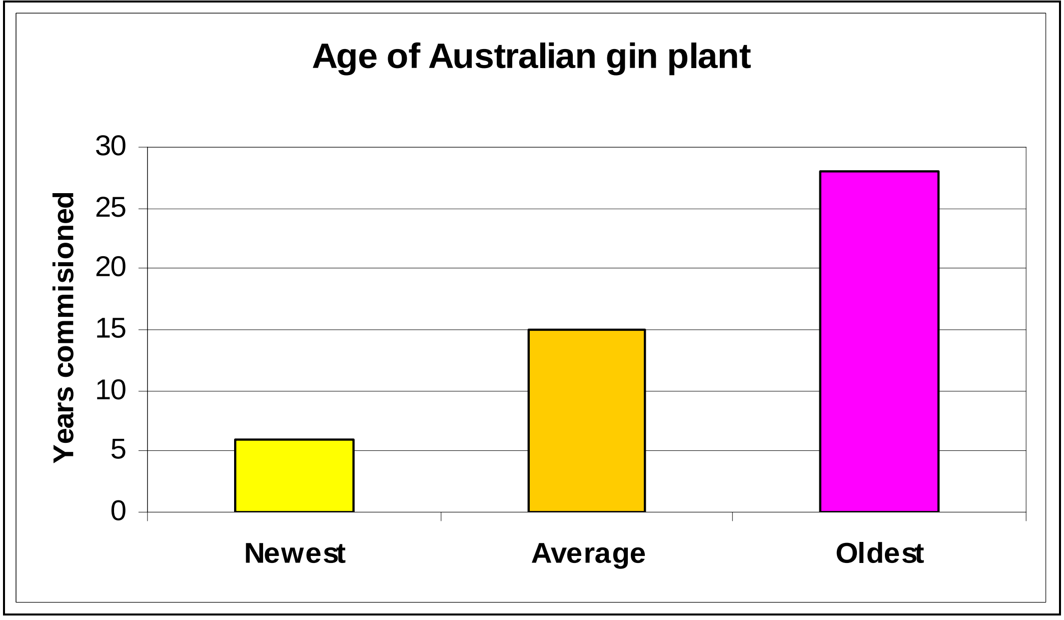

Figure 5 – Age of gin plant surveyed

Figure 5 shows the age of gin plant surveyed. The average age of gin plants was 15 years old with the newest plants being six years old. The oldest gin surveyed was 28 years old. Plant in older gins is often a mix of older and newer equipment.

MAINTENANCE and SETTINGS

GIN STAND

How often are gin saws replaced or sharpened?

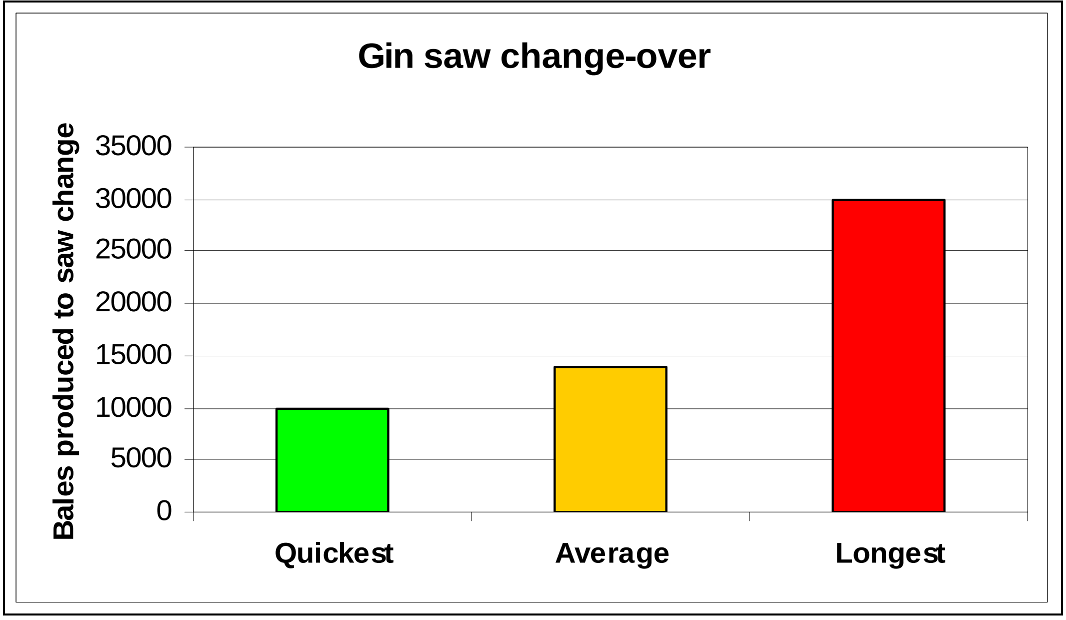

Figure 6 -

Sharp saws are required for efficient and clean removal of lint from the seed. Dulled or damaged saws mean more power usage, less turn-out and an increase in damaged fibre.

Figure 6 shows the average number of bales ginned before gin saws are replaced. Every ginner surveyed had a specific number of bales in mind before they contemplated changing saw blades although this number was dependent on the type of cotton being ginned in a given year e.g., whether or not the cotton in a particular year was dirty and/or had been stripper harvested. These types of cotton will blunt saws more quickly. The distribution of results was skewed towards shorter times around the average or less.

Gin operating efficiency was mostly measured in terms of bales per day or bales per shift.

LINT CLEANER

What combing ratio i.e., saw-to-feed roller speed, do you use?

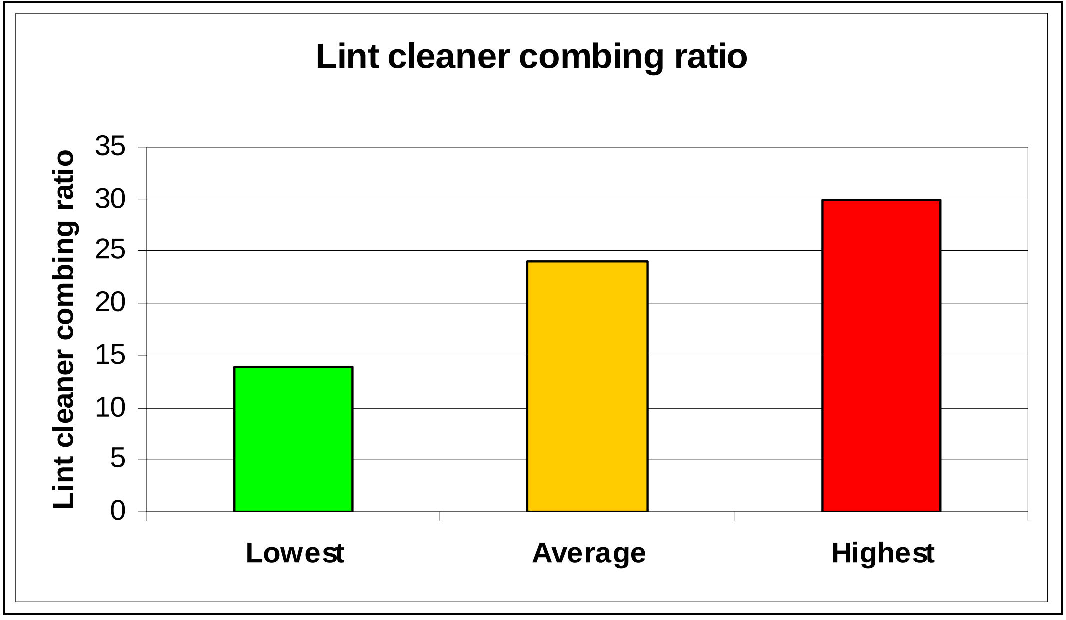

Figure 7 –

CSIRO research has shown lower CR produce less short fibre and where the batt is controlled adequately on to the saw, lower neps.

Only one of 14 ginners thought that combing ratio (CR) affected fibre length and as such had set a low CR on their lint cleaners (@14) – see Figure 7. All others had CRs set in the middle of the geared range of speeds i.e., a CR (or draft) of 24 or higher. A higher CR means more combing action in the fixed batt lint cleaner.

What cotton qualities (classing grades) does the gin typically produce/process?

What criteria do you use to decide the number of lint cleaner passages?

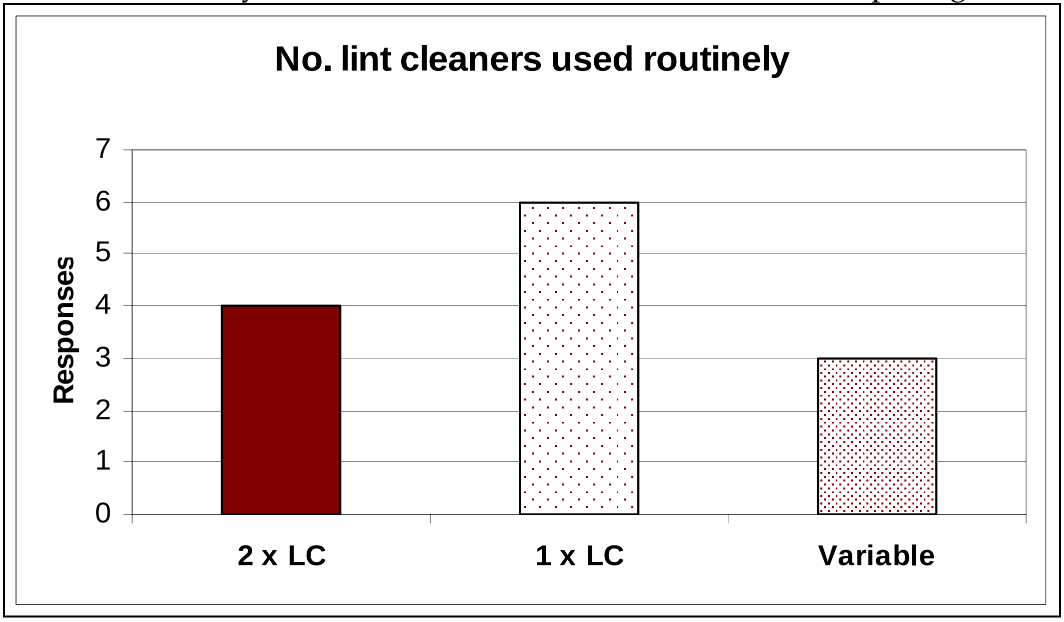

Figure 8 – No. lint cleaner routinely used

Figure 8 shows the average number of lint cleaner (LC) passages used routinely by ginners. Four of the ginners still used 2 LCs as a standard process. Most ginners however used one or varied the number of LC passages according to the grade of cotton being ginned, and assessed for grade in near real-time.

Two gins are currently using the Schaffner Technologies 'Iso-Tester' instrument, which is able to provide near real time objective measurements of cotton colour and trash grade so that the ginner can react to lint cleaning requirements more immediately. Other ginners used classing boxes to assess grade.

Lint cleaning is often criticized as the process that damages cotton most. How can the lint cleaning process be improved to reduce fibre damage?

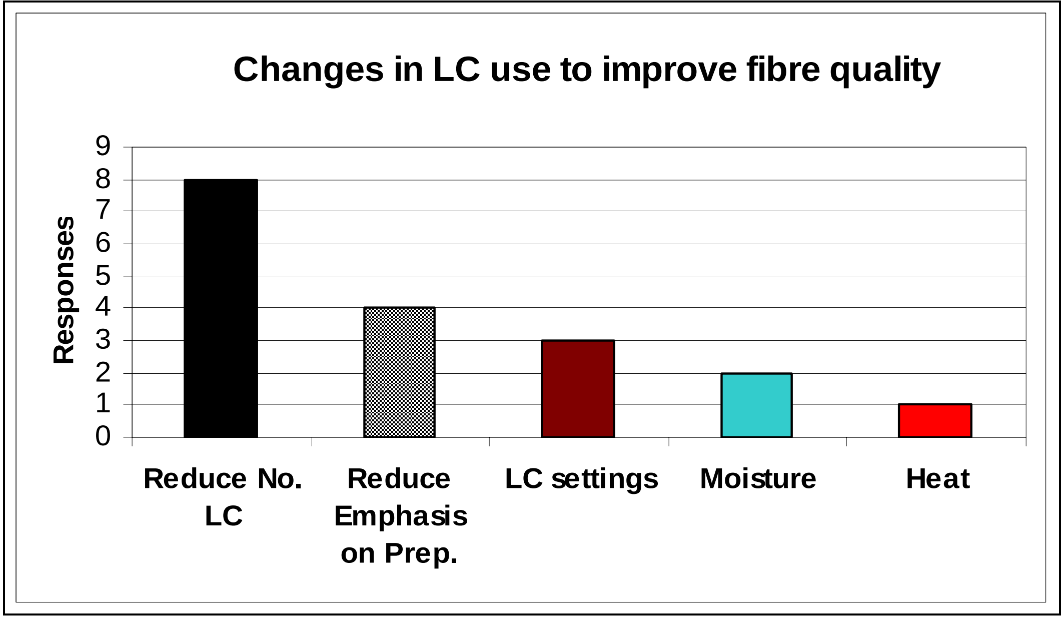

Figure 9 – Changes in LC use to improve fibre quality

Figure 9 illustrates that ginners are aware cotton is damaged as it passes through LCing, and further, understand the compromise between grade and fibre damage. Most however were unaware of the amount of damage created in the LC with the majority of ginners unaware of the nep and SFC levels in the cotton they ginned. Only three ginners nominated moisture and drying control as a means of reducing fibre damage.

GIN OPERATION

How many employees (in gin): Casual & permanent?

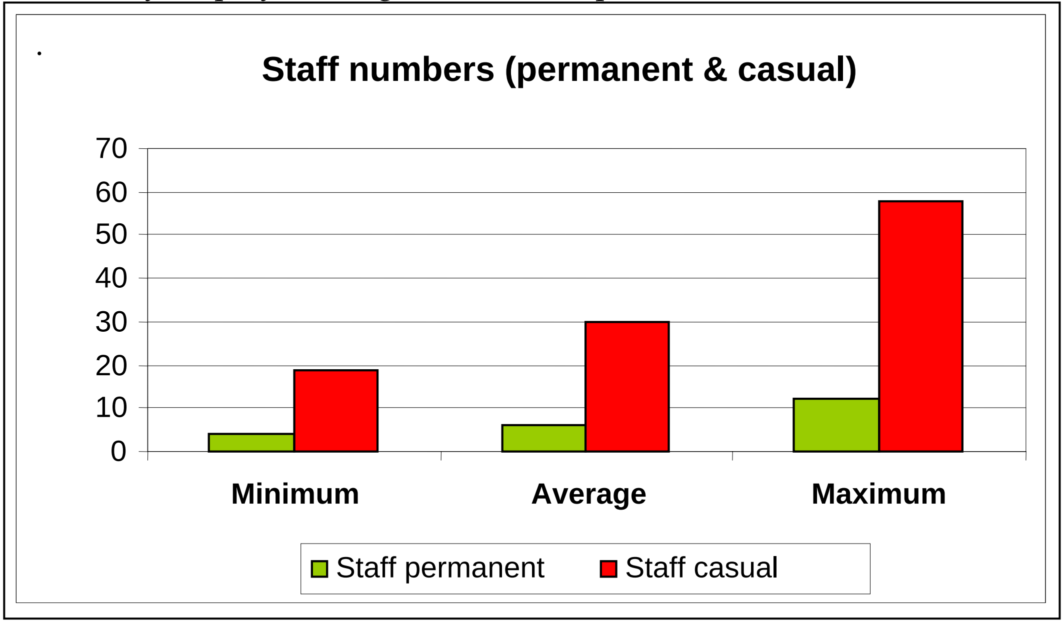

Figure 10 – Staff Numbers

Figure 10 shows the average number of permanent and casual staff employed by gins surveyed. Permanent employees are usually full-time, and casual staff is usually employed for the ginning season on a full-time shift cycle, which lasts from three and up to six months.

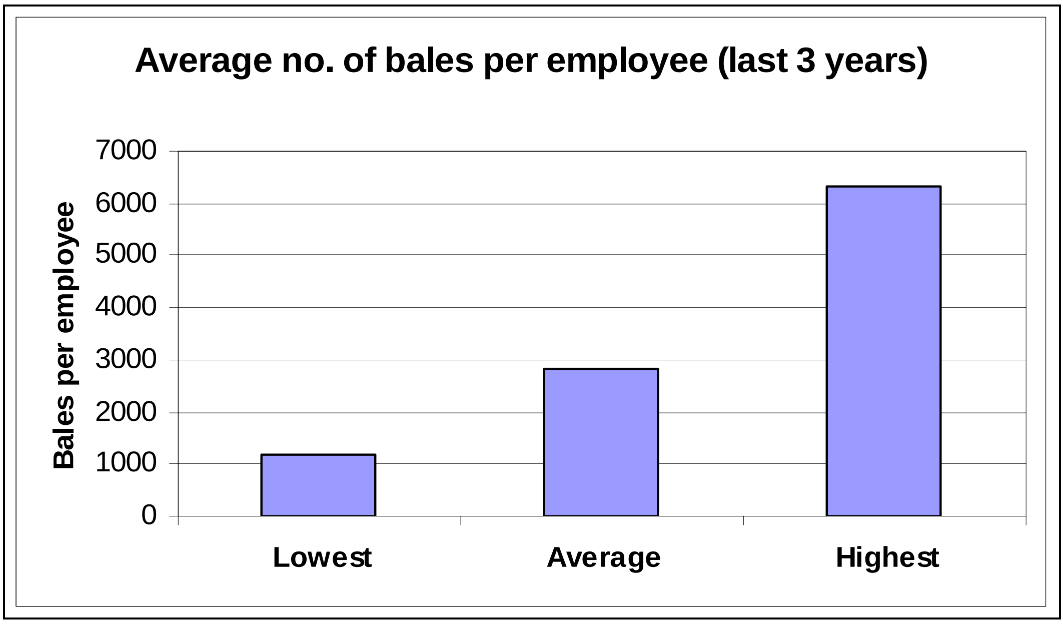

Figure 11 -

Figure 11 shows the bales produced per employee. The number is a simple division of the average number of bales (over the last three seasons) ginned by number of employees (permanent and casual) during the gin season. Not taken into account is the number or definition of positions held by casual staff.

It is noted that the maintenance period, lasting six to nine months, required on a gin plant is equal in man-hours to the operating period of the gin season i.e., one operating hour requires close to one hour of maintenance.

Which gin equipment/process do you believe needs targeting for research to improve the operation of?

What part of the ginning process i.e., from module through to baling represents the biggest bottleneck?

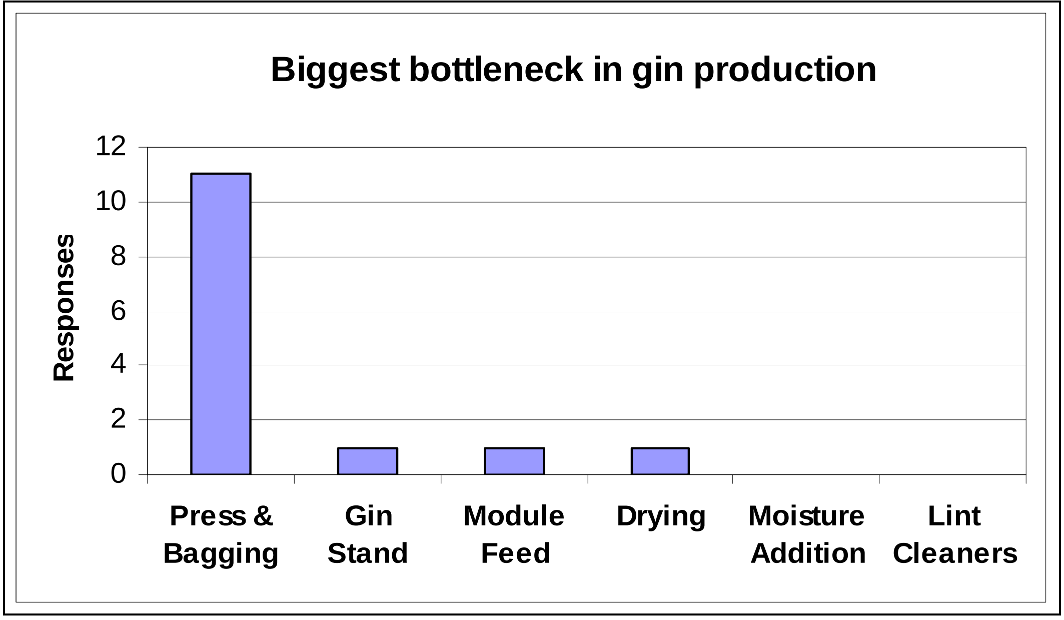

Figure 12 – Production advances required in the gin

Of all the processes involved in ginning, bale pressing and bagging rated highly amongst gins surveyed as areas requiring further research and development. Ginners thought the number of staff required to operate the bale press and wrap bales; especially considering the occupational hazards in these areas, versus press time and bale output was too high. All ginners wanted faster press times and reduced human input in these processes.

