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ENERGY USAGE FOR COTTON GINNING IN AUSTRALIA

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ABSTRACT Ginning is an energy intensive process. This paper evaluates the energy usage inside the cotton gins in Australia. Benchmark electricity use is found to range between 44 and 66 kWh per bale, with average being 52.3 kWh. The electricity consumption for different gins is nearly linearly correlated with bale numbers produced. The electricity network charge is a significant cost in cotton ginning operations. All gins monitored had an overall power factor of higher than 0.85. It is found that drying gas usage is strongly influenced by the cotton moisture reduction and regulated drying temperature. Overall, electricity and gas usage comprises about 61% and 39% respectively of total energy use (GJ/bale). 60.38 kg of CO2 are emitted for ginning each bale of cotton. A method for detailed monitoring of energy performance in cotton gins is developed and described. Detailed monitoring and analysis are carried out at two gin sites. It is found that changes in trash content in the module, degree of moisture and lint quality produced do not have significant influence on electricity usage, while the cotton variety is shown to affect the energy usage. Overall, cotton handling is found to be the largest energy user and it takes up to nearly 50% of power use in both gins. Packaging and handling together use some 70% of total power required.

Keywords: Benchmark, Detailed monitoring, Incoming cotton, Energy use.

INTRODUCTION Ginning is an important operation within the overall cotton production system. It is the process where cotton seed and foreign matter (trash) are removed from the lint. Ginning is also a seasonal process which operates only 3-4 months in a year.

Within highly mechanized production systems, energy inputs present a major cost to growers and processors (Chen and Baillie, 2009). Nowadays, energy is becoming increasingly important in the context of rising energy costs and greenhouse gas emissions. It was reported that ginning represents approximately 38% of cotton processing cost in the USA (Cleveland and Mayfield, 1994). In Australia, ginners also have to pay between $68,000 and $400,000 per year to cover the ginning energy costs. Considerable opportunities therefore exist for the improvement of energy efficiency in the cotton gins.

The aim of this project is to determine the energy usage patterns in Australian cotton gins and specifically to determine where energy is utilized inside the cotton gins. This project also aims to show how the electricity and gas usage is affected by the condition of incoming cotton, including the ginner‘s decision in regulating the dryer temperature, and other operational decisions such as determining the sequences of machine operations (e.g., removing and re-introducing machines into the ginning process).

METHODOLOGY This research is conducted based on real practices in Australia. The energy data collection will be divided into two levels, namely:

1. Basic level, and
2. Advanced level.

The study will first involve the surveys with cotton ginners. This is then followed by collecting the historical records, and in-situ site monitoring.

Energy data collection - Basic level The basic level of energy data collection is aimed to establish an energy usage benchmark within the Australian cotton ginning industry. This is achieved by collecting the historical data of the last 24 months of energy consumption (electricity and gas) bills, the monthly production volume (number of bales produced) and (if available) the records of incoming cotton (e.g incoming moisture content, dryer’s temperature applied, variety and trash levels). This data is then analysed to establish energy performance benchmarks where the individual company can compare their performance with the benchmark to gauge their own performance.

Energy data collection - Advanced level The aim for this level of data collection is to calculate the energy usage breakdown between the different ginning sub-processes (drying, cleaning, gin stand and baling) and to determine where the energy is consumed inside the cotton gins. For this level, detailed monitoring of the cotton ginning operation has been undertaken at two ginning sites. The monitoring involved the measurement of power and energy consumption for individual motors. The process began by analysing the plant layout and motor ratings. The motors that operated under one line of the ginning process were selected and monitored.

At the time of monitoring, the energy usage of each meter inside the gin was also routinely recorded by the electricity company every 15 minutes. Each of these meters measured the energy usage of a group of motors inside the gin in each sub-board. A form (to be completed by the ginner) to collect relevant information about the incoming cotton (e.g. moisture content, variety, lint quality and trash level) was developed. The collected energy usage data is then correlated with the conditions of incoming cotton, lint quality and quantity of bales produced to find the most affected process by the incoming cotton and to determine where energy is spent inside the cotton gin. The energy usage for each sub-process in producing one bale will also be calculated.

RESULTS

Basic Level

Benchmark of Electricity Consumption The electricity use benchmark is developed as an electricity performance indicator for ginners to evaluate their electricity consumption. The benchmark is established using yearly electricity usage and production data for all eight gins where the data were gathered. It is found that yearly minimum and maximum production for these gins varied between 6,303 and 45,000 bales. The benchmark for electricity use (kWh) per bale ranged between 44-66 kWh, with average being 52.3 kWh. This was consistent with the data available from overseas that recorded 40-60 kWh/bale (Anthony and Eckley, 1994). There was no correlation between a gin's capacity and energy use per bale. The electricity consumption is nearly linearly correlated with bales produced (Figure 1). This may be a consequence of similar machines following the similar operation procedures for all incoming cotton.