SUMMARY & COMMENTS

In terms of production the Australian ginning industry is by far the most productive internationally on a per gin plant basis with an average of a little over 70,000 bales per gin per year over the three years to 2005. This number can be contrasted to the USA gin industry, which in 2001 averaged 20,000 bales per year[1].

The Australian cotton ginning industry therefore has an incredible maintenance to run time ratio, heading in the direction of 1:1. With this in mind the machinery is certainly being pushed to its maximum capacity, perhaps beyond. Maintenance is therefore critical in Australian gins both for production and preserving fibre quality.

If the actual efficiency of the various fibre transfer mechanisms is considered then additional efficiency gains through objective assessment and automatic feedback of machine condition and improved design, stand waiting to be exploited. For example, whilst a gin stand may be capable of 15 bales per hour, when this efficiency is expressed on a (saw) tooth basis it reveals that 20 gin saw teeth remove only ~ 3 mg of fibre; equal to the amount found on one end of a single cotton bud. This is surprising considering the massive amount of current supply (up to 200 amps are drawn) by the motor driving the saw shaft.

It is well known that gin stand saw blades decrease in efficiency as the tooth point becomes blunt, furthermore the horsepower required to drive the saw shaft through the seed roll increases. The survey revealed a factor of two in terms of saw blade life, the variation in which could be attributed to management belief and sensitivities to plant performance. The survey did not delve into the impact on gin stand efficiency; in terms of lint removal, power consumption and maintenance costs.

The pressing and bagging of the bales is by far the greatest issue that ginners have as far as bottlenecks go. Most of this issue would appear to be related to resource issues more than bale press times, although this also is an issue. Most ginners interviewed indicated a preference for automated bale and pressing processes and with that relief from the OH&S problems associated with this process.

With most ginners not understanding the extent of the damage that is/can occur(ing) on the lint cleaners, Figure 9 demonstrates that there is little research carried in gins to improve fibre quality. While only one ginner is using a CR of 14 and the other ginners are up as high as 30. It should be noted that improper control (large clearances) of the fibre batt to the saw, feed bar and feed rollers also leads to an effective zero draft, which in turn creates fibre damage and poor cleaning.

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[1] Hughs, et al, 'USA Ginning Costs', BCC, Atalanta GA, 2001

Sensor Control of Fibre Damage

Continental Eagle Lint Cleaner Research Report

CSIRO Textile & Fibre Technology

Belmont

November 25th 2005 – February 17th 2006

Sue Suraphol

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1. Project Brief

Supervisor: Dr Stuart Gordon

November 25th 2005

Sensor Control of Fibre Damage in Saw Lint Cleaners

CFTF has found that an even spread of moist fibre from the feed works onto the saw cylinders in the lint cleaner minimizes damage (nepping and SFC) inflicted by grid bars and the feed plate where fibre is transferred from the feed works to the saw cylinder. Producing a lighter more even feed also enhances the cleaning ability of a controlled batt saw type lint cleaner.

Mechanical elements in the lint cleaner (gin) could be controlled via sensor and electrical/digital signals back to **motor drives, mechanical cleaning elements and hydraulic systems** in order to improve the fibre quality and productivity.

Areas in the lint cleaner what would benefit include:

- The application of an auto-leveling system between the condenser, final feed roller and the saw cleaner to ensure a constant feed/combing ratio of fibre onto the saw.

- The application of metered moisture/lubricant to lint prior to saw cleaning by the use of moisture meters and dosing pumps (moisture adds strength to cotton)

- The application of fibre property sensors (moisture meters/colorimeters/cameras) in the gin and lint cleaner to change the position of mechanical cleaning elements such as the gin ribs, feed rollers, feed bar, grid bars etc in order to optimize mechanical settings in real time to affect changes in fibre quality.

2. Introduction

Three areas were addressed in the brief for this twelve week project. The requirements for the development of an auto-leveling, moisture control and fibre property system were outlined.
This report contains sections relating to the research and recommendations for the overall system.

This sensor control report is divided into three sections two of these address the functionality requirements of the project while the third explores the implementation of a control system.
The project was tackled in three distinct stages because the auto-leveling and moisture components are basically independent systems that share a common controller.

The moisture section looks at moisture detection and the system used to deliver wetting agents to the lint. Auto-leveling involves fibre sensing, measurement and modulation of rollers inside the lint cleaner.
The selection of a programmable logic controller (PLC) and power supply are the basis of the control system enabling pumps and drives to be connected and controlled via sensor inputs. Once combined these three sections make up the complete sensor system for the Continental Eagle lint cleaner.

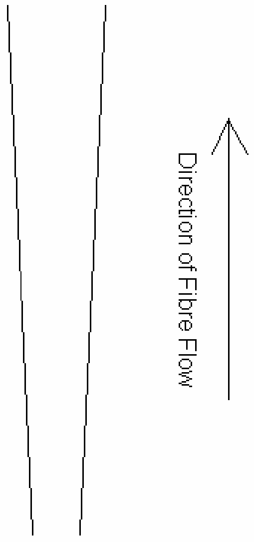
The issues of fibre property are complex and overlap into the areas of auto-leveling and moisture control whilst also containing mechanical elements. Changing the positioning of cleaning mechanisms require mechanical expertise and went beyond the scope of electrical engineering.
However the findings of this report will optimise the benefits of any mechanical modifications made to lint cleaner in the future. As a result a separate fibre property section using sensors such as colorimeters/cameras was not explored.

3. Moisture Control

Setting up moisture monitoring and designing a dosing system within the lint cleaner is the focus of moisture control. The moisture content of lint is an important factor in determining the quality of ginned cotton. Maintaining 6% moisture improves strength and cleaning efficiency of the lint cleaner and this system potentially minimizes the damage inflicted on the fiber.

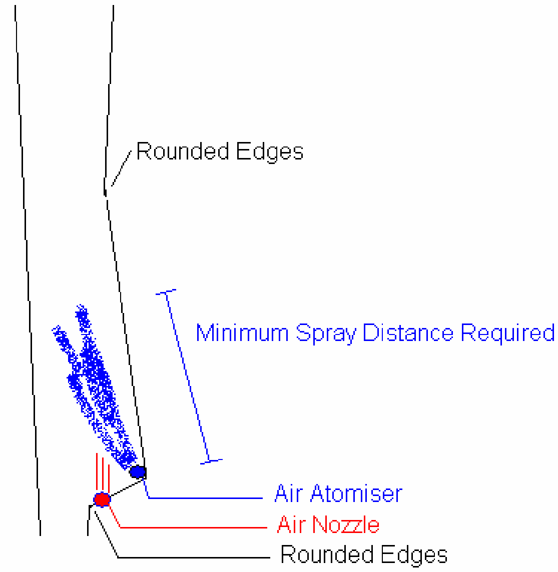
Ideally the lint cleaner should have at two moisture sensors one at the input and output feed of the unit. Lint entering the cleaner is not condensed so the surface area of the cotton is at a maximum making moisture absorption more effective. Fitting nozzles into the incoming chute would require modification of the chutes because the cross sectional area is very narrow and the nozzles need minimum distances to accommodate their spray patterns.

Cross Sectional View of Feed Chute into Lint Cleaner



Original Feed Chute

Figure 1.



Chute Modification

Figure 2.

Objectives

Moisture Monitoring
Analyze in real time the percentage moisture content in the lint. Collect data from the moisture sensors and process the information to accurately control dosing of the fiber.

Dosing Requirements
Install fine spray nozzles for water and/or wetting agents to effectively wet the lint to ideal moisture levels. Minimize snagging of lint on the nozzles where dosing occurs. Select a dosing pump for the dosing volumes and range required.

3.1 Moisture Monitoring

Cotton is ginned in Narrabri during the winter months of May to August when the climate is cool and humidity is low. On average the cotton bales arriving at the gin will have a moisture content of 4% excluding instances of unusually wet or dry conditions. According to ginning literature the moisture content of lint to be machine should be maintained at 6% to improve strength and cleaning efficiency.

The lint entering the cleaners will require an additional 2% dosing on average. The moisture sensors required for this application need a high degree of accuracy (at least ±0.5%) and a small working range (3 – 10%). As the sensors are to be located in chutes where lint is flowing though, the measurements should be taken quickly, continuously, online and without contact. Inside the cleaner the lint can be traveling anywhere between 1 – 30km/hr. The airflow and low density of cotton allows the assumption that the surface moisture of the lint is consistent with the entire cross section of the sample.

3.1.1 Moisture Sensors

Moisture sensors turned out to be one of the most challenging areas of this project. The two most important characteristics of a moisture sensor are accuracy (< 0.5%) and the ability to function online and without contact with the material.

A variety of options were explored before selecting near infrared moisture (NIR) sensors. Contact or invasive moisture sensors can provide the desired moisture data at low cost however the systems may not have capabilities to communicate with the controller. These sensors require physical sampling and/or extended contact with the material during measurement both of which are cumbersome for an automated moisture system.

Unlike other sensors available microwave sensors operate online without contact and are very fast and accurate. Microwaves are capable of measuring the overall moisture content in very dense or compacted material rather than just surface moisture. Unfortunately this also means that microwaves are unable operate as effectively on very low density materials such as cotton webbing.

The difficulty in finding sensors for this project application stemmed from the fact that high accuracy online moisture measurement is a very specialized field usually restricted to particular industries. Typically the near infrared moisture sensors available on the market are designed for process systems such as food, grain, flour, pharmaceuticals and tobacco. As a result the capital investment for two of these sensors far exceeds the cost of all other components of the project combined.

3.1.2 Zeiss Spectral Sensors

Spectral sensors sometimes referred to as photodiode arrays or near NIR detectors. They provide an accurate indication of moisture content by measuring the transmission of NIR light through materials. Near infrared (NIR) wavelengths between 980 – 1600 nm are most suited for surface moisture detection. As these sensors are non-contact, fast and online satisfying all necessary requirements of the system application.

Spectral sensors cannot be plugged directly into a PLC but require a PC using software calibration and analysis of data to determine moisture content. These types of online sensors offer excellent wavelength stability and accuracy.

Zeiss has an Australian distributor based in Sydney and were able to provide detailed information about their products. These sensors are an integral part of the dosing system but their accuracy and the compact packaging required for installation come at a high price. In terms of investment the sensors start at AUS$20,000 each and this is consistent with a number of their competitors.

3.2. Dosing Requirements

Narrabri during the ginning season is cool and humidity is low, the moisture content of cotton arriving at the gin is on average four percent. The dosing range for the lint cleaner has been designed for this climate. The moisture content of bales rarely fall below four percent and maximum moisture content should not exceed six percent.

If 227kg bales are processed at a rate of 10-15 bales/hour in 3-4 gin stands (227 * 15 * 4) 1362kg of lint is processed per hour. Assuming one litre of water equals one kilogram. The kilogram value of moisture content is calculated using percentage of output weight.

Lint Cleaner Output = 13620kg

Moisture Content			Dosing Required			Flow Rate	
%	Weight (kg)		%	Weight (kg)		litres/hr	litres/min
6.0%	817.2		0.0%	0.00		0.00	0.000
5.5%	749.1		0.5%	68.1		68.1	1.11
5.0%	681.0		1.0%	136.2		136.2	2.27
4.5%	612.9		1.5%	204.3		204.3	3.41
4.0%	544.8		2.0%	272.4		272.4	4.54

Table.1

Maximum flow rate: 272.4 l/hr 4.54 l/min
Minimum flow rate: 00.00 l/hr 0.000 l/min

(An error in calculating the volume of water to be pumped has been made – numbers have been corrected to this point. Note: Pump specifications still need to be revised – Stuart Gordon 8/11/06)

3.2.1 Nozzle Selection

Ideally the nozzles selected should produce a fine fog-like mist which is evenly distributed throughout the webbing and quickly absorbed.

Initially direct pressure nozzles seemed good for functionality and required minimal design. They provided fine mist but were hard to control over the dosing range. Fine misting nozzles producing droplets under 10 microns require high pressure water pumps (50+ bar) to operate.

> *Cloud, fog and mist droplets are very small. Their mean diameter is typically only 10-15 micron (1 micron = 1/1000 mm).* www.sundog.clara.co.uk/droplets/clouds.htm

Using one pump on a narrow but long piping system would compromise pressure. The system couldn't be reliably adjusted to meet criteria and needed large and extremely high pressure pumps up to 40 horsepower.

For this project snagged or clogged spray heads are an issue that plagues any dosing system design. The source of the problem is the low flow rate requirement of zero to twenty-seven litres per hour and the quality of water used in the dosing (possibly bore water). Regardless of the style or droplet size of a nozzle the orifice will be tiny (a fraction of a millimeter) due to the low flow rates.

Air atomizers are guaranteed not to drip and produce fine and consistent droplet size regardless of dosing volume. They are extremely accurate as part of an automatic moisture control system. Using air atomizers would deliver a technically superior dosing system. Employing theses

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nozzles would require the development of a system for proportional water to air flow control. The effectiveness of this design relies heavily on nozzle maintenance which requires frequent cleaning due to calcium and other mineral build up. At least ten stainless steel atomizers would be needed costing $300.00+ each.

During the trip to Narrabri similar air atomizers recommended in this report had already been purchased by a ginner as part of a back-up system to an existing commercial humidification unit. Despite the maintenance needs of atomizers they are an effective dosing tool. Even nozzles in Samuel Jackson humidifiers require routine maintenance so cleaning blockages is not a foreign concept to the ginners.

Due to the nature of the internal mechanics of the lint cleaner the distribution of moisture is aided by the mixing, compression and cleaning occurring inside. Delicate nozzles producing fine mist may not be necessary however the spray system needs to be robust and easy to modify and maintain.

Another spray nozzles which could be used are the garden variety irrigation spray heads. They are robust, require minimal water pressure to operate, are simple to install or modify and cheap to replace. Nozzles designed to work in muddy gardens are unlikely to become blocked with adequate filtering of high sediment water sources and in any case replacements can be made easily.

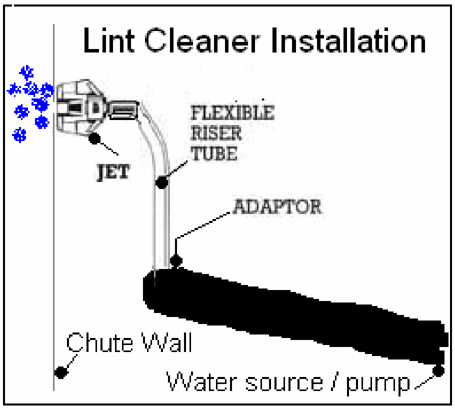


Diagram courtesy of Philmac Pty Ltd., Plastic Fittings, Valves and Irrigation →

Figure 3.

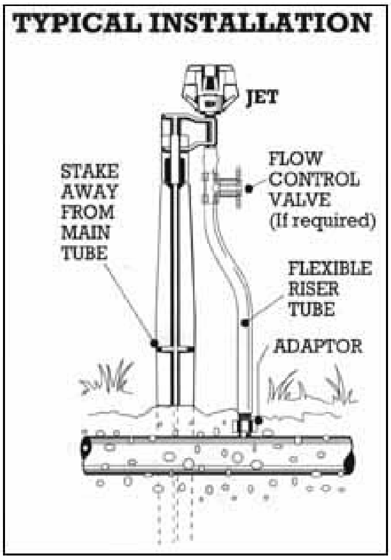


Figure 4.

Representative diagram of a garden spray nozzle installed in the feed chute to dose cotton inside the lint cleaner. Overlapped half circle spray heads would adequately cover the 2.6m dosing length. Specific nozzle models and prices are mentioned in this report although these products can be obtained from most garden or hardware store.

The installation of the spray nozzles into the lint cleaner requires modification to the feed chute. The final nozzle selection determines the minimum required spray distance and dimensions of the modification. Adequate smoothing of the joins is needed and additional air nozzles should be set to periodically release high pressure streams of air to dislodge tags before they become dangerously large.

3.2.2 Dosing Pump

A PLC controlled pump needs to automatically adjust dosing levels within the range of 0-27L/hr depending on the moisture levels of the lint. Precision control of water at a low flow rate such as

27L/hr made the selection of a pump difficult. Explosion proofing is not always available in lab pumps while industrial pumps are robust but can have difficulty providing precision dosing at low flow rates.

The advantage of using a PLC controlled pump with low pressure spray heads is that solenoid valves controlling flow rates are no longer necessary. With fewer moving components the system is more simplistic and less likely to require extensive maintenance.

Air atomizers require a minimum pressure to operate and have a smaller dosing range per spray head. Precision control over a large volume such as 0-27L will require solenoid valves to shut off particular sets of nozzles when minimal dosing is required.

Watson Marlow cased drive peristaltic lab pumps seemed to fit all requirements for the dosing system in one compact unit. It was low maintenance, reliable and designed for accuracy while running 24hr/7day. The only draw back was the need for specialized explosion proofing for a unit designed for use in fairly clean and sterile lab environments.

3.2.3 Alldos Pump

The TrueDos 209D digital dosing pump is used in a variety of industrial environments so explosion proofing is a standard feature. The model chosen can dose up to 20L/hr with a high degree of accuracy and is also PLC controllable.

Dosing two percent moisture would require at least 27L/hr. Finding a single pump with a higher capacity than 20L/hr would require a reduction in accuracy of dosing at the lower end of the spectrum (*figure 5*). This sacrifice does not justify the benefit gained from using two pumps in parallel (*figure 6*). This adds flexibility to the system with a larger capacity of up to 40L/hr.

The water supply for each installation needs to be assessed for quality and consistency. Appropriate filtration is necessary for supplies high in sediment to stop build-up and blockages inside the pump, thin tubing and spray nozzles. Gravity fed water tanks would provide more control of the dosing system and ensure reliable water supply and pressure. These issues are application specific and will need to be addressed for each installation as necessary.

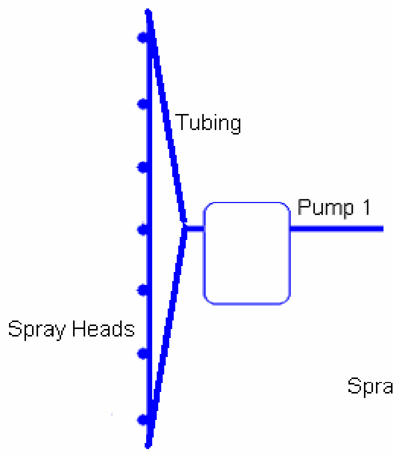


Figure 5.

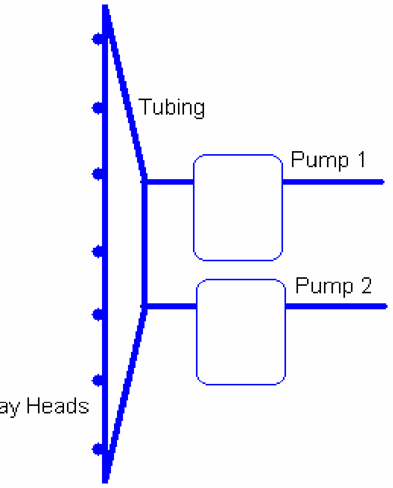


Figure 6.

4. Auto-leveling

The lint cleaner contains a variety of rollers, some of these include the feed, doffing rollers, brush and cleaning saw. The entire unit is powered by a single 40 HP (30kW) motor and regardless of the rate of fiber flow the motor runs at full speed. There are currently no sensing capabilities in the lint cleaner.

Excessive speed and over processing increases unnecessary damage to the lint hence more neps and short fibers are created. Implementing an auto-leveling system requires sensors and variable speed devices to maintain a consistent flow of material. Monitoring and controlling the even distribution of lint can maximize fiber quality. The goal is to create an intuitive system that produces consistent and high quality output.

Objectives

Input Feed Monitoring

Monitor incoming lint using a switch. Whilst cotton can be detected the variable speed systems of the lint cleaner operates. When lint is not detected for an extended period, perhaps seconds, the doffing and feed rollers decelerate to an idle speed. As the feed resumes accelerate the rollers back to processing speeds.

Lint Flow Measurement

Measure the displacement of the doffing roller spring with a high accuracy and durable proximity sensor. The calibrated spring allows the calculation of lint volumes passing between the rollers at any given moment.

4.1 Input Feed Monitoring

The input feed determines if the lint cleaner has the necessary material to process effectively. The flow of fiber into the lint cleaner is dependent on the output from other machinery in the

ginning process. Jams and malfunctions further down the production line have a flow on effect on the lint cleaner.
Switches used to track lint flow and can aid systems of quality control. The quality of irregular clumps of lint being processed is compromised and energy is wasted when the cleaner is operating at full speed while empty.

The output signal provided by the reflex switch takes precedence in the control system. It overrides other signals controlling speed because it tracks fibre entering the lint cleaner.
If incoming lint is no longer detected by the photoelectric reflex switches for a set period the doffing rollers will decelerate to an idle speed. When the feed resumes the rollers will accelerate back to processing speeds.

4.1.1 SICK Sensor Intelligence Photoelectric Reflex Switch

SICK Sensor Intelligence sensors transmit a visible beam of red light towards a reflector, when interrupted by an object the output signal is triggered. Visible light sensors are user friendly and easier to calibrate than their infrared counterparts. These sensors can be calibrated to cope with vibration and dust expected in industrial environments such as a gin.

A pair of photoelectric reflex switches will monitor the presence of material in the lint cleaner. The width of the lint cleaner is 4 meters but the width of the internal cavity containing the rotating barrels is 2.6 meters. The Sick switches are able to operate at 2.6m and they have an 80mm spot size at 3 meters.

The switches will be mounted around the curvature of the drum assembly to increase accuracy. The sources and reflectors of consecutively positioned sensors are orientated in opposing directions to minimize errors.

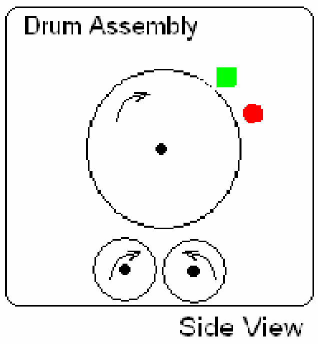


Fig.7

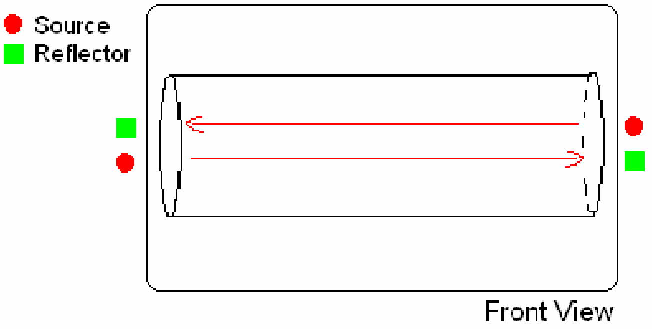


Fig.8

4.2 Measuring Lint Flow

Measuring lint flow monitors the consistency of material moving between the feed rollers. Achieving consistency in density maximizes the cleaning efficiency of the saw and the quality of the end product.

An existing spring attached to one of the three feed rollers expands or contracts according to the pressure of lint being forced between the rollers. The sensor picks up very small changes in the proximity of the sensor and a stationary steel plate.

Trials will be required to determine the position of the feed rollers and lint flow to produce optimal lint grade & quality. Once a reference signal is determined it is used to control roller modulation. The PLC & VSD automatically convert sensor outputs into speed adjustment signals for the motor.

Proximity Sensor Mounting

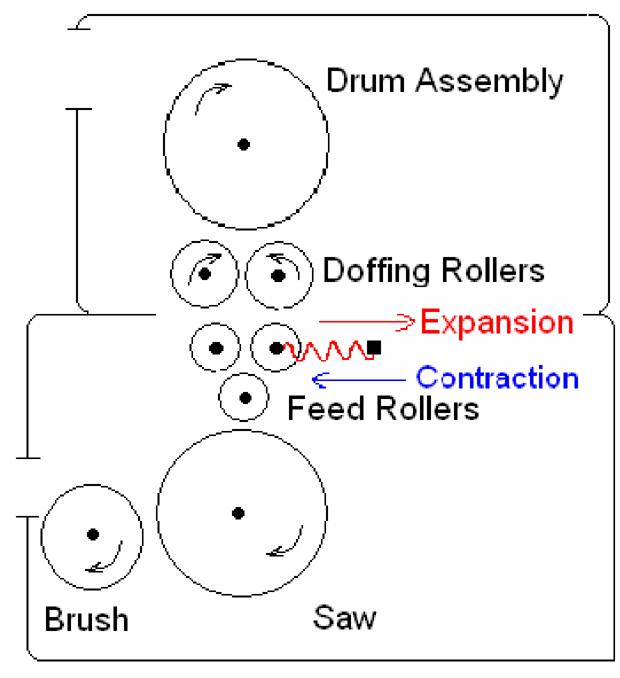


Figure 9.

4.2.1 TURCK Proximity Sensor

A CSIRO TFT project 'Noilscan' used Turck proximity sensors to accurately monitor movement of material through a set of rollers. The accuracy was to the extent that a single human hair could be detected moving between the rollers. Along with superb accuracy the sensor has shown solid performances for this application.

Turck sensors are more economical and robust than load cells and other proximity devices. Furthermore by calibrating the existing spring attached to the floating roller the sensor provides data for material flow.

A square 1mm thick piece of mild steel is used as a target for the sensor signal. The length and width of the square is determined by either the diameter of the circle (25mm) inscribed on the active face of the sensor or 3 times the rated operating distance (75mm), whichever is larger. As with 'Noilscan' a steel elbow will provide the frame for the device once attached to the lint cleaner.

Spring for Proximity Sensor Calibrating

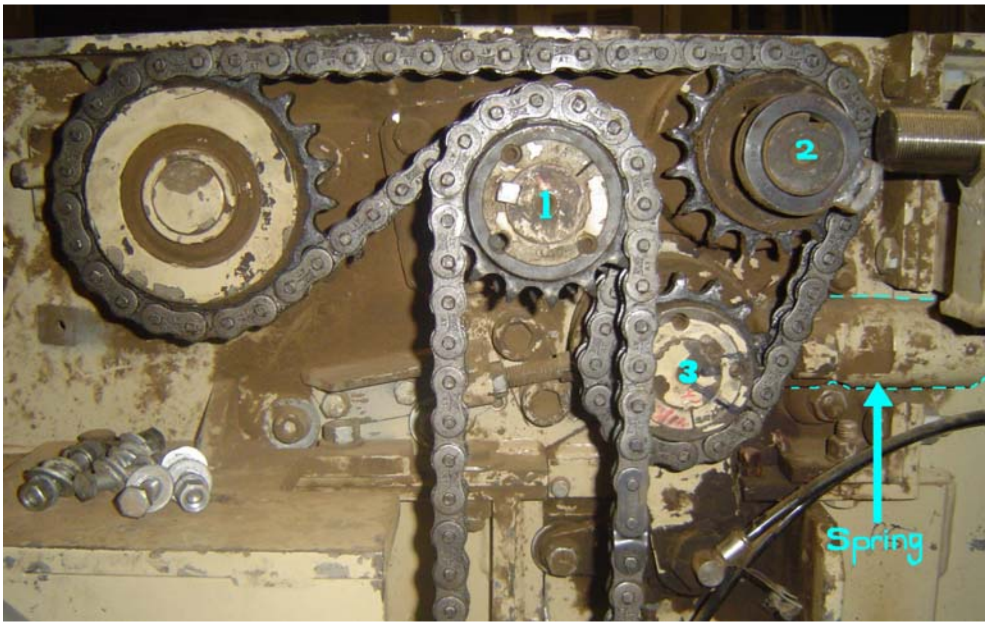


Figure 10

5. Motor Sizing

The auto-leveling system should react to the influx or seizure of fiber by accelerating or decelerating the rotation speeds of the various components in the unit. Ideally the lint cleaner should employ a variable speed drive to all rotating drums inside the unit however this requires a higher level of sophistication which is impractical for this project timeline.

Commercial realities are an important factor in determining viable modifications for the lint cleaner. The profitability of ginning relies on maximizing output and any reduction in saw speed would affect seasonal ginning volumes. Furthermore operating the saw at full speed (at all times) ensures cleaning efficiency and it removes the need for expensive high torque breaking mechanisms.

The two doffing rollers and three feed rollers is essentially one unit driven from a single connection to the motor, their speeds have been predetermined by an existing gear ratio. The variable speed drive will make use of this gear ratio when modulating speed.

Modulating the doffing rollers and controlling them with a separate variable speed motor provides even fiber distribution onto the saw. The rollers are physically smaller and currently travel at a 3.33km/hr (thirty times slower than the saw) making them an ideal choice for variable speed control. This is a cost effective means to cope with fluctuations in lint volume.

Internal Lint Cleaner Speeds

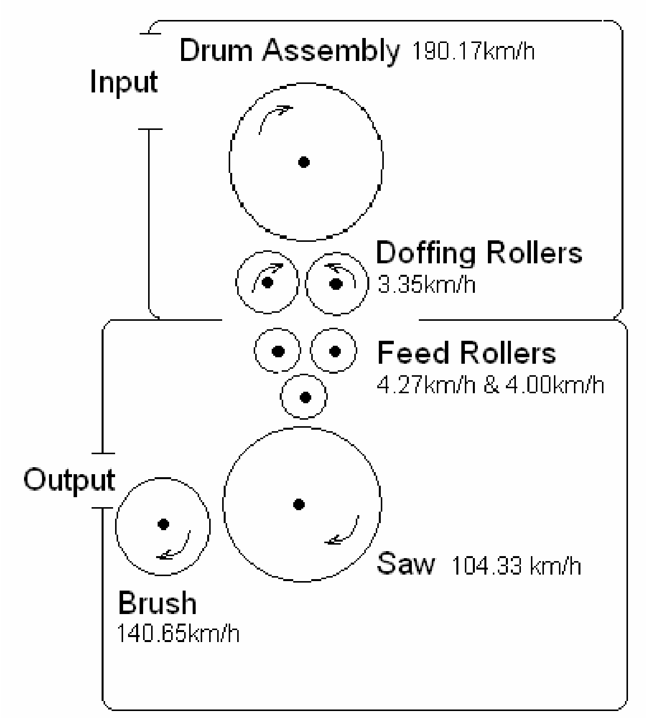


Figure 11.

Existing Motor 40 HP = 30 kW
RPM 1720 RPM
Comparison of speeds inside the lint cleaner.

Saw
Diameter: 24.00 inches
60.96 cm
Circumference: 75.40 inches
191.51 cm
RPM / Speed: 908 / 104.33 km/hr

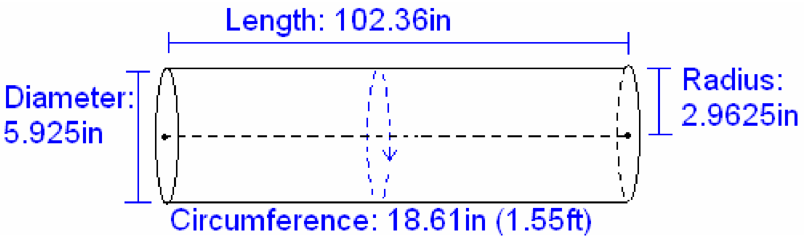
Doffing Rollers
Diameter: 5.925 inches
15.05 cm
Circumference: 18.62 inches
47.29 cm
RPM / Speed: 117.91 / 3.35 km/hr

The control system of the variable speed motor has to process sensor outputs from both digital switches and analogue proximity sensors. The signals from the reflex switch indicate the presence of fibre and these signals take precedence over the proximity sensor.
Variable speed drives and programmable logic controllers are responsible for processing these signals. The variable speed motor driving is connected to the rollers via a transmission responsible for gearing down the revolutions per minute.

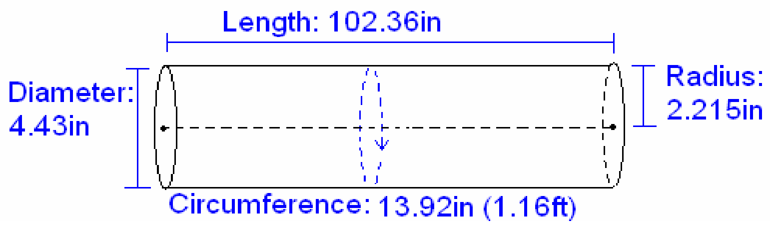
5.1 Motor Load & Required Torque

The motor selected for variable speed control powers 5 separate rollers, 2 doffing and 3 feed rollers. The rollers are 102.36in (2.6m) long and are processing less than half a kilogram of fibre per second. The motor is connection to one of the doffing rollers and as mentioned previously and the five rollers are geared together. From the motors' perspective there is just one very heavy doffing roller to move.

The current speed of the doffing rollers will be increased by 23% up to 4.33km/hr. The power required for this increase in speed will be calculated using the dimensions and speed of one doffing roller and the combined mass of each of the five rollers.
For simplicity the calculations for motor size do not take into account additional inertial load from other rollers in the lint cleaner or equivalent inertia to overcome friction in system.



Doffing Roller Dimensions
Figure 12.



Feed Roller Dimensions
Figure 13.

5.2 Roller Speeds

Doffing Rollers:

Current RPM:	117.91 RPM	Current Speed:	3.33 km/hr
New Maximum RPM (+30%):	152.67 RPM	Maximum Speed:	4.33 km/hr
New Minimum RPM (- 30%):	35.24 RPM	Minimum Speed:	1.00 km/hr

Two doffing rollers are currently traveling at 3.33km/hr on the 40HP motor. Speed ranges selected for the variable speed motor accommodate for thirty percent variation in speed (increase and reduction).

Feed Rollers:

Current RPM (R1):	201.25 RPM	Current Speed:	4.27 km/hr
Current RPM (R2&3):	188.67 RPM	Current Speed:	4.00 km/hr

Two of the feed rollers are traveling at a slower RPM of 188.67 than the other which is completing 201.25 RPM. The feed roller speeds will be geared in proportionally to the rotation of the doffing rollers so calculating their new speed ranges are not necessary.

5.3 Roller Specifications

The mass for the feed rollers were not available from Continental Eagle.
The mass was estimated as a percentage of the doffing roller mass proportional to volume.

		Doffing	Feed
Radius	Inch	2.9625	2.215
	Feet	0.2469	0.1846
	Meter	0.0752	0.0563
Diameter	Inch	5.925	4.43
	Feet	0.4938	0.3692
	Meter	0.1505	0.1125
Circumference	Inch	18.61	13.92
	Feet	1.55	1.16
	Meter	0.4727	0.3536
Weight	Pounds	217	121.29
	Kilograms	98.5	55.02
Speed	RPM	152.67	-
	km/hr	4.33	-
Total Weight (2 doffing + 3 feed) = 362kg			

Table.2

5.4 CMG Variable Speed Motor

Dimensions of One Doffing Roller Radius = 0.2469 feet

Maximum RPM = 152.67rpm

Total Mass of Five Rollers 217 + 217 + 121.29 +121.29 + 121.29 = 797.87lb

Motor Size:

Torque (lb ft) = Force (lb) * Radius (ft)

Torque = 797.87 * 0.2469
Torque = 196.99 lb ft

Horsepower = (Torque * Max RPM) / 5252

Horsepower = (196.99 * 152.67) / 5252
Horsepower = 5.73 HP

Kilowatt = Horsepower / 4 * 3

Kilowatt = 4.29 kW

CMG Motors come in 4.0kW and 5.5kW sizes. A 5.5kW motor will provide power for auto-leveling with more than ample range for additional inertial load and friction in the system. The 5.5kW motor has a start torque of approximately 360Nm. The doffing roller with a load of 797.87lb (362kg) requires approximately 270Nm of starting torque.

Although sold separately CMG motors and transmissions are designed to work as a unit. Once the correct motor for the application was selected the transmission were chosen according to the motor size.

5.4.1 CMG Transmission

Company	CMG Australia
Part / Series	Geared Motor / NORD geared motors
Specifications	5.5kW motor power IP 55 enclosure Insulation Class F 415V 50Hz Rated current 11.4A Output speed 1445 r/min

5.4.2 CMG / Vacon Variable Speed Drive

Company	VACON Finland
Part / Series	Variable Frequency Drives / NXL series
Type	Vacon Frequency Invertor
Product Code	NXL00165C5H1
Cost Estimate	$1297.00
Specifications	5.5kW rating IP21 protection 415V

6. The Control System

The control system reads sensor inputs, processes the information and relays a signal to the components such as motors and pumps. The control system is the programmable logic controller. The controller and the sensors all require a power supply to function.

6. 1 Programmable Logic Controller

Programmable Logic Controller Selection Criteria

Table 3.

MOISTURE CONTROL

Part	Options	Power	No.	Input	Output	Specifications
Reflex Switch	10-30V	24V	2	Digital	-	-
Proximity Sensor	15-30V	24V	1	Analogue	-	0-10V, 0-20mA
Moisture Sensor	Either	24V	2	Digital	-	-
Dosing Pump	Either	24V	1	-	Either	4-20mA
CMG Drive	415V	415V	1	-	Digital	4-20mA, +/-10V
CMG Motor	415V	415V	-	-	-	Connects to drive
CMG Transmission	415V	415V	-	-	-	Connects to motor

Moisture sensor 1:	Dictates the dosing quantity.
Moisture sensor 2:	Gives feedback about dosing efficiency.
PLC:	Receives data from both sensors (delayed from moisture sensor 2) to calculate dosing quantities. Ensures dosing quantity is sufficient according to dosing scale.
Dosing Pump:	Receives control signals from PLC.

AUTO-LEVELING

Switch 1 & 2:	Detects fibre. Reduces motor to idle speed when no fibre is present or allows proximity sensor to control speed.
Proximity sensor:	Measures fibre flow.
PLC:	Receives signals from switches to slow motor to idle speed or modulate motor speeds from data collected by the proximity signals.
VSD:	Converts PLC signals into control signals for the motor. The motor and gear motor are connected to the VSD for speed modulation.

SUMMARY OF INPUTS & OUTPUTS

Digital Input	Analogue Input	Digital Output	Analogue Output	Real Input Power
12 inputs 24V dc sink/source	2 voltage (±10V) 2 current (0…20 mA)	8 contact outputs	1 voltage/current (0…10V, 4…20 mA)	7W @ 24V dc
12	4	8	1	TOTAL = 25

Table 4.

6.5 Power Supply

24V Power Supply Load Requirements

Company/ Part	Part No.	Watts	Current Consumption	Qty	Total Current Consumption
SICK Reflex Switch	WL 12-2 N480		40mA	2	0.08A
Turck Proximity Sensor	Ni25-CK40-LIU-H1141		20mA	1	0.02A
CMG / Vacon Variable Speed Drive	NXL00165C5H1		20mA	1	0.02A
Alldos Dosing Pump	M209-20D	20	833mA	1	0.83A
Zeiss Moisture Sensor	Corona NIR		1.5A	2	3.00A
Allen Bradley PLC	1761-L20BWB-5A		200mA	1	0.20A
Total Current Consumption Power					4.15A 99.60W

Table 5.