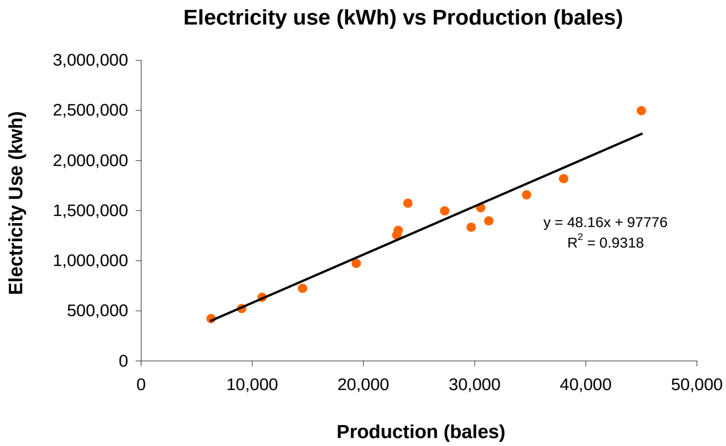

Figure 1. Relationship between electricity consumption (kWh) and production (bales)

As an average, electricity usage contributed 61% of total energy use and 77% of energy cost per bale (Figures 2 and 3).

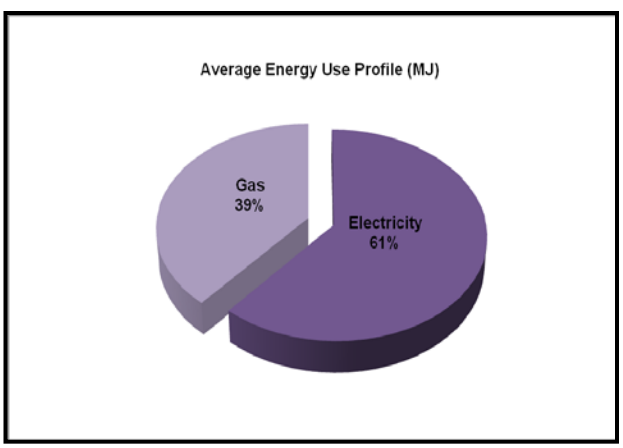

Figure 2. Average energy use profile

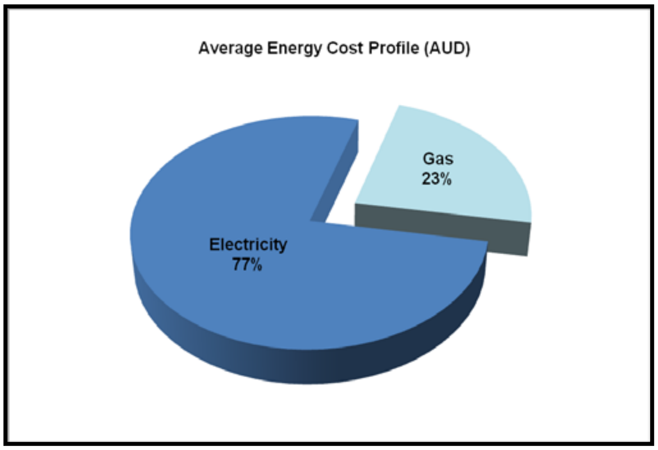

Figure 3. Average energy cost profile

Electricity Costs Based on the last 24 months data, the average electricity cost per kWh used ($/kWh), the electricity usage per bale (kWh/bale) and the total electricity cost per bale ($/bale) are calculated. The average ranged between $0.10 - 0.23 /kWh, 46.5 – 58.55 kWh/bale and $5.12 – 11.94/bale respectively. Overall, the fixed charges could occupy up to 68% of the annual electricity cost. Electricity cost was strongly influenced by electricity usage and maximum demand. For similar electricity consumption per bale, the electricity cost per bale ($/bale) could be up to 100% difference for different electricity tariffs.

Power Factor Power factor for each gin is also calculated. It is found that the average power factor was not less than 0.85 and the maximum is 0.97. This was satisfactory.

Benchmark of gas usage The gas usage benchmark is established using yearly gas usage and production for all gins gathered. It is found that the drying process used about 0.74-3.90 m^3/bale of natural gas or 2.27-5.61 litres/bale of LPG gas. This was equivalent to 0.029-0.154 GJ/bale. The average was 0.1 GJ/bale. This was less than half of the data available from overseas which was about 0.29 GJ/bale. In addition to the drying temperature and number of dryers used, it is noted that gas usage may also be influenced by other factors such as cotton condition and moisture content and ginner’s decision in the drying and heating time.