Allen Bradley 24V power supplies comes in 100W and 120W sizes. The current consumption calculation is very close to 100W. Selecting the 120W power supply will allow for additional sensors or other modifications to be made to the design of the system without overloading.

7. Diagrams

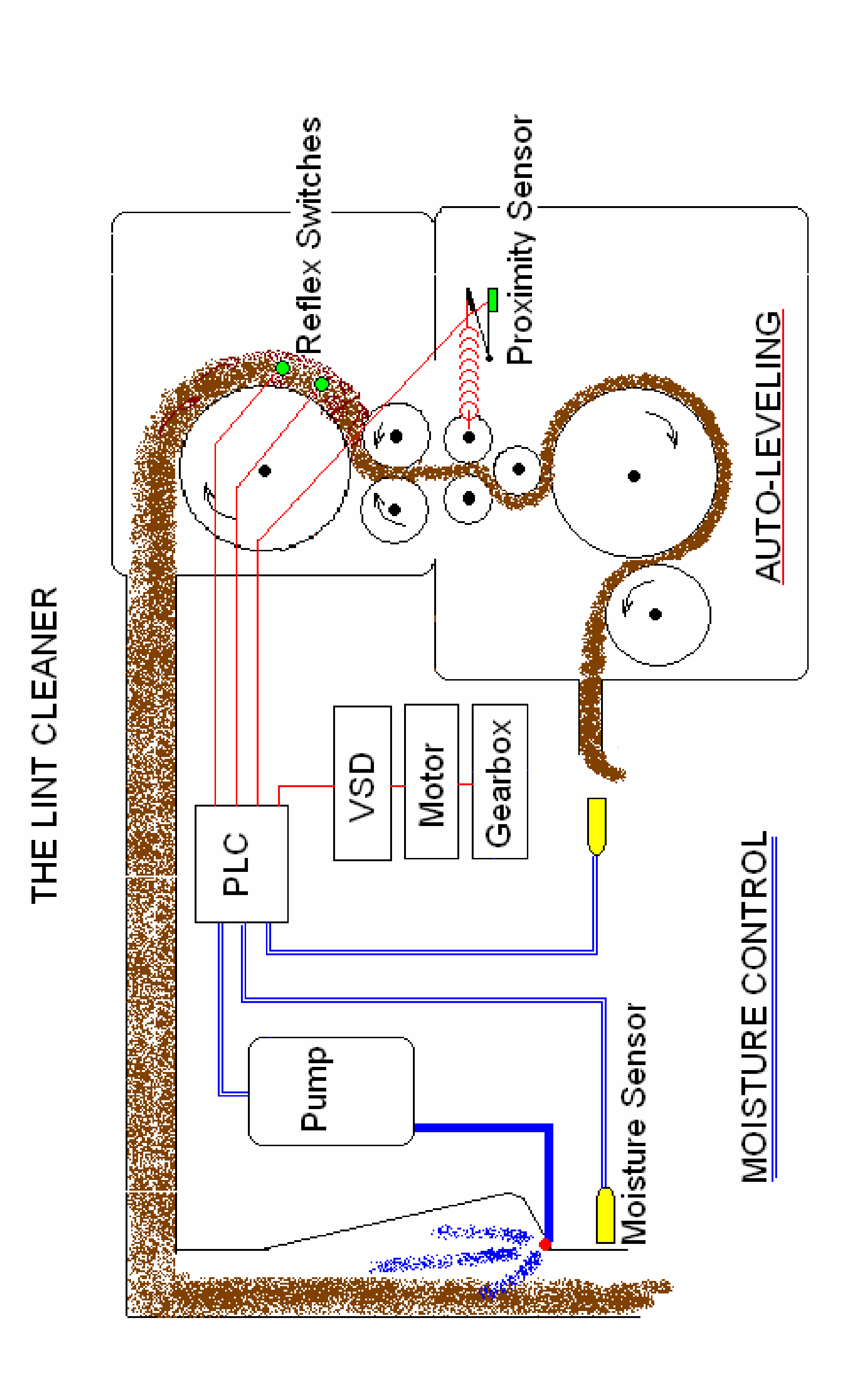

THE LINT CLEANER
Reflex Switches
Proximity Sensor
AUTO-LEVELING
PLC
VSD
Motor
Gearbox
Pump
Moisture Sensor
MOISTURE CONTROL

Figure 14.

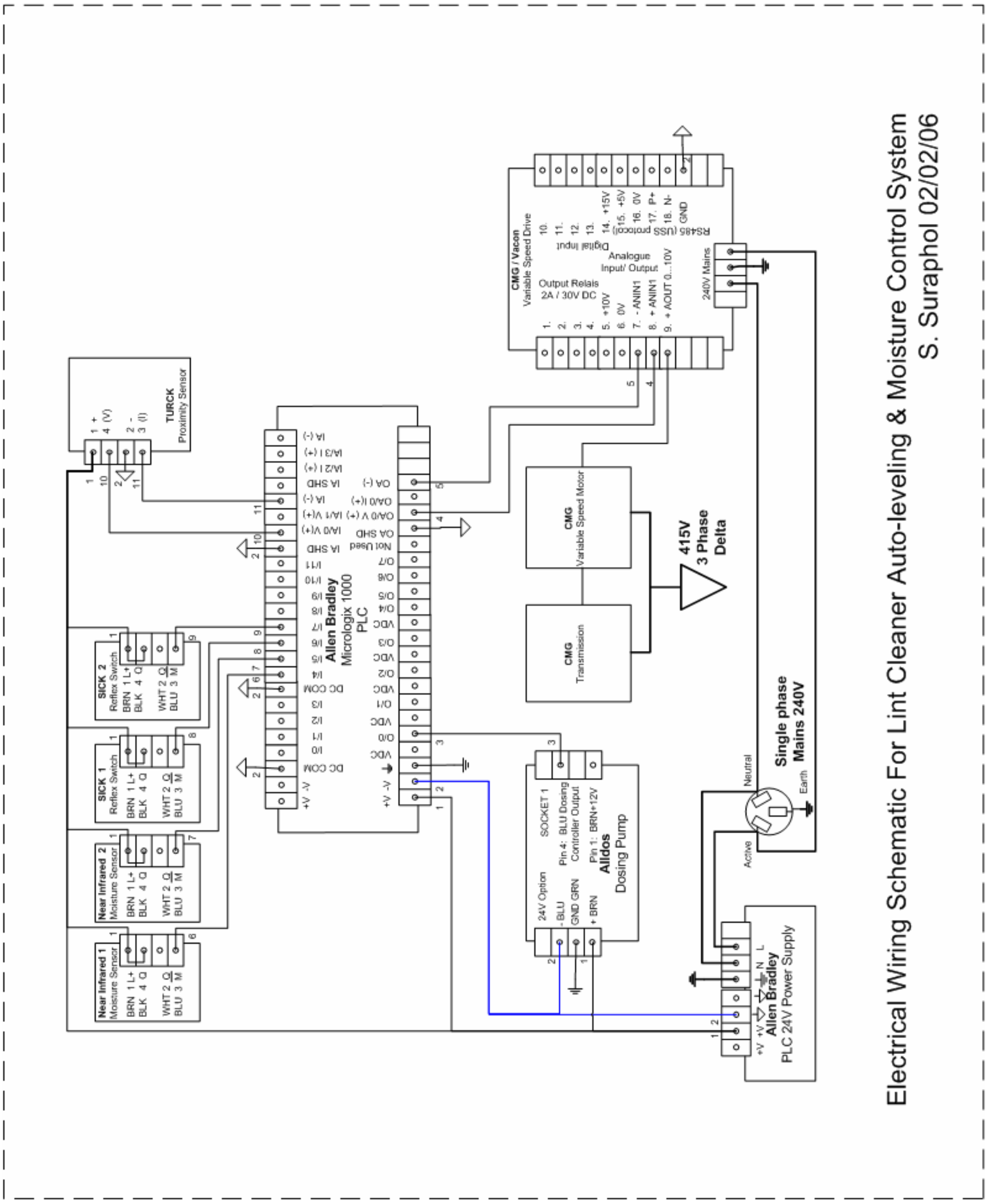


Figure 15.

8. Parts List

Component / Part	Quantity	Company	Model / Product Code
Photoelectric Reflex Switch	2	SICK Sensor Technology	WL12-2N480
Proximity Sensor	1	Turck	Ni25-CK40-LIU-H1141
Moisture Sensor	2	Carl Zeiss, Inc.	Corona NIR
Dosing Pump	2	Alldos	TrueDos 209 M209-20D
Spray Nozzles / Tubing	- 10	Irrigation Warehouse or Lechler	Various *or* 156.446.16.15 (SS)
Variable Speed Motor	1	CMG Australia	M3400550.SGA#
Variable Speed Drive	1	CMG Australia	NORD SK32-132s/4
Geared Motor / Transmission	1	VACON / CMG Australia	NXL00165C5H1
24V Power Supply	1	Allen Bradley	1606-XLP120D

Table 6.

9. Appendix

9.1 MOISTURE CONTACTS, SUMMARY & PRICE

Moisture Sensors

1. Zeiss, Moisture Sensor

Spraying Nozzles

2. Irrigation Warehouse Group Pty Ltd, Vari-Jet Spray 1/2 Circle
3. Lechler, Air Atomising Nozzles

Dosing Pumps

4. Alldos, Dosing Pump

<u>Zeiss Moisture Sensors</u>

Company	Carl Zeiss, Inc.
Contact	Lino Montuno Carl Zeiss Pty Ltd North Ryde, Sydney Ph 02 9020 1364 (direct) Ph 02 9020 1333 (office) Fax 02 9020 1330 Ph 1300 365 470 (operator) www.zeiss.com.au info@zeiss.com.au
Part	Spectral Sensor
Series	Corona
Model	NIR
Cost Estimate	$30,000 - $40,000 per sensor
Accessories	Software, PC
Specifications	Near infrared (NIR) 900 - 1600nm

All the sensors use photodiode arrays which are collected by gratings that are sensitive to different wavelengths (visible or NIR). The unit requires a PC and software to process the data.
NIR are expensive compared to visible range models because they need additional cooling.

Basic Visual	400 – 1100nm	$26,000
Basic NIR	900 - 1600nm	$30,000 - $40,000
Full Range Model	400 – 1600nm	$45,000 - $50,000

Irrigation Warehouse Group Pty Ltd, Vari-Jet Spray 1/2 Circle

CONTACT

Irrigation Warehouse Group Pty Ltd
Ph (02) 6732 6333
404 Grey St, Glen Innes NSW, 2370.
Enquiries: wendy@irrigationwarehouse.com.au
Technical assistance: rod@irrigationwarehouse.com.au
Fax (02) 6732 6311

SOURCE www.irrigationwarehouse.com.au

OUTCOME

Small droplet size comes at a high price as quoted by air atomizers. An irrigation system will be used to dose the cotton it's cheap, easy to install or modify. Blockages can be fixed by anyone by simply throwing away the offending nozzles or piping. This will be user friendly and economical for the gin. More high tech spray systems can be developed later on if necessary.

Vari-Jet Spray - 1/2 circle

The Vari-Jet spray is perfect for small to medium garden beds and should be installed along the front or back edge. These are adjustable in distance of throw and so this will eliminate water spraying onto concrete paths or other areas that don't need water. The adjustment tap will also provide a limiting factor for wind drift of the spray. Install on a Micro stake with Tube adaptor. This item is for 1/2 circle application and is flow adjustable from 0 - 130 L/hour with a radius from 0m - 3.4m.
Price: $1.21 inc GST within Australia

Micro stake with tube and adaptor

The micro stake is used to supply water to any of our 4mm threaded sprays and micro-sprinklers. It provides a very secure mounting and is easy to connect to the low-density poly supply line. You simply punch a small hole into the supply line and push in the connector. This stake and tube will fit all brands of 4mm micro sprays and micro-sprinklers.
Price: $2.48 inc GST within Australia

4mm Flexible Tube - 25m Roll

This is the best 4mm flexible tube that we can source. It is made from PVC and is perfect for connecting all 4mm and 4.5mm fittings, Vortex sprays, Adjustable sprays and even to the barbed inlet of our drippers. To make it easy to push the tube onto a fitting, dip the end into hot water for 10 seconds and immediately connect. This is the 30m coil.
Price: $16.50 inc GST within Australia

<u>Lechler Air Atomising Nozzles with Air Piston</u>

CONTACT Leon Knight
Project Engineer (Stauff Corporation PTY. Ltd.)
Lechler in Oceania
24-26 Doyle Ave, Unanderra
P.O. Box 227 Wollongong N.S.W.
Unanderra 2526 Australia
Mob +61 412 425816
Ph: +61 2 4271 9481 (direct line)
Ph: +61 2 4271 1877
Fax: +61 2 4271 8432
bseelis@stauff.com.au
lknight@stauff.com.au

SOURCE www.lechlerusa.com

OUTCOME
Model 156.446.16.15 (SS303) or 156.446.30.15 (Brass) shown at the top of the 60* box on page 1.11.

This flat- fan nozzle works on the liquid pressure supply, internal mixing, principle which will be the best for precise flow control of clean fluid. It can readily be adjusted between 3.0 and 6.6 l/hr at 1.5 bar supply pressure and around 2 bar air pressure, if you are aiming at a ideal flowrate of 4 l/hr per nozzle and 5 nozzles. This nozzle would have a spray coverage of around 280mm at 230mm range from the roll at the pressures mentioned above, widening as the air pressure increases. You will need some overlap of the spray edges to achieve even coverage (say 50 to 100mm), so 5 nozzles will not be enough if your target is 2000 wide....

Have a play for a little while and call me if you have any questions - if you are happy with the nozzle I suggest, I will quote you for 8 of them in either brass or stainless, including the pneumatically controlled shut-off needle valve shown on page 1.15 (015.601.35.05 to suit the above nozzle). We can also assist with Watson-Marlow peristaltic pumps with fine control of flowrates in the range you need, and Mueller co-axial valves to control both air flows and the liquid flow.

10	pcs	156.446.16.15 (SS)	$297.00 each, 4-5 weeks est.
10	pcs	156.446.35.15 (Brass, Ni-Plated)	$99.50 each, 3-4 weeks est.
10	pcs	015.601.35.05 (SS Needle, Brass/Ni Body)	$395.00 ea, 2 weeks

Alldos Pump

CONTACT Tony Hourigan
Regional Manager
Alldos Oceania Pty Ltd
Ph: 03 9543-3933
Fax: 03 9543-3088
Mobile: 0437 042 284
alldos.au@alldos.com
t.hourigan@alldos.com.au

Jason Johnson
Technical Sales
ALLDOS Oceania Pty Ltd
Ph: (07) 3712 6888
Direct: (07) 3712 6825
Fx: (07) 3272 5188
Info@alldos.com.au
j.johnson@alldos.com.au

SOURCE www.alldos.com

OUTCOME

A TrueDos 209 made by Alldos is a compact pump that can be controlled by a direct connection to the PLC. This pump can provide a flow rate as low as 0.005l/h and has an accuracy of 1.5% per volume. This model comes with explosion proofing as a standard feature.

TrueDos 209

M209-2.5D	- Truedos 2.5lt/hr Max	$1099.00+GST
M209-13.8D	- Truedos 13.8lt/hr Max	$1437.00+GST
M209-20D	- Truedos 20lt/hr Max	$ 1478.00+GST

9.2 AUTO-LEVELING CONTACTS, SUMMARY & PRICE

Reflex Switch

1. Sick, Photoelectric Reflex Switch

Proximity Sensor

5. TURCK, Proximity Sensor

Variable Speed Drive

6. CMG / Vacon, Variable Speed Drive

Variable Speed Motor

7. CMG, Variable Speed Motor

Transmission

5. CMG, Geared Motor

SICK Photoelectric Reflex Switch

Company	SICK Sensor Intelligence
Part	Photoelectric Reflex Switch
Series	WL 12-2
Model	N480
Order Number	1 016 089
Cost Estimate	$200.00 per sensor
Specifications	Red Light (LED) Without polarization filter Reflective sensor 80mm spot size at 3 meters Maximum scan distance 0 - 7 meters Recommended scan range 0 - 5 meters Insensitive to external light sources Adjustable sensitivity M12 plug , 4 pin (rotates by 90 degrees) Supply voltage 10 - 30V DC
Accessories	Reflector, C 110 / PL 30 A (operating range 0 – 3m) **Cable

The WL12-2 series comes in standardized, compact housing model making it possible to use high-performance sensors that operate reliably even in cramped mounting conditions.
The WL12-2 model has red light transmitters as a standard feature. The sensor can be aligned on the object quickly and precisely using the visible light spot. In models with Teach-In function, the sensor optimizes its sensitivity automatically to the given operating conditions at the push of a button.

TURCK Proximity Sensor

Company	Turck
Part	Proximity sensor
Part Number	Ni25-CK40-LIU-H1141
ID Number	M1537891
Cost Estimate	Unused sensor from Noilscan project available for use.
Specifications	Linear operating distance 5-25mm Housing Style 40mm Non-embeddable, *eurofast* Quick Disconnect 30 Hz Response Frequency Output 4-wire DC current and voltage Output voltage 0 – 10V / current 0 – 20mA Operating temperature -10 to +70 degrees Celsius IP 67 protection Slew rate 0.6V/ms, 1.2mA/ms Ripple ≤ 10% Differential travel (Hysteresis) 3 – 15% (5% typical)
Accessories	Mating cord, cable length RK 4.4T-*

CMG / Vacon Variable Speed Drive

Company	VACON Finland
Part	Variable Frequency Drives
Series	NXL series
Type	Vacon Frequency Invertor
Product Code	NXL00165C5H1
Cost Estimate	$1297.00
Specifications	5.5kW rating Constant Torque IP21 protection 415V

CMG Variable Speed Motor

Company	CMG Australia
Part	Variable Speed Motor
Series	SGA series motors
Product Code	M3400550.SGA#
Cost Estimate	$1100.00
Specifications	415V 50Hz IP 55 enclosure Insulation Class F Temperature rise class B 1500 r/min = 4 poles Motor Frame 132S Speed 1450 r/min Weight of foot mounted motor 63kg

The 5.5kW motor has a start torque of approximately 360Nm. The doffing roller with a load of 797.87lb (362kg) requires approximately 270Nm of starting torque.

CMG Motors come in 4.0kW and 5.5kW sizes. A 5.5kW motor will provide power for auto-leveling with more than ample range for additional inertial load and friction in the system.

Accessories	Although sold separately CMG motors and transmissions are designed to work as a unit. Once the correct motor for the application was selected the transmission were chosen according to the motor size.

CMG Transmission

Company	CMG Australia
Part	Geared Motor
Series	NORD geared motors
Specifications	5.5kW motor power IP 55 enclosure Insulation Class F 415V 50Hz Rated current 11.4A Output speed 1445 r/min

OPTION A

Model	Helical geared motor, Inline style
Type	SK32-132s/4
Cost Estimate	$1152.00 (Inline style)
Specifications	Output torque 355Nm Motor Frame 132S Weight approximately 74kg

OPTION B

Model	Helical geared motor, Right angle style
Type	SK42125-132S/4
Cost Estimate	$2661.00 (Right angle style)
Specifications	Output torque 317Nm Weight approximately 140kg

9.3 CONTROL SYSTEM CONTACTS, SUMMARY & PRICE

Programmable Logic Controller

1. Allen Bradley, PLC

Power Supply

2. Allen Bradley, 24V Power Supply

<u>Allen Bradley Programmable Logic Controller</u>

Company	Allen Bradley
Distributor	Westcoast Industrial Controls
Contact	Glen Wright

Head Office:
164 Victoria St
North Geelong 3215
Ph: 5240-7222
Fx: 5272-1950

Branch Office:
Unit 1, 32 Westside Dr
Laverton North, 3026
Ph: 9362-4222
Fx: 9318-9100

Part	Programmable Logic Controller
Series	Micrologix 1000
Bulletin Number	1761
Model Number	L20VWB5A
Cost Estimate	$779.20 (24V dc) or $872.00 (240V ac)
Specifications	Up to 1K memory Built-in EEPROM (non volatile memory) Embedded I/O (max) 32 Analogue embedded: 2 (I) inputs, 2 (V) inputs, 1 (I or V) output. High speed counters 1@ 6.6kHz Operating Power 120/240V ac or 24V dc

Allen Bradley 24V Power Supply

Company	Allen Bradley
Distributor	Westcoast Industrial Controls
Contact	Glen Wright

Head Office:
164 Victoria St
North Geelong 3215
Ph: 5240-7222
Fx: 5272-1950

Branch Office:
Unit 1, 32 Westside Dr
Laverton North, 3026
Ph: 9362-4222
Fx: 9318-9100

Part	24V Power Supply
Model	1606-XLP100E
Cost Estimate	$247.50
Rating	Class 1 Division 2
Specifications	DC 24…24V/ 100W 115 – 230V Auto Select Input Efficiency typically 90%

The unit is not explosion proof and will need to be housed in an explosion proof electrical cabinet. The unit requires just under 100W, however the 120W model may be chosen to allow for additional components in future.

Model	Description	Rating	Price
1606XLP100E	1 Phase power supply DC 24-28V, 100W	Class 1 Division 2	$247.50
1606XL120D	1 Phase power supply DC 24-28V, 120W	Class 1 Division 2	$349.50

10. References

1. Continental Eagle, Service/Parts Manual: Golden Eagle Lint Cleaner Model 24D, 102 inch. Bulletin No. 315 (C553476). Table 1-2, Page 1-10

2. W.S Anthony and William D. Mayfields (eds.) *Cotton Ginners Handbook*. .December 1994. United States Department of Agriculture, Agricultural Handbook Number 503. pages 44-67.

Gin saw blade research & future work

Kevin Bagshaw

October 2006

Introduction

During visits to gins in early 2006 as part of the Australian Gin Survey the topic of gin saw wear, longevity and gin efficiency was often raised in discussion. Gin saw blades have a limited life and face a number of problems while in service. As a result CTFT set out to examine both Continental Eagle & Lummus Corporation gin saw blades in terms of wear, tooth profile and metal fatigue. Blades were subject to numerous tests and trials at CSIRO and at a cotton gin in NSW.

Problem definitions and test aims

Cotton gin saw blades suffer from a number of problems:

1. A lack of run time (or life). As the teeth go blunt they become less efficient, increase heat build up and increasing running costs.

   Aim: Investigate metal treatments that prolong metal wear.

2. Gin saw blade teeth have remarkably low collecting power. One saw tooth collects around 0.00172 grams of fibre each pass.

   Aim: Investigate design of saw teeth profile.

3. The cotton seed while in the seed roll presses up against the side of the saw blade and acts as a disk brake, increasing running costs and causing heat build up.

   Aim: Investigate design of saw blade surface.

4. Gin stand saw rib inserts. As the gin rib insert wears, small cotton seed is allowed to pass through this opening, in turn some seed is placed with the lint.

   Aim: Design new rib inserts that direct seed away from ginning (wear) point.

Gin saw blade life

Gin stand saw blades wear at the tip of the tooth creating a less efficient tooth and requiring more horsepower to drive the teeth through the see roll. The blades, after a period of time can fatigue and in turn they can crack or break apart causing fires. To try and increase the life of the blade, i.e. to keep a point on the tooth, several treatments were applied to the saw blades, which were then tested at a gin in NSW.

The following treatments were applied to stock blades for a Lummus gin: Nickel (N), Titanium Nitride (TN) and a cryogen treatment (C). Of the treatments carried out, both the Nickel and the Titanium Nitride are applied to the surface of the blade as coatings. In contrast the cryogen treatment, which is carried out over a period of 3 to

5 days, affects the crystalline structure of the steel of the blade. The cryogen treatment is said to increase the wear life of metals without increasing the hardness [ref?].

Ten treated blades (3 x N, 3 x TN & 4 x C) were fitted onto a saw shaft prior to a 10,000 bale change-over in the NSW gin during this last season. Blades were photographed at 4 points every 90 degrees around each blade. A jig was used to mark the location of teeth to be monitored before they were fitted onto the saw shaft. After ginning for nominally 10,000 bales the blades were returned to CTFT where they were examined.

Unfortunately 8 of the blades were severely damaged during ginning preventing a full evaluation of the treatments.

Results

As a result of the teeth of the gin saw blades being damaged, no meaningful evaluation could be carried out. The field trial will need to be carried out again during the 2007 season. More blades will need to be treated and these blades should be positioned over several gin stands.

The figures below show a new gin saw blade (Figure 1) while the same blade and teeth are shown after sustaining damage during ginning (Figure 2). As a result of the damage to the saws no consistent data could be collected on the saw teeth wear rate (Figure 3).

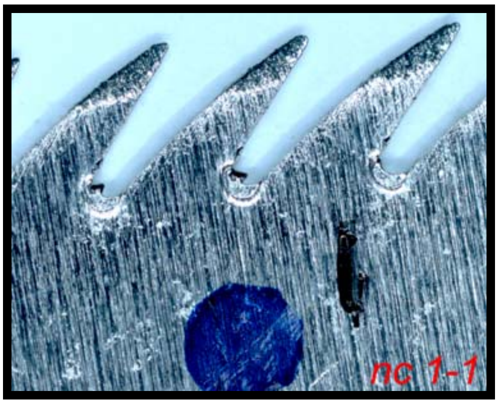


Figure 1 – saw blade teeth before use

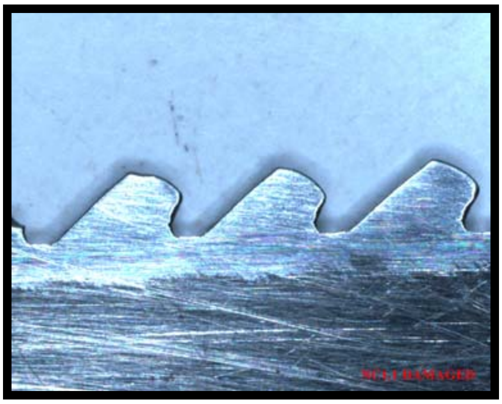


Figure 2 – saw blade teeth after damage

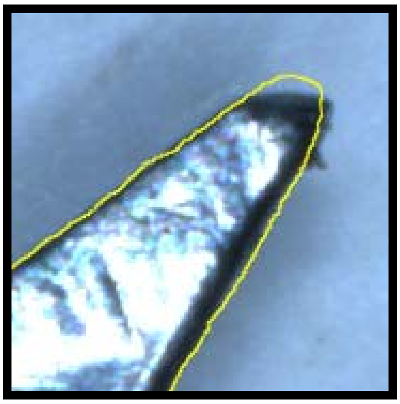


Figure 3 – tooth profile showing wear

Fatigue testing of saw blades

To enable a better understanding of the Cryogen treatment, four gin saw blades; 2 x Continental Eagle and 2 x Lummus Corporation, were tested at CSIRO for metal fatigue. One blade of each brand was treated using the cryogen treatment.

Specimen geometry for tensile and fatigue testing

The saw blades specimens were water cut into the test shape in Figure 4. Around 13 test specimens were cut radially from each saw blade.

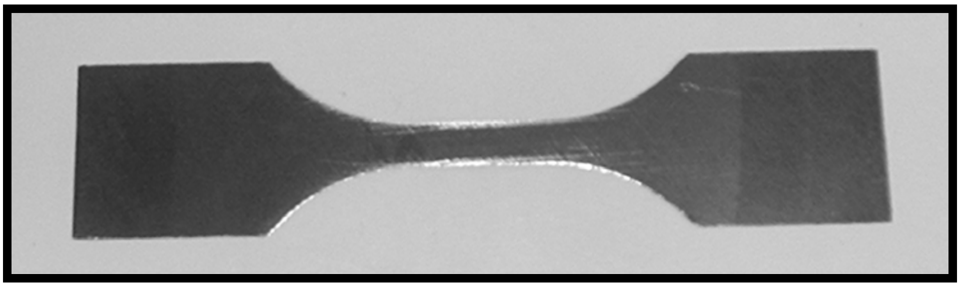


Figure 4 – Test specimen for metal fatigue test

The geometry of the fatigue specimens was based on the dimensions given in ASTM E466 for specimens with a rectangular cross section and tangentially blended fillets between the gauge length and the ends (Figure 3 in Appendix A). However, due to the size of the saw blade the dimensions of the fatigue specimens used in this programme were modified. Instead specimens were extracted from blades in a radial direction, which limited their total length. The final dimensions of the fatigue specimens – see Figure 5 – differ from the recommended standard. Specifically, the radius of the fillets was reduced from the recommended eight times the width of the test section to approximately four times. This could have had the effect of increasing the stress concentration factor of the specimen.

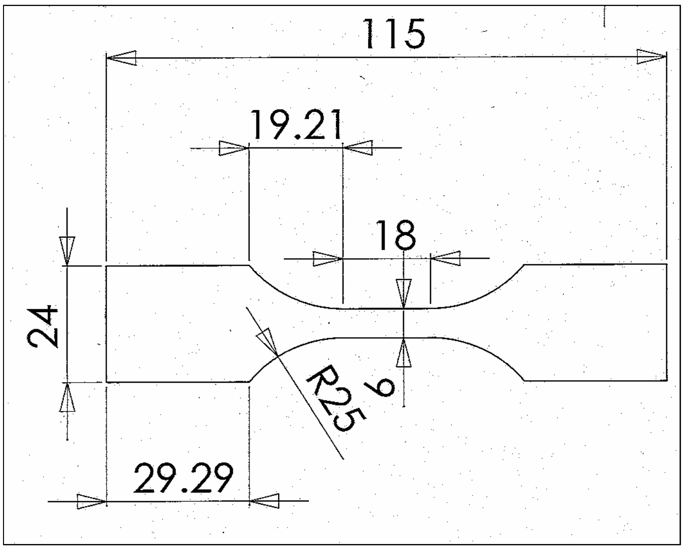


Figure 5 - Dimensions of fatigue specimens

Tensile Tests

Specimens for tensile testing were prepared with the dimensions given in Figure 6. The tensile properties of the materials were determined prior to fatigue testing. Results of the tensile tests are listed in Table I. This data was used to determine the stress at which to conduct fatigue tests.

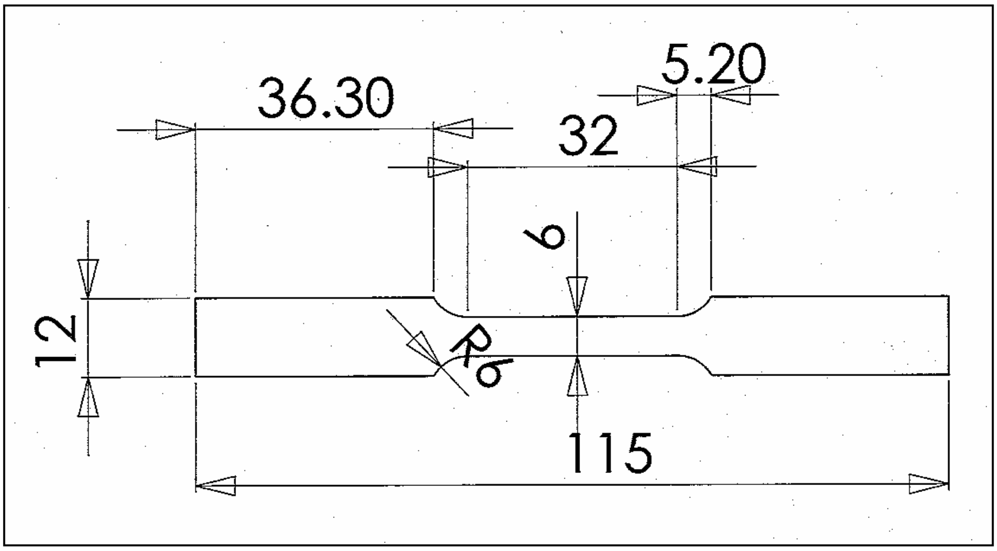


Figure 6 - Dimensions of tensile specimens

Table I - Results of tensile tests

Blade Type	Treatment	Offset Yield Stress (MPa)	Maximum Stress (MPa)
Lummus	Control	1080	1098
Lummus	Cryogen	1099	1117
Continental	Control	1045	1090
Continental	Cryogen	1052	1097

Fatigue Tests – Initial tests

The surfaces of all specimens were polished longitudinally prior to testing using silicon carbide papers from 240 to 1200 grit. Roughness measurements were done on the two wider surfaces to ensure a maximum average surface roughness of 0.2 μm as required by ASTM E466. Two measurements were carried out on each surface. The marks resulting from these measurements were removed by polishing before testing. The roughness of the edge surfaces could not be measured.

The values for the peak stresses were chosen as a fraction of the maximum tensile stress. A stress ratio, R, of 0.1 and a test frequency of 15 Hz were used for all experiments. The tests were done using a computer-controlled servo-hydraulic MTS 250 kN testing machine. The temperature in the laboratory was maintained at 23°C during the tests. The first four specimens were used to determine an appropriate stress level at which to test and compare all other specimens. The aim was to select a peak load which would achieve a fatigue life of approximately $5x10^5$ as a compromise between testing time and level of peak load.

The results of these preliminary experiments have been recorded in Table II below and Table B1 in Appendix B. The results of the first four tests on the Lummus specimens indicated that a peak stress of 770 MPa resulted in failure at approximately 10^5 cycles. Similar conditions were therefore used to test the specimens from the Continental blades.

Table II – Results of fatigue tests (Specimens 1 to 12)

Blade	T'ment	Specimen No.	Peak Stress (MPa)	Fatigue Life (cycles)	Comments
Lummus	Control	1	660	2266231	Did not fail. Test stopped.
Lummus	Control	2	880	76620	Failed in gauge length
Lummus	Cryogen	3	770	314327	Failed in gauge length Initiation of fatigue from surface defect near corner of specimen
Lummus	Control	4	770	107051	Failed in gauge length Initiation from surface defect at edge of specimen
Continental	Control	5	770	55248	Failed in gauge length Initiation from surface defect at corner of specimen
Continental	Control	6	770	132015	Failed in gauge length Initiation from surface defect at corner of specimen
Continental	Cryogen	7	770	130594	Failed in gauge length Initiation from surface defect at corner of specimen
Continental	Cryogen	8	770	176795	Failed in gauge length Initiation from surface defect at corner of specimen
Lummus	Cryogen	9	770	$>2.5\text{x}10^6$	Specimen edges polished until no evidence of surface marks were visible under microscope Did not fail after $2.5\text{x}10^6$ cycles
Continental	Control	10	770	$>2.5\text{x}10^6$	Specimen edges polished until no evidence of surface marks were visible under microscope Did not fail after $2.5\text{x}10^6$ cycles
Continental	Cryogen	11	770	$>2.5\text{x}10^6$	Specimen edges polished until no evidence of surface marks were visible under microscope Did not fail after $2.5\text{x}10^6$ cycles
Lummus	Control	12	770	$>2.5\text{x}10^6$	Specimen edges polished until no evidence of surface marks were visible under microscope Did not fail after $2.5\text{x}10^6$ cycles

The fracture surfaces of Specimens 3 to 8 were examined under a SEM to identify the type of defect at the initiation point of fatigue failure. It was found that in all cases fatigue failure initiated from a surface defect at the edge or corner of the specimens (see micrographs in Figures 7 to 12). The examination also showed that marks/defects remained on the surface after polishing and were the likely cause of fatigue failure at this stress level (see Figure 9). On this basis the fatigue tests might not be valid and should not be counted as any effects and differences in the microstructure of the steel would have been masked by the effects of surface roughness and defects.

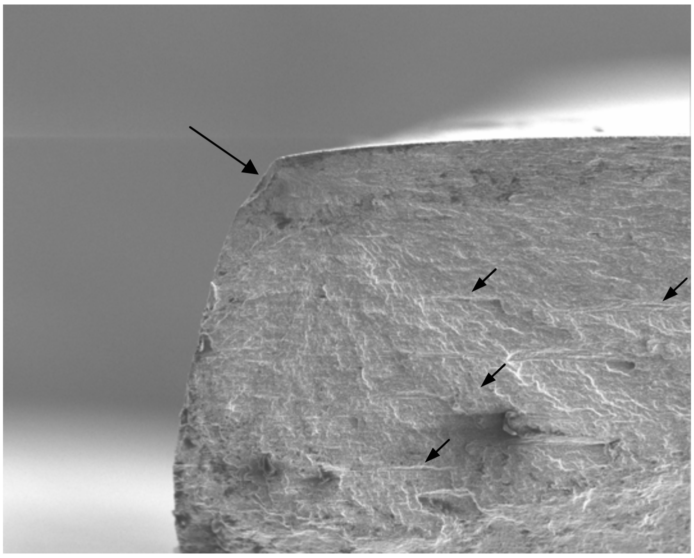


Figure 7 - Lummus cryogen – Specimen 3. The surface defect at the initiation point is arrowed (@100X)

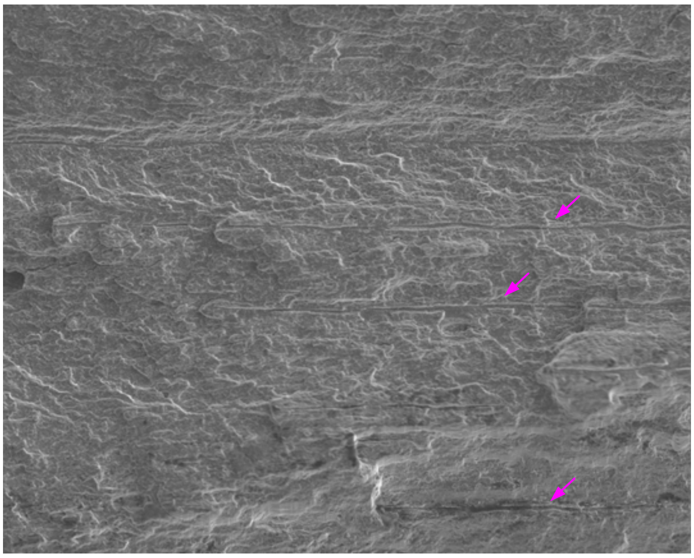


Figure 7a - Lummus cryogen – Specimen 3. Higher magnification micrograph of fatigue fracture surface (@250X)

In Specimen 3, the chevron marks in the fatigue region point to one defect in the initiation region, which appears to be a small cavity at the corner of the specimen. The fracture surface of this specimen was examined further. The fatigue fracture region of the fracture surface appears to consists of two different zones: A zone closest to the defect (corner) which at higher magnification shows features typical of fatigue fracture (the lack of evident striations suggesting a relatively brittle material), and which was likely affected by the defect. A second zone beyond the first one was observed, which shows the presence of stringers (arrowed in Figures 7 and 7a). These stringers (possibly MnS) were observed in the microstructure of the blades from a polished cross section. It is possible that in this second zone fatigue failure could have been affected by these stringers in the microstructure. The region of the fracture surface which corresponds to the tensile overload also shows the presence of stringers.