The cost of gas in producing one bale in Australia was around $0.98 - 3.39 /bale. The overall thermal efficiency of the drying process was less than 15%.

Greenhouse gas emission Using the above average data, the calculation of GHG emission shows that the ginning process on average emits about 60.38 kg CO2 of greenhouse gases.

Advanced Level This level was accomplished by doing the monitoring based on real ginning practice at two gins.

Electricity usage and trash removed It is found all that the motors were nearly running at the same load regardless of the quantity of trash removed.

Electricity usage patterns based on incoming cotton moisture The monitoring results show that the electricity usage were quite scattered even when the module moisture was the same. So it appeared that the electricity usage was not significantly influenced by the incoming module moisture. This may be understandable since the incoming moisture was already reduced to the optimum moisture in the dryer (an earlier process) before it actually went through other processes.

Electricity usage patterns based on cotton variety The data shows that electricity data related to gin stands varied significantly for different varieties. The electricity usage of some varieties can reach almost twice that of other varieties. This variation may be attributed to changes in the average fibre-to-seed attachment force of different varieties.

Electricity usage patterns from lint quality The results show that lint quality only ranged from 3 to 4 and appeared to have little impact on electricity use.

Electricity usage pattern with increasing bales The results show that the electricity use of both gins were slightly increased as the bales produced increased. Most of this increase was due to primary lint cleaners and gin stands. Because the capacities of these motors were quite large, they tended to have a significant impact on the total electricity use as their load increased.

Electricity usage breakdowns for sub-processes and cost per bale To find the energy breakdown according to the sub-processes, all the motors are divided into 4 major ginning processes according to their functions. The definition of the classification is:

- Cleaning – consists of the motors that have relevance to seed cleaning and lint cleaning
- Ginning – consists of gin stands
- Packaging – consists of motors that have relevance to pressing and bale packaging
- Handling – consists of motors used for seed cotton handling, lint handling, trash handling and all other motors that are not included in other three sub-processes stated.

The motors that operated under one line including the common motors that operated for all lines were selected for detailed monitoring. It was assumed that the identical motors located in other lines were also operating at the same load.

For the first gin (Gin #1), the energy usage (kWh) for each bale is calculated by dividing the average measured input power (kW) with the average production rate of 40 bales per hour. The average dollar paid by the ginner per kWh was estimated from the utility bills. The results are shown in Table 1.

For the second gin (Gin #2), the energy usage per bale (kWh/bale) was also calculated by dividing the input power with the average production rates for this gin (51 bales/hour). The average dollar paid by the ginner per kWh was estimated from the utility bills. This was also $0.13/kWh. The results are shown in Table 2.

Table 1: Average energy use and cost per bale (Gin #1)

Gin Process	Input power (kW)	Energy use per bale		Cost ($) per bale[1]
		kWh	Percent of total	
Cleaning	147.63	3.69	8.84	0.48
Ginning	296.00	7.40	17.72	0.96
Packaging	374.27	9.36	22.42	1.22
Handling	852.00	21.30	51.02	2.77
Total	**1669.9**	**41.75**	**100**	**5.43**

[1]Based on $0.13/kWh

Table 2: Average energy use and cost per bale (Gin #2)

Gin Process	Input power (kW)	Energy per bale		Cost ($) per bale
		kWh	Percent of total	
Cleaning	327.82	6.43	15.70	0.84
Ginning	439.91	8.63	21.07	1.12
Packaging	345.76	6.78	16.56	0.88
Handling	974.75	19.11	46.67	2.48
Total	**2088.24**	**40.95**	**100.00**	**5.32**

CONCLUSION This paper has evaluated the energy usage and cost contribution to cotton processing inside the gin in Australia. The evaluation of energy usage has been divided into two levels: (1) basic level – reviewing the energy usage and energy profile at the whole gin level (2) advanced level – finding the performance of individual motors and the energy usage breakdowns in each sub-process.

Overall, it has been found that the electricity usage (kWh) ranged between 44-66 kWh per bale, while electricity cost per bale ($/bale) varied between $5.12~11.94 /bale. Electricity and gas usage respectively comprises 61% and 39% of total energy use (GJ/bale). In terms of cost, electricity and gas costs respectively constitute 77% and 23% of the total energy cost. For normal harvest seasons, the drying process uses 0.74-3.90 m^3/bale of natural gas or 2.27-5.61 litres/bale of LPG gas. The cost of gas in producing one bale ranged between 0.98-3.39 $/bale.

In advanced level, it has been found that the electricity usage at both gins increased as production rates of bales increased. Changes in trash content in the module, degree of moisture and lint quality produced did not have significant influence on electricity usage. The cotton variety was shown to affect the energy usage. Overall, cotton handling was the largest energy user and took up of nearly 50% of power use in both gins. Packaging and handling together use some 70% of total power required.

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