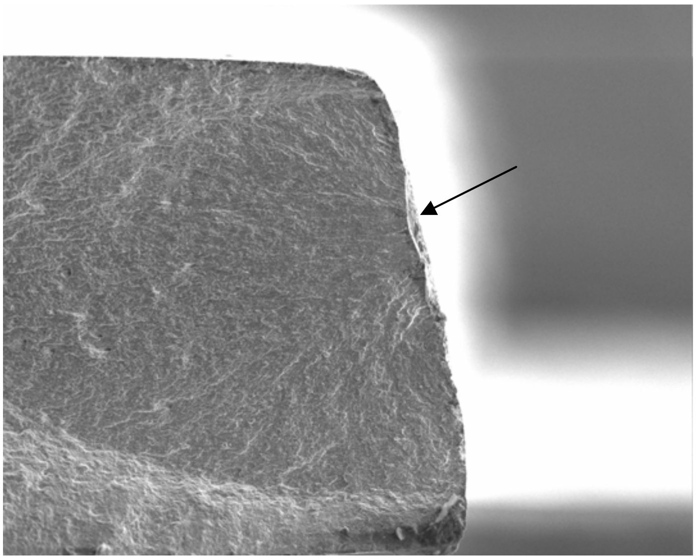


Figure 8 - Lummus control – Specimen 4. The surface defect at the initiation point is arrowed (@100X)

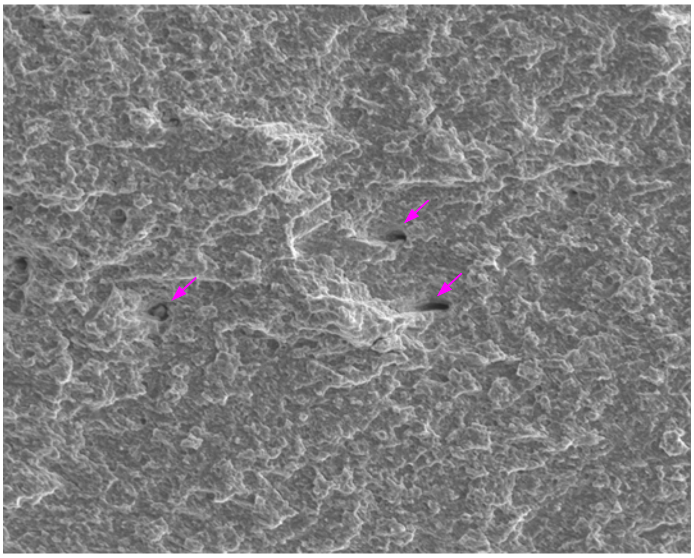


Figure 8a - Lummus control – Specimen 4. Stringers on fracture surface (@250X)

Similarly, the chevron marks in the fatigue region of the fracture surface of Specimen 4 points to one defect at the edge of the specimen. The stringers are also evident on the fracture surface (arrowed in Figure 8a) but appear to be oriented differently to those in Specimen 3 (at approximately 90° to the stringers observed in Specimen 3).

It is not clear whether these stringers affected the fatigue failure of the specimens at 770 MPa. The results from the tests on Specimens 9 to 12 suggest that surface roughness is a more significant factor.

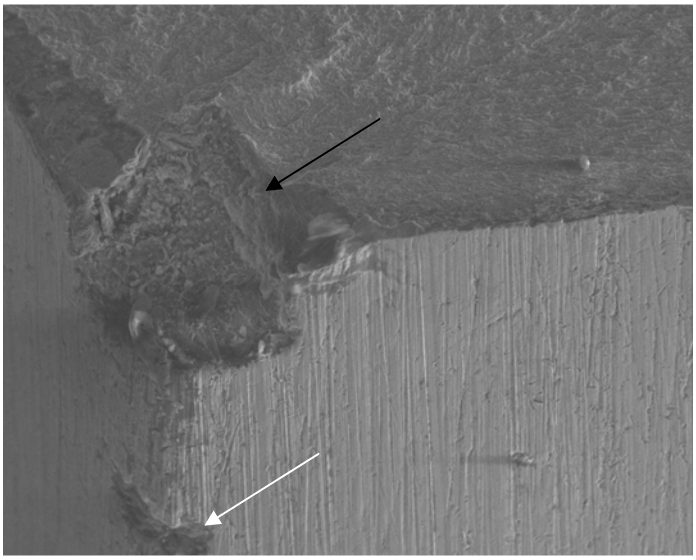


Figure 9 – Continental Eagle control – Specimen 5. The surface defect at the initiation point is arrowed. A mark/defect due to the water jet cutting operation and not removed during the surface preparation process is arrowed (white arrow) at the bottom of the micrograph (@250X)

For Specimen 5, fatigue failure originated from a large defect at one corner of the specimen. The chevron pattern in the fatigue region indicates that multiple initiation points are present near the corner. The micrograph in Figure 9 shows that a large piece of material was loosened or broke off during fatigue testing. A mark or defect underneath the main defect at the corner of the specimen can also be seen in the micrograph, which was probably caused by the water jet cutting operation.

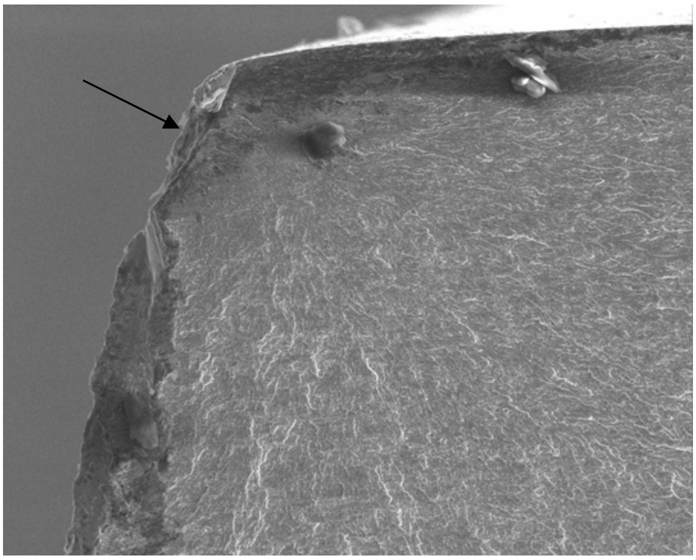


Figure 10 - Continental control – Specimen 6. The surface defect at the initiation point is arrowed (@250X)

The defect at the initiation point of fatigue failure for Specimen 6 is a small cavity near the corner. The stringers observed on the fracture surface of the previous specimens were not observed on the fracture surface of this specimen.

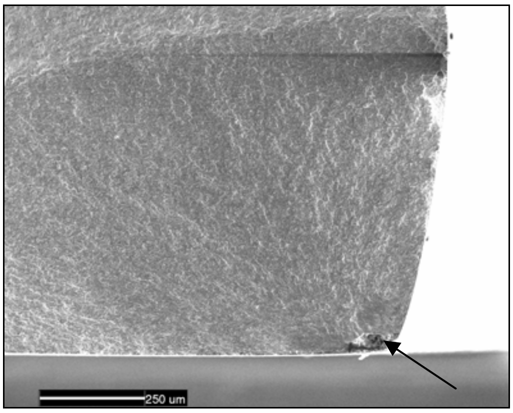


Figure 11 - Continental Eagle cryogen – Specimen 7. The surface defect at the initiation point is arrowed (@100X)

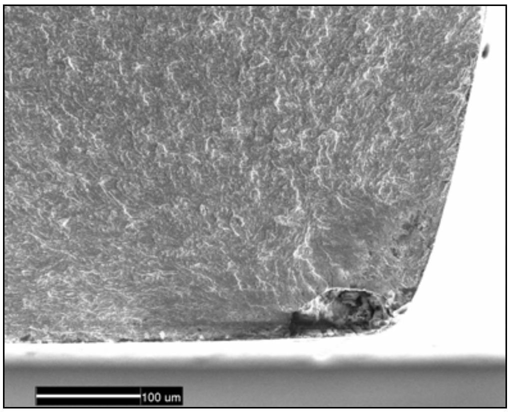


Figure 11a - Continental Eagle cryogen – Specimen 7. Higher magnification micrograph of defect (@ 250X)

Similarly for Specimen 7, the defect in the initiation region is a small cavity near the corner. Stringers were not observed in the fatigue region of the fracture surface. It is possible that their orientation relative to the fracture surface does not make them evident.

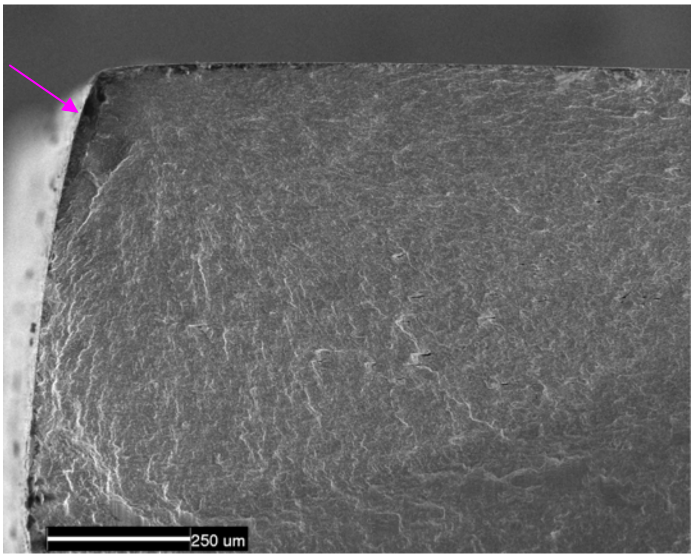


Figure 12 - Continental cryogen – Specimen 8. The surface defect at the initiation point is arrowed (@100X)

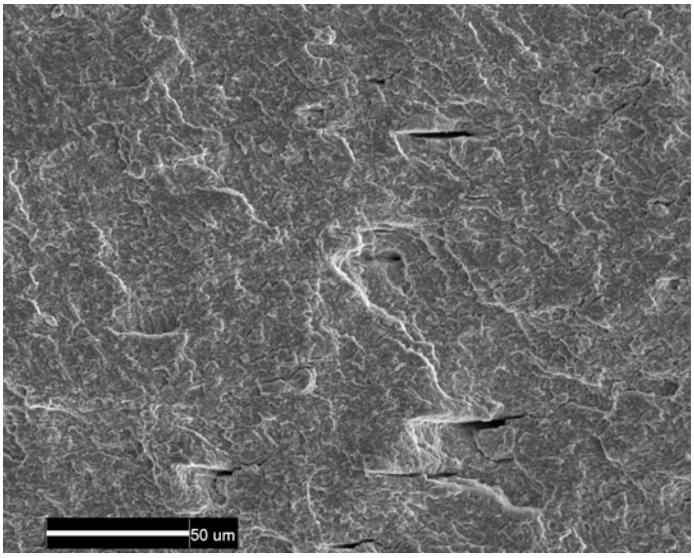


Figure 12a - Continental cryogen – Specimen 8. Fatigue fracture region at higher magnification (@500X)

A small cavity was observed at the initiation point of fatigue in Specimen 8. Stringers were observed on the fracture surface in this case as suggested by the small crack-like features in Figure 12a (these features appeared in greater proportion near the centreline of the specimen).

The edges of Specimens 9 to 12 were then polished until no marks due to water jet cutting were visible under the optical microscope (see Figure 13), and were tested a the same stress level of 770 MPa. The significantly longer fatigue lives of these specimens (the specimens did not fail after 2.5x10^6 cycles) suggest that the degree of surface preparation of the edges was a significant factor in the failure of the previous specimens (numbers 3 to 8).

Figure 13 - Optical micrograph showing surface of edge of specimen 11 after polishing (specimen thickness is 0.9 mm).

Fatigue Tests – Further tests

The remaining specimens were polished until no marks due to water jet cutting were visible under the optical microscope (as per specimens 9 to 12) and tested at a peak stress level of 880 MPa. Five repeats were done at each condition (brand of blade and treatment) except for Lummus control for which four repeats were done. The results are given in Table III.

Table III - Results of fatigue tests (Specimens 13 to 31)

Blade Type	**Treatment**	**Specimen No.**	**Peak Stress (MPa)**	**Fatigue Life (cycles)**	**Comments**
Lummus	Control	15	880	$>2.5\times10^6$	Did not fail after 2.5×10^6 cycles
Lummus	Control	29	880	157161	**Failed outside gauge length**
Lummus	Control	30	880	$>1.2\times10^6$	Stopped after 1.2×10^6 cycles
Lummus	Control	31	880	47166	Failed within gauge length
Lummus	Cryogen	17	880	151000	**Failed outside gauge length**
Lummus	Cryogen	18	880	$>2.5\times10^6$	Did not fail after 2.5×10^6 cycles
Lummus	Cryogen	23	880	195553	Failed at edge of gauge length
Lummus	Cryogen	27	880	$>2.5\times10^6$	Did not fail after 2.5×10^6 cycles
Lummus	Cryogen	28	880	1018136	Failed at edge of gauge length
Continental	Control	14	880	67029	Failed at edge of gauge length
Continental	Control	16	880	189047	Failed at edge of gauge length
Continental	Control	19	880	158110	Failed at edge gauge length
Continental	Control	25	880	65415	**Failed just outside gauge length**
Continental	Control	26	880	$>2.5\times10^6$	Did not fail after 2.5×10^6 cycles
Continental	Cryogen	13	880	127305	Failed at edge of gauge length
Continental	Cryogen	19	880	158110	Failed at edge of gauge length
Continental	Cryogen	20	880	90928	Failed at edge of gauge length
Continental	Cryogen	21	880	$>2.5\times10^6$	Did not fail after 2.5×10^6 cycles
Continental	Cryogen	22	880	232717	**Failed outside gauge length**

Some specimens failed outside the gauge length. This could be due to the specimen geometry and dimensions. The standard recommends that the radius of the blending fillet be at least eight times the width of the gauge length. Due to the length restrictions in this case a radius approximately four times the gauge width was used, which could have increased the stress concentration factor of the specimen.

The optical micrograph in Figure 14 shows the presence of small pores on the surface of the specimen (across the width) after polishing. The pores, or cavities, that intersect the edge of the specimen could contribute to fatigue failure, and may also correspond to the cavities observed at the initiation point of fatigue on the fracture surfaces.

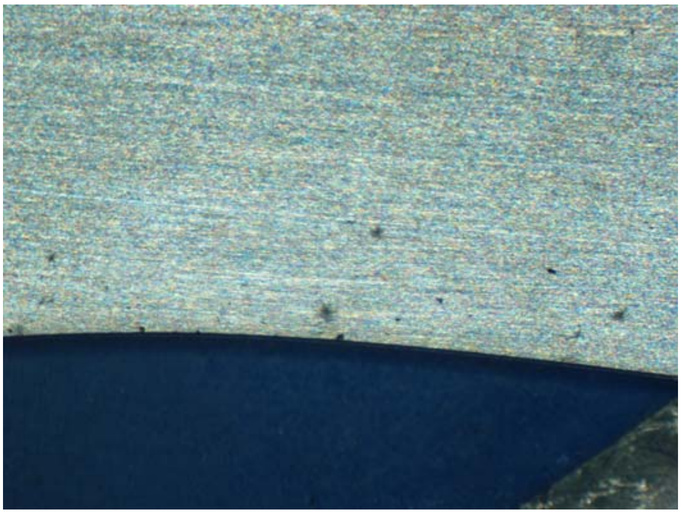


Figure 14 - Optical micrograph showing surface of Specimen 25 after polishing.

Investigate new saw tooth design

Saw Production Rate

CONTINENTAL 16" SAW

Current **Continental Eagle** gin stands have the following characteristics:

- Overall production rate of single gin stand is 5 bales per hour @ 227 kg each = 3405 kg per hour or 56.75 kg/minute
- Each gin saw has the following characteristics: 161 saws x 332 teeth per blade = 53,452 teeth per gin stand
- Saw speed = 615 rpm
    - Gives 53,452 x 615 rpm = 32,872,980 teeth working per minute to produce 56.75 kg per minute → 579 teeth per gram of cotton fibre or 1 tooth removes 0.00172 grams of fibre.

LUMMUS 12" SAW

Current **Lummus Corporation** gin stand have the following characteristics:

- Overall production rate of single gin stand is 5 bales per hour @ 227 kg each = 3405 kg per hour or 56.75 kg/minute
- Each gin has the following characteristics: 158 saws x 282 teeth per blade = 44,556 teeth per gin stand
- Saw speed = 950 rpm
    - Gives 44,556 x 950 rpm = 42,328,200 teeth working per minute to produce 56.75 kg per minute → 745 teeth per gram of cotton fibre or 1 tooth removes 0.00133 grams of fibre.

Note: If you take a cotton bud and remove the cotton from one end only, you will have in your fingertips approximately 20 times more fibre that a single gin saw tooth will remove! (The cotton on a single cotton bud end will weigh around 0.030 ~ 0.0320 grams) see Figure 15.

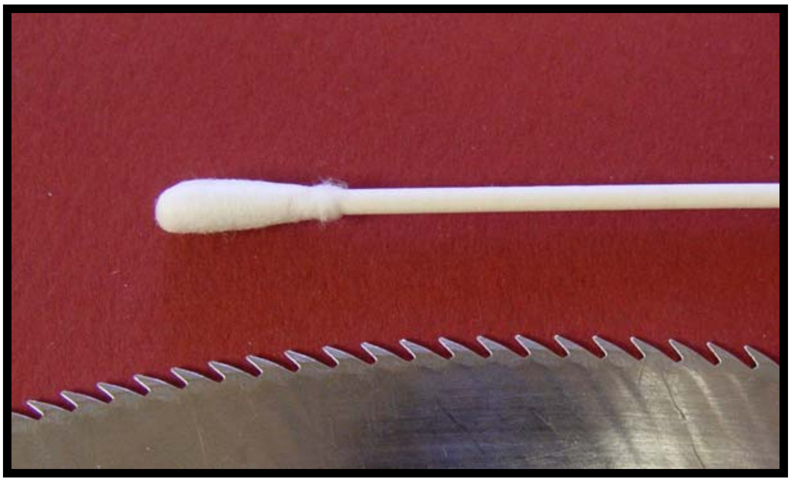


Figure 15 - The saw blade teeth have remarkably low collecting power. One saw tooth collects between 0.0013 and 0.0017 grams of fibre at each revolution

The current tooth profile has a single direction as shown in Figure 16. Whereas Figure 17 shows a proposed dual, direction profile. This new profile should not involve manufacturing a new blade. The existing gin saw blade teeth will be required to be positioned in a jig to allow setting of the teeth to a predetermined set/splay. It is envisaged that this new profile will increase the productivity of the saw teeth. The new tooth profile will be tested as part of the new CRDC CCC CRC ginning projects.

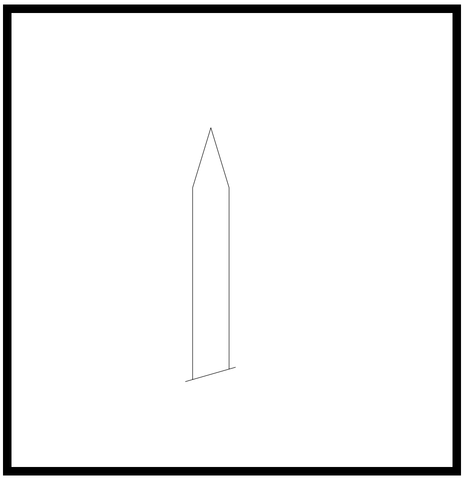


Figure 16 – Regular saw tooth profile

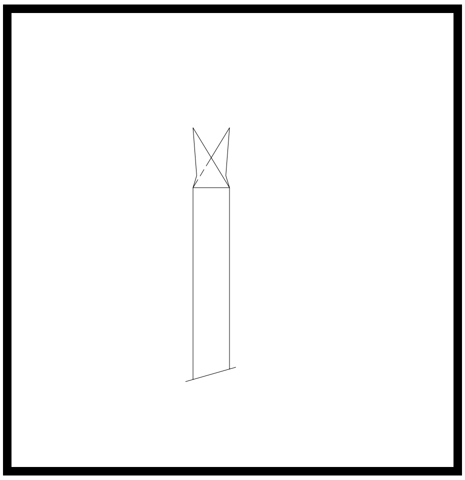


Figure 17 – Proposed saw tooth profile

Gin saw blade edge surface

The loads in a seed roll (of the seed cotton gripping the breadth of the revolving saw) become so great that they act as a disk brake, requiring more horsepower to turn the shaft. The horsepower required is around 150~200 hp. Heat build-up and gin fires are a result of this action.

Can a redesigned surface of a gin saw reduce heat build up, increase rigidity of the saw and possibly reduce the horse power required to drive the shaft?

The following diagram is an illustration of a saw that may help improve the saw qualities – see Figure 18. The radial lines in the saw diagram represent miniature corrugations in the steel surface creating a reduced surface area for the seed to rub against, possibly creating an air passage for cooling and also increasing blade stiffness.

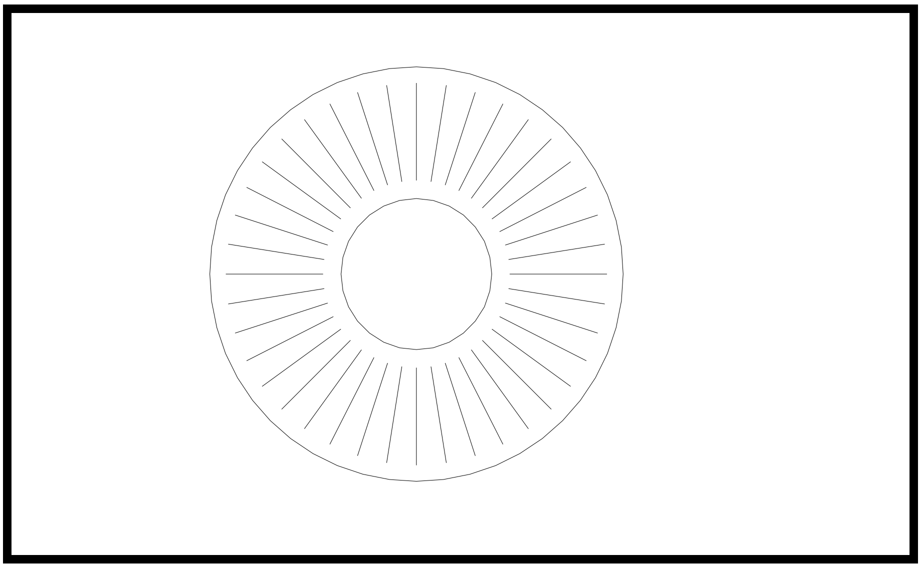


Figure 18 – Proposed radial corrugations to reduce surface area presented to seed roll

Gin stand rib inserts

As gin stand rib inserts wear, they allow for small cotton seed to enter into the ginned lint which is undesirable. A new insert has been designed to allow for the seed to move away from the ginning point inturn reducing the amount of cotton seed entering into the ginned cotton flow. The new rib insert is shown in Figure 19 below. Experimental inserts can be machined from a high grade steel to allow the new insert to be tested. Although the insert won't last as long due to the steel used, it will still give valuable information on the design. A final version could be made of the same material as conventional inserts giving a long user life.

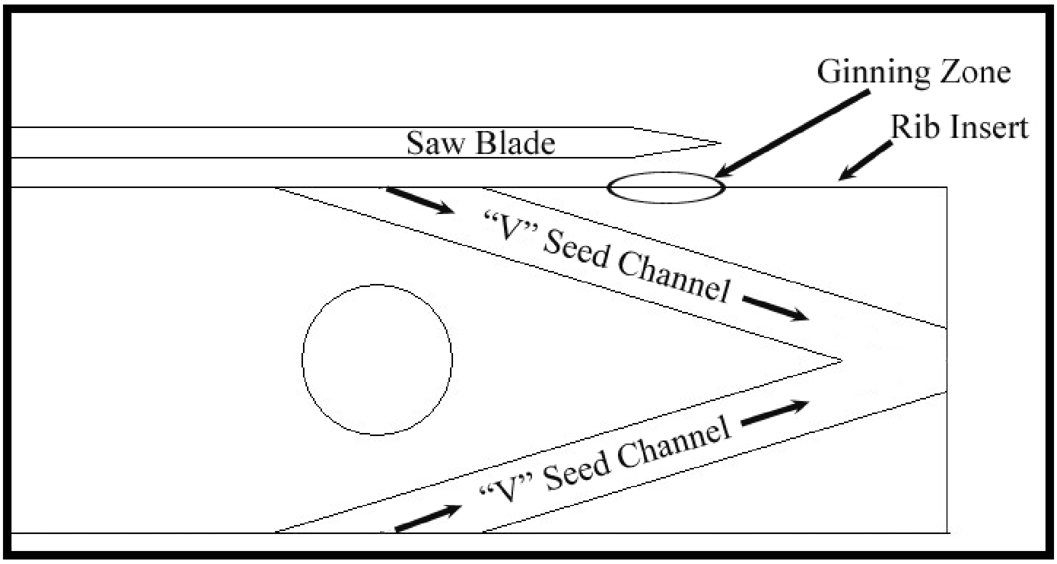


Figure 19 – proposed new rib insert

It should be noted that a trial will also be conducted during the 2007 ginning season to investigate the cryogen treatment used on gin rib inserts. Half of one gin stand is being set up with the treated inserts while the other side of the gin will have the identical insert, only untreated.

Recommendations for further work (as of November 2006)

- Analyse saw blades that have failed in practice, identify location of initiation of failure and the type of defect in this region.
- Analyse the fracture surfaces of the fatigue specimens (Specimens 13 to 31) using scanning electron microscopy to determine the defects at the origin of the fatigue failures. Determine the effect of surface preparation on fatigue failures (are the defects at the initiations points related to surface preparation?). Also determine the role, if any, of the inclusions/stringers on fatigue initiation (and crack propagation).
- Perform hardness tests on saw blades to check for uniformity of heat treatment across batches of samples (different brands plus treatments). Perform hardness tests on the surface of the blades to obtain a preliminary indication of wear properties.
- Investigate differences between the two brands of blades in terms of microstructure (presence of inclusions/stringers, composition of stringers), presence of any defects in the microstructure (small pores).
- Pursue trials of saw tooth profile measuring motor load on saw shaft, fibre quality, turn-out and seed condition.
- Pursue trials in saw blade side profile measuring motor load on saw shaft, seed condition and ginning speed.
- Pursue trials of gin-rib inserts measuring motor load on saw shaft and ginning speed.

Appendix A

The results for the fatigue tests were very erratic. To obtain some indication we have scored only those that made it over a million cycles; on this basis the Lummus Corporation blades are some 2.5 times better than the Continental Eagle saws – see Figure A1, which shows the average reading obtained for each brand and treatment. However the results are too wide spread to have any meaningful data.

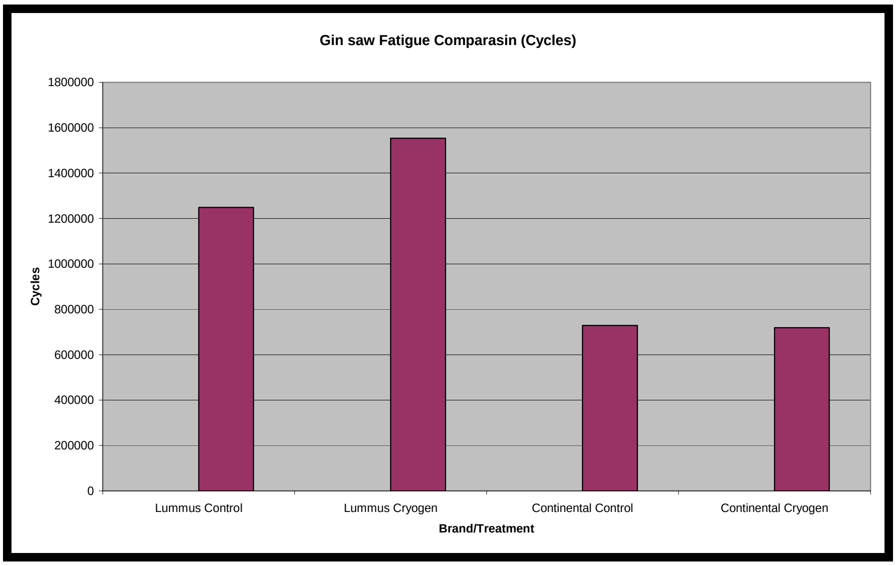


Figure A1 – Gin saw fatigue test results

Further work needs to be carried out to fully understand the fatigue of the blades. It is interesting to note that the edge obtained through water cutting the samples led to premature failure of the samples. Once the samples were polished using 1200 grit emery paper the samples obtained far greater fatigue life at a stress of 770 mpa. See Table B1, Specimens 3 to 31.

Appendix B

Table B1 – Results of all fatigue tests

Blade Type	Treatment	Specimen No.	Stress (MPa)	Peak Load (kN)	Specimen Width (mm)	Fatigue Life (cycles)	Comments
Lummus	Control	1	660	3.45	5.80	2266231	Did not fail
Lummus	Control	2	880	4.66	5.88	76620	Failed in gauge length
Lummus	Cryogen	3	770	4.07	5.88	314327	Failed in gauge length Initiation of fatigue from surface defect near corner of specimen
Lummus	Control	4	770	4.05	5.98	107051	Failed in gauge length Initiation of fatigue from surface defect at edge of specimen
Continental	Control	5	770	4.28	5.92	55248	Failed in gauge length Initiation of fatigue from surface defect near corner of specimen It appears that a large piece of material broke off from the corner of the specimen (probably due to the water jet cutting process)
Continental	Control	6	770	4.14	5.84	132015	Failed in gauge length Initiation of fatigue from surface defect near corner of specimen
Continental	Cryogen	7	770	4.18	5.90	130594	Failed in gauge length Initiation of fatigue from surface defect near corner of specimen
Continental	Cryogen	8	770	4.02	5.80	176795	Failed in gauge length Initiation of fatigue from surface defect near corner of specimen
Lummus	Cryogen	9	770	3.91	5.71	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles
Continental	Control	10	770	3.77	5.44	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles
Continental	Cryogen	11	770	3.77	5.44	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles
Lummus	Control	12	770	3.77	5.56	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles
Continental	Cryogen	13	880	4.49	5.55	127305	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed at edge of gauge length

Continental	Control	14	880	4.40	5.44	67029	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed at edge of gauge length
Lummus	Control	15	880	4.37	5.52	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles
Continental	Control	16	880	4.36	5.50	189047	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed at edge of gauge length
Lummus	Cryogen	17	880	4.39	5.54	151000	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope **Failed outside gauge length**
Lummus	Cryogen	18	880	4.39	5.54	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles
Continental	Control	19	880	4.25	5.37	158110	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed at edge of gauge length
Continental	Cryogen	20	880	4.24	5.36	90928	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed at edge of gauge length
Continental	Cryogen	21	880	4.30	5.44	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles
Continental	Cryogen	22	880	4.36	5.50	232717	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope **Failed outside gauge length**
Lummus	Cryogen	23	880	4.47	5.64	195553	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed at edge of gauge length
Continental	Cryogen	24	880	4.24	5.35	185961	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed within gauge length
Continental	Control	25	880	4.40	5.56	65415	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope **Failed just outside gauge length**
Continental	Control	26	880	4.20	5.30	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles

Lummus	Cryogen	27	880	3.87	5.23	>2.5x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Did not fail after 2.5x10^{6} cycles
Lummus	Cryogen	28	880	4.21	5.70	1018136	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed at edge of gauge length
Lummus	Control	29	880	4.36	5.57	157161	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope **Failed outside gauge length**
Lummus	Control	30	880	4.31	5.50	>1.2x10^{6}	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope **Stopped after 1.2x10^{6} cycles**
Lummus	Control	31	880	4.51	5.70	47166	Specimen edges polished until no evidence of surface marks were visible under the stereo microscope Failed within gauge length

Brighann Gin Moisture Trials – June 2006

Samuel Jackson (SJ) humidifiers (Humidaire) fitted over Lummus gin stands were turned on and off in two cycles over five hours. Cotton supplied to gin was Brighann cotton of same variety in successive modules from nominally similar positions in field. Oven measured moisture of cotton samples ex-gin stand with humidifiers on was 6.4% and 5.8% when off; under the prevailing conditions only 0.6% moisture was added from 'dry' state. Humidaire temperature and fan speeds were not altered during this trial, and module moisture was not noted.

Samples were collected every 10 minutes from the back of gin (LC0) and the back of each (Sentinel) lint cleaner passage (LC1 & LC2). Test results presented here compare LC0, LC1 and LC2 sample averages under wet and dry conditions.

Generally the level of difference between wet and dry treatments decreased as the cotton passed through successive lint cleaner passages. It is proposed that the main reason for this is the 'wet' cotton equilibrates back quickly to its dry state under the air flow volumes in the lint cleaners. We have previously measured (oven dry) moisture losses of up to 0.75% in cotton between LC0 and LC2.

Sentinel lint cleaners added between 28% (dry) and 30% (wet) more neps over two successive passages. The difference was greater between LC0 and LC1, than between LC1 and LC2.

Overall the nep levels the fibre damage levels (nep and SFC) are quite acceptable. The addition of moisture via the Humidaire did not ameliorate damage to cotton subject to two lint cleaner passages. The largest effect from adding moisture was seen immediately after ginning. It remains to test a wider range of moisture levels and the effect of these on fibre damage levels.

LC0 (post-gin)

Property	**Wet**	**Dry**	***Probability of difference***
Neps (cnt/g)	165	176	*0.050 sig. difference*
SFCw (%)	9.42	10.28	*0.012 sig. difference*
UQL (inches)	1.251	1.235	*0.003 sig. difference*
Trash (cnt/g)	73	69	*0.518 no sig. difference*

LC1 (post-1st lint cleaner)

Property	**Wet**	**Dry**	***Probability of difference***
Neps (cnt/g)	205	210	*0.598 no sig. difference*
SFCw (%)	9.94	10.90	*0.024 sig. difference*
UQL (inches)	1.237	1.223	*0.037 sig. difference*
Trash (cnt/g)	69	49	*0.000 sig. difference*

LC2 (post-2nd lint cleaner)

Property	**Wet**	**Dry**	***Probability of difference***
Neps (cnt/g)	215	226	*0.181 no sig. difference*
SFCw (%)	9.93	10.20	*0.377 no sig. difference*
UQL (inches)	1.236	1.236	*0.967 no sig. difference*
Trash (cnt/g)	51	41	*0.057 no sig. difference*

Two-Sample T-Test and CI: NEP, Wet/Dry

```
Two-sample T for nep

Wet/Dry   N   Mean  StDev  SE Mean
1        15  165.3   11.9      3.1
2        12  176.1   14.5      4.2


Difference = mu (1) - mu (2)
Estimate for difference:  -10.8167
95% CI for difference:  (-21.6391, 0.0058)
T-Test of difference = 0 (vs not =): T-Value = -2.08 P-Value = 0.050 DF = 21
```

Two-Sample T-Test and CI: SFCw, Wet/Dry

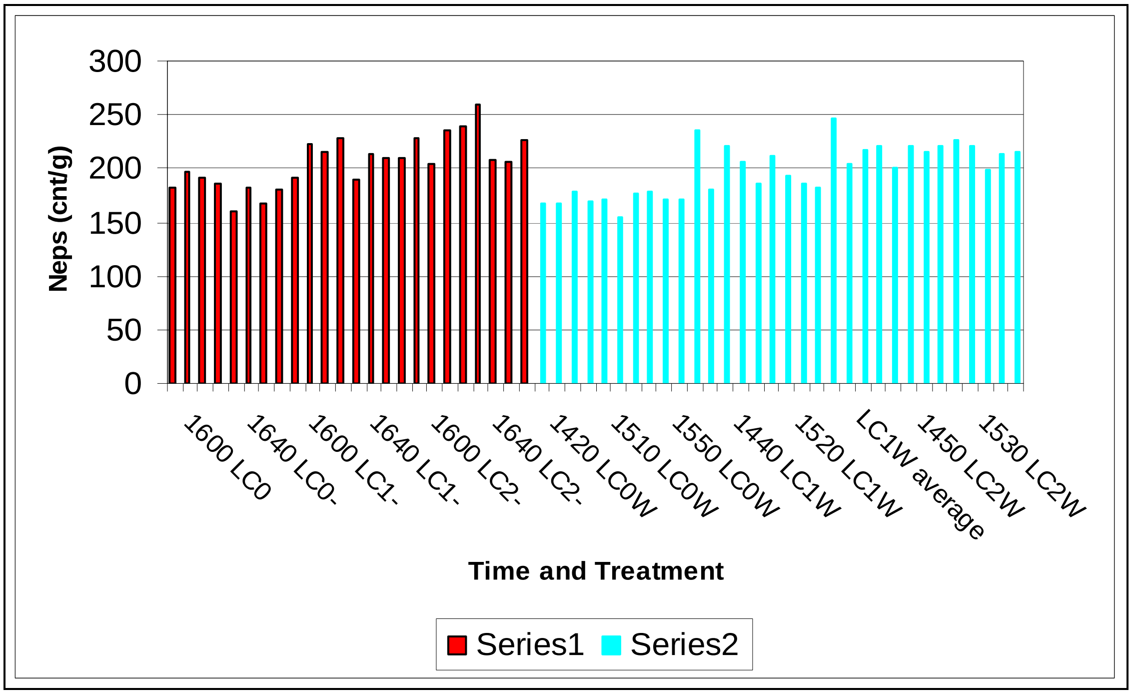
```
Two-sample T for sfcw

Wet/Dry   N    Mean  StDev  SE Mean
1        15   9.420  0.637     0.16
2        12  10.275  0.902     0.26


Difference = mu (1) - mu (2)
Estimate for difference:  -0.855000
95% CI for difference:  (-1.499478, -0.210522)
T-Test of difference = 0 (vs not =): T-Value = -2.78 P-Value = 0.012 DF = 19
```

Two-Sample T-Test and CI: UQL, Wet/Dry

```
Two-sample T for uql

Wet/Dry   N    Mean   StDev  SE Mean
1        15  1.2513  0.0151   0.0039
2        12  1.2333  0.0137   0.0040


Difference = mu (1) - mu (2)
Estimate for difference:  0.018000
95% CI for difference:  (0.006552, 0.029448)
T-Test of difference = 0 (vs not =): T-Value = 3.25 P-Value = 0.003 DF = 24
```

Two-Sample T-Test and CI: Trash, Wet/Dry

```
Two-sample T for Trash

Wet/Dry   N  Mean  StDev  SE Mean
1        15  73.1   17.7      4.6
2        12  68.8   16.9      4.9


Difference = mu (1) - mu (2)
Estimate for difference:  4.38333
95% CI for difference:  (-9.40302, 18.16969)
T-Test of difference = 0 (vs not =): T-Value = 0.66  P-Value = 0.518  DF = 24
```



Dry cotton (red bars) vs. moist cotton (blue bars) – x-axis shows progression of samples through LCO (post-gin), LC1 (post-1st lint cleaner) and LC2 (post-2nd lint cleaner)

COMPARISON OF GIN MOISTURE MEASUREMENT SYSTEMS

2005/06 season

Objective: Test VOMAX and ISOTESTER measurement systems against moisture determined gravimetrically i.e., by oven-dry methodology.

Materials: Consecutive bales/modules ginned at Brighann Gin, Moree on 2/6/06 between 1000 and 1700 hours: Starting bale number = 495648.

Method: Receive part bale sample (between 45 and 65 grams) post press and determine percent moisture by weighing sample to one decimal place before drying for 15 minutes in CSIRO Regain Tester Oven. We note that > 95% of the moisture in a small cotton lint sample is lost in the first 10 minutes of drying (at 105^o C). Moisture determined on wet and dry basis and converted to percentages – see below:

Wet basis percent (WB%) = (sample in (g) – sample out (g))/sample in (g) x 100

Dry basis percent (DB%) = (sample in (g) – sample out (g))/sample out (g) x 100

Note: CTFT do not know the basis on which the VOMAX expresses moisture content i.e., wet or dry basis. Standard oven-dry methods apply a ± 0.2% error to test results. A nominal test error of ± 0.4% is applied to the oven-dry tests reported here given the shortened drying time (of 15 minutes), weighing conditions (non-standard) and resolution of scales (0.1 grams). For convenience, the same test error is applied to the VOMAX results.

Results: Oven-dry determined moisture content (wet and dry basis) of the part bale samples were compared with the VOMAX and ISOTESTER moisture results for the same bale. Test results by all methods are listed in Table I. VOMAX values recorded from 1017 to 1124 hrs (on bale nos. 495660 to 495705) were affected by improper alignment of bales to microwave antennae. Figures 1 to 3 exclude these results.

Figures 1 and 2 show the relationships between VOMAX and oven-dry values on a wet and dry basis respectively. Whilst the relationships are significant they are affected by a reasonable degree of scatter and in particular by three VOMAX results above 8.5% for samples measured at around 7% by the oven-dry method. Without extensive replicate testing through the profile of each bale it is difficult to know why these high values were recorded by the VOMAX. We note that transmission of microwave radiation is affected not only by bale moisture but also by the density of the bale and the occurrence of stationary packing materials e.g., bale bands, wires etc, which might reflect the radiation.

Figure 3 shows VOMAX, oven-dry (dry basis) and ISOTESTER results over the test period. Excepting the three VOMAX values above 8.5%, a reasonable relationship can be seen between the VOMAX and oven-dry dry basis results. Error bars depicting a nominal test error of ± 0.4%, interpreted as a confidence

interval, for the VOMAX and oven-dry values show the extent to which the VOMAX results agree with the oven-dry method results.

ISOTESTER results were largely static as a result of what appeared to be improper placement of the sample against the ISOTESTER moisture sensors. If the sample does not extend beyond the ISOTESTER's measurement window contact between the sample and these sensors is not complete, and therefore the result is erroneous.

Table I – Moisture test results recorded 2/6/06

Time in (hrs)	Bale No.	Mass in (g)	Mass out (g)	Wet Basis (%)	Dry Basis (%)	VOMAX (%)	ISOTEST (%)
1017	495660	55.7	52.1	6.5	6.9	9.3	6.3
1034	5670	62.1	58.3	6.1	6.5	6.2	6.5
1050	5682	51.3	48.0	6.4	6.9	10.3	6.1
1106	5693	58.8	55.4	5.8	6.1	8.3	6.0
1124	5705	53.5	50.4	5.8	6.2	6.9	6.1
1142	5717	55.5	52.1	6.1	6.5	6.5	6.0
1158	5730	57.5	54.0	6.1	6.5	6.2	6.0
1214	5741	45.2	42.1	6.9	7.4	7.0	6.0
1232	5755	61.9	57.7	6.8	7.3	7.7	6.0
1249	5768	62.5	58.5	6.4	6.8	8.8	6.0
1346	5777	59.5	56.1	5.7	6.1	5.5	6.0
1402	5788	55.7	52.3	6.1	6.5	6.2	6.0
1418	5797	59.6	55.7	6.5	7.0	6.8	6.0
1434	5805	55.1	51.4	6.7	7.2	6.9	6.3
1450	5814	65.3	61.1	6.4	6.9	-	-
1506	5826	56.0	52.2	6.8	7.3	7.8	6.1
1522	5837	58.5	54.9	6.2	6.6	7.2	6.1
1538	5845	61.0	57.1	6.4	6.8	7.4	6.1
1555	5857	63.1	59.0	6.5	6.9	8.4	6.1
1612	5869	60.1	56.4	6.2	6.6	7.0	6.9
1628	5880	55.6	51.6	7.2	7.8	7.7	7.9
1645	5892	58.5	54.6	6.7	7.1	8.9	6.4
1704	5906	59.0	55.1	6.6	7.1	6.7	6.6

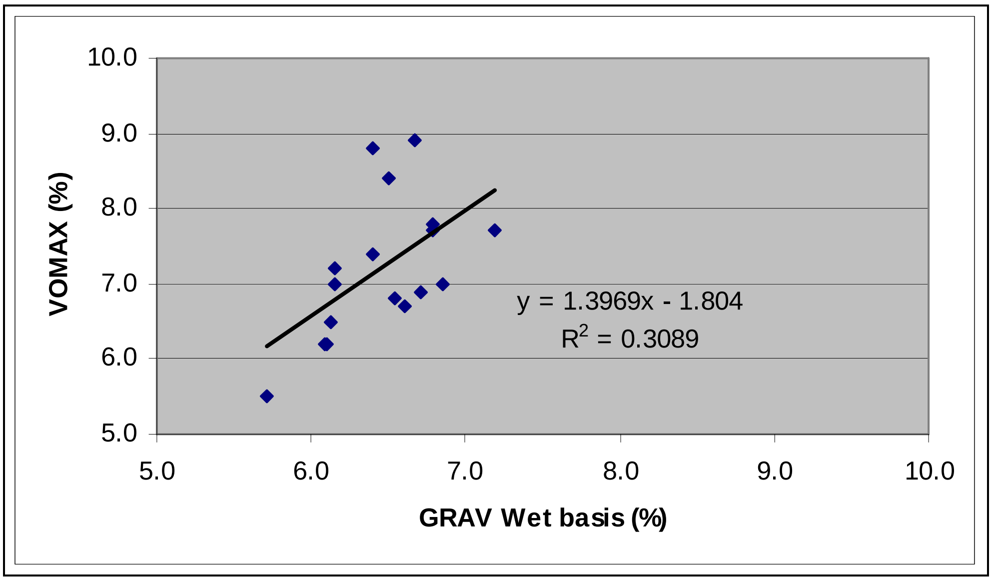


Figure 1 – VOMAX versus oven-dry moisture determination (wet basis)

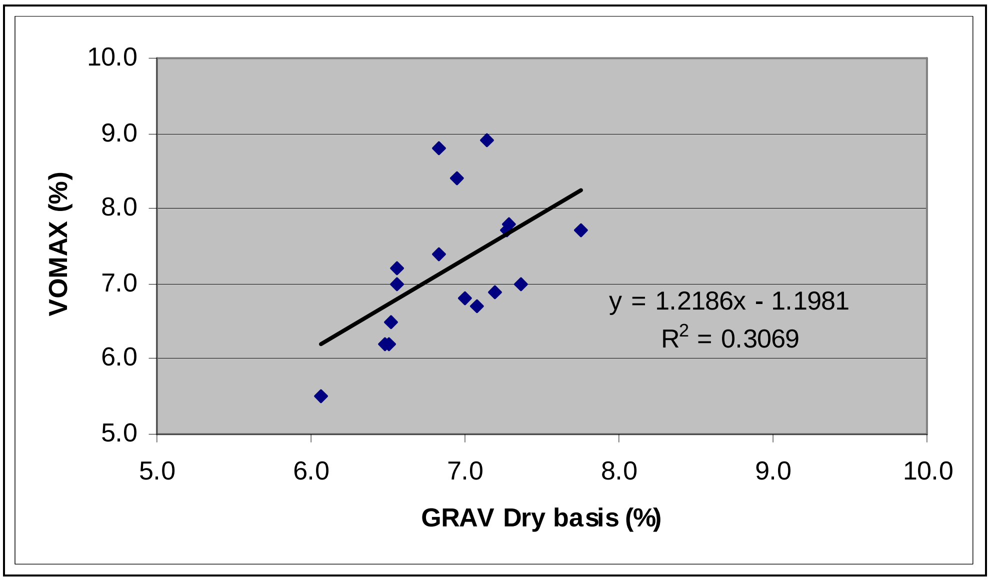


Figure 2 – VOMAX versus oven-dry moisture determination (dry basis)

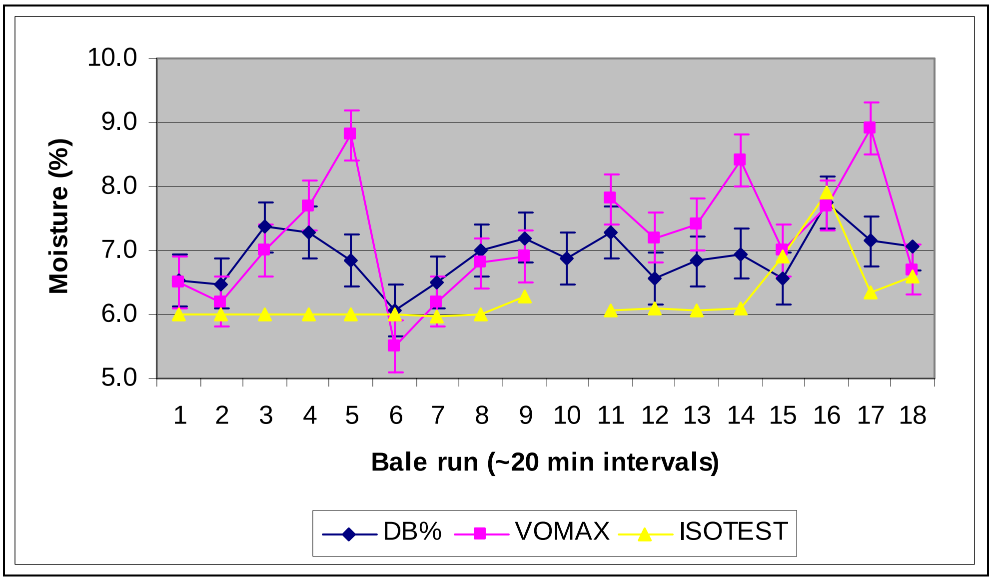


Figure 3 – Moisture test results by three methods recorded over time (DB% = oven-dry moisture expressed on dry basis)

GINNING FOR QUALITY

Stuart Gordon, CSIRO Textile and Fibre Technology

The quality of cotton assessed at the gin has for too long been associated with grade. The properties of colour, trash and 'preparation' are not as important to the final product as the focus at the gin and across the merchant desk would attest. The spinner would rather have fibre that was long, even in length, strong and fine. The spinner would also prefer the fibre without neps and short fibres. These last two parameters are unfortunate characteristics of cotton harvested and ginned by mechanized means. Whilst not included in existing classification systems for cotton, the presence of nep and short fibre is seriously affecting the marketing ability of our cotton.

Modern gins are highly automated and productive systems that incorporate many processing stages besides the removal of lint from the cotton seed. Seed cotton delivered in modules is opened by a series of beaters and transported by air through a drying tower that dries seed-cotton to a moisture level that ensures efficient trash removal. From the drying tower seed cotton can be transported to one or a series of pre-cleaners, which remove large trash e.g., sticks, stones, unopened bolls, before the gin. At ginning the lint is separated from the seed after which it travels by air to one or two lint cleaners for further cleaning and preparation. Preparation is a relative term describing the amount of cleaning or combing given to cotton so that it matches official (USDA) physical 'grade' standards upon which cotton is valued.

Central to 'preparing' cotton without damaging it i.e., without creating nep and short fibre, is managing fibre moisture and the impact of (lint) cleaning properly in the gin. Many studies have shown the detrimental effects of lint cleaning cotton that is too dry. Table I lists data that illustrate the effect of over-drying good quality cotton. The data were collected by the NCEA and CSIRO in 2000/01 as part of a trial [1] involving ginning seed-cotton, subjected to three different storage conditions (dry, ambient and wet) and three drying conditions in the gin (zero heat, standard heat and high heat). One lint cleaner was applied in all treatments.

Table I – Length, short fibre index, trash and neps as a function of seed-cotton moisture and drying temperatures

Treatment	Length[1] (inch)	SFI[2] (%)	Trash[3] (%)	Neps[4] (cnt/g)
Dry x Zero heat	1.13	2.7	0.78	347
Dry x High heat	1.12	3.2	0.75	334
Ambient x Std. heat	1.12	5.6	0.77	420
Wet x Zero heat	1.16	2.9	1.24	287
Wet x High heat	1.14	4.7	1.04	na

1. HVI staple length
2. HVI short fibre index (by weight)
3. Trash content gravimetrically determined ('Shirley' Analyser)
4. Neps as per AFIS Pro

The effect of the wet storage treatment, which resulted in seed-cotton with 10% moisture, amounted to keeping the seed-cotton at the recommended moisture i.e., between 10 and 12% [2]. Under the dry and ambient storage conditions, the seed-cotton had dried to less than 7% moisture. Without any moisture replenishment in the gin this cotton was subject to the greatest amount of damage particularly when dried at high temperatures. There was no difference in classer's grade between treatments and only one leaf grade difference separated 'normal' cotton from the wet, zero heat cotton; 31-2 *cf.* 31-3. The wet, zero heat cotton contained only 0.7% by weight more trash in the bale than cotton treated 'normally' i.e., stored under ambient conditions and treated to standard heat. In the mill the wet, zero heat cotton performed better in terms of yarn properties and fabric performance and interestingly, contained less trash, dust and fibre fragments after mill processing than the 'normally' treated cotton.

In 2001/02 Roberts [3] found that cotton re-injected with moisture before the gin feeder, so that it had a regain of 7% at the gin-stand, was prone to less fibre breakage compared to the same cotton not treated and which had 4% moisture at the gin-stand. Roberts found all fibre property attributes were better when the fibre was ginned at 7% moisture. The message from this work is that cotton needs to have at least 6.5% moisture in it prior to the gin-stand to ensure damage is minimized during ginning and lint cleaning.

Table II lists the results from a US study [4] similar to the NCEA/CSIRO study except that the effect of gin machinery was also measured. This study showed low moisture content during gin processing increased short fibre content by over 50% and neps by 16% whilst different machine treatments impacted short fibre content by 55% and neps by 26%.

Table II – Short fibre content and neps as a function of moisture and cleaning machinery for a cotton variety at the gin [4]

Treatments	**SFC[1] (%)**	**Neps[2] (cnt/g)**
Moisture		
Low	9.0a	204a
Medium	6.4b	181b
High	5.9c	175c
Machines		
Gin stand	5.5a	170a
One LC	7.1b	188b
Two LC	8.2c	211c
Standard[3]	8.5c	230d

Means not followed by the same letter are significantly different at the 5% level as per Duncan's Multiple Range Test

1. Short fibre content determined by Peyer AL101
2. Neps as per AFIS Pro
3. Standard = dryer, cylinder cleaner, dryer, stick machine, 'Trashmaster', extractor-feeder/gin stand and two lint cleaners

These studies illustrate the need for growers and ginners to keep a watchful eye on the moisture of the cotton they gin and the mechanical processes they subject cotton to during cleaning. Low moisture means more damage to the fibre during ginning and particularly lint cleaning. The addition of moisture via humidified air improves cotton fibre tensile properties resulting in greater strength, extensibility and work-to-break values. These effects make the cotton fibre more resilient during ginning and lint cleaning, and less prone to damage.

Commercial, integrated systems for modulating dryers and introducing humidified air before the gin stand are available and are a good idea. Application of these systems also helps to improve gin efficiency in terms of turn-out and power (gas and electricity) usage.

CSIRO is testing the effects of moisture management on Australian cotton fibre and is hoping to increase its research effort to affect more rigorous and accurate moisture testing and replenishing systems that allow moisture to be added during ginning to protect the fibre during lint cleaning. Another aim of this research would be to improve the management of bale moisture such that moisture never exceeds 7% in the stored bale – but for which there is enough moisture in the bale to allow it to be compressed efficiently.

With world cotton supplies at record highs and competitive export growths from the USA, Brazil, Europe and even China, Australia is facing a challenge. Cotton is selected by spinners for many reasons but price and value together remain the main motivators. Australian fibre quality needs to improve to keep our spinning customers motivated.

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3. Roberts, G., ‘Cotton Ginning with Emphasis on Quality’, Occasional paper for the CRDC, Project No. NEC7C, 81 pp., 2003
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Reducing Maintenance Costs on Lint Cleaners

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Unlike conventional saw wire, once interlocking wire is applied, the saw cylinder no longer needs to be machined when the wire is replaced. Further, the cylinder diameter does not change meaning that it does not need to be replaced after three or four re-wirings. Inter-lock wire is used widely in more aggressive textile applications such as the rag ripping industry without incidences of it unravelling.

The currently accepted method of attaching wire to the lint cleaner saw cylinder is to tightly wind it into grooves that have been cut into the lint cleaner cylinder. The metal between the grooves is then swaged to hold the wire tightly in place. This method prevents the wire from unravelling and springing off the cylinder surface, also known as “bird nesting”, when it breaks as a result of large objects, particularly metal contamination, entering the system.

The textile industry uses similar wire types, predominantly on carding machines, which also must allow for wire breakage from heavy objects entering the system. However, the textile industry does not use the same grooving method as the ginning industry for laying the wire onto cylinders. Instead, for at least the last 20 years, it has used a wire that tightly inter-locks along the heel of the wire to hold the wire strands firmly in place. The inter-lock mechanism ensures that it does not unravel or “bird nest” as a result of a break after heavy objects come into contact with the wire. Figure 1 shows a cylinder wound with an inter-lock wire that has been machined through and across four wire strands to demonstrate its inter-locking ability after a catastrophic multi-wire break. Figure 2 shows a close-up cross-sectional view of the inter-locking mechanism present in the heel of the wire.

“Think of the wire like tongue and groove floor boards, each one holding the opposing board in position. You can’t just lift one out without firstly removing the boards from the end until you reach the board of concern, interlocking wire is no different.”

Wire manufacturers make heavy inter-locking wires specifically for the rag ripping industry, which is a more aggressive application of the inter-lock mechanism. ECC, a wire manufacturer, have designed an inter-locking wire specifically for lint cleaning in ginning.

In terms of cost, traditional and interlocking wires are comparable. Expect to pay around $AUD27 per kg for interlocking wire with a pin density of 48 pins per square inch[1]. A 108 inch x 16 inch diameter saw will require around 56 kg of wire, while a 102 inch x 24 inch diameter saw will require around 79 kg of wire.

The advantages of inter-lock wire are significant. They include:

- Minimal resetting of the saw in the lint cleaner even after repeat wire rewinds because the cylinder circumference has not been altered.

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[1] Note that 40 & 64 pins per square inch pin densities are also available

- All spare saw cylinders will be exactly the same size making them interchangeable and allowing for quick fitting during the season.
- Potentially large savings in maintenance costs. Instead of getting three or four rewinds from a cylinder before it needs replacing, the cylinder will now last indefinitely. We note the current price of a 24D lint cleaner saw cylinder is around $20,000.

The ECC interlock wire specifically designed for the lint cleaner has the designation V8B/4.23/60. Other manufacturers of inter-locking wire may also have suitable products for the ginning industry. The ECC wire manufacturers web site is www.ecc-cardclothing.com and the agent for ECC in Australia is Ramsay McDonald. Their web address is www.ramsaymcdonald.com.

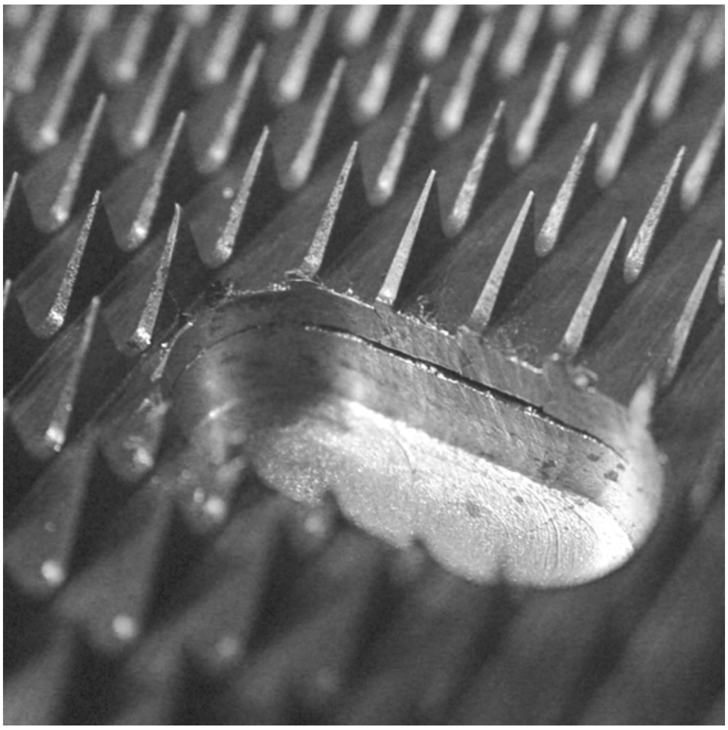

Figure 1 illustrates that even after machining a slot through at least 4 rows of inter-lock wire and into the cylinder the saw wire remains intact.

Figure 2 shows a cross sectional magnified view of the inter-locking mechanism of the wire wound onto the saw cylinder.