ENERGY MONITORING IN GINS- 2011

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Abstract

Energy costs are the second largest source of variable costs for gins, accounting for 27% of variable costs. Energy use has typically not been a major consideration in gin design and previous studies of energy use have utilized instantaneous readings or aggregated season-long values. Electricity use was monitored throughout the season for several gins across the cotton belt in 2010 and 2011, while fuel consumption was measured at two gins during the 2011 season. Motor loads were recorded for gin stands, fans, cleaning machinery, module feeders, and bale presses. Power consumption and power factor were recorded at motor control center disconnects. Temperatures and air flow rates in drying systems were measured to estimate fuel use. In 2010, the monitored gins averaged 35.8 kWh bale^{-1}, slightly less than the annual average values reported in past surveys. The breakeven idling time varied from 7.6 to 16.6 min. Gins monitored in 2011, used slightly less electricity than in 2010, likely due to plant modifications. Differences in electricity use between monitored gins were due to differences in layout and installed equipment. Average LPG consumption by the first stage drying system was 1.54 L bale^{-1} (0.41 gal bale^{-1}). Only one gin operated the burner for the second stage drying system, using 0.35 L bale^{-1} (0.09 gal bale^{-1}). Processing rate was the primary factor affecting electricity use per bale at a specific gin and also affected dryer fuel use. For maximum energy efficiency, cotton ginners should operate at full capacity as much as possible and avoid idling equipment during significant downtime.

Introduction

Energy costs- electricity and dryer fuel- account for 27% of a cotton gin's variable costs and are the second largest component of variable costs, after seasonal labor (Valco et al., 2009). A significant opportunity exists to improve gin profitability by reducing energy use. Since 2000, the average nominal electricity costs for US industrial consumers have increased 46%, propane costs 90%, and natural gas prices 21% (USDOE–EIA, 2011). Propane and natural gas costs have been quite volatile recently, with a peak price in 2008, more than twice the cost in 2002. Furthermore, energy costs are likely to increase due to future scarcity of energy sources and increased demand for energy. Higher energy costs emphasize the importance of increased energy efficiency at gins and increase the economic benefit of implementing conservation measures.

Objectives

The goal of this research was to gain a greater understanding of electricity and fuel use in cotton gins. Greater knowledge of energy use patterns should result in improved management strategies and new technologies that improve energy efficiency. This research project was started during the 2010 ginning season. The objectives of this research for the 2011 ginning season were:

- Monitor individual motor loads and total gin electricity consumption, for comparison with 2010 data
- Measure air flow and dryer temperatures to estimate fuel use
- Identify factors significantly affecting electricity and fuel use
- Quantify potential energy savings from implementing improved management strategies

Literature Review

Numerous studies over the past 50 years have found that per bale electrical energy requirements have consistently been near 50 kWh bale^{-1}, despite significant increases in processing rate and connected power (Holder and McCaskill, 1963; Wilmot and Alberson, 1964; Wilmot and Watson, 1966; Anthony, 1983; Funk and Hardin, 2011; Ismail et al., 2011). Several of these studies have demonstrated that the least efficient gins use 2.5-3 times more electricity per bale than the most efficient gins (Holder and McCaskill, 1963; personal communication, T.D. Valco, USDA–ARS). The majority of electricity consumed by gins is used for materials handling, primarily fans (65% – Wilmot and Watson, 1966; 60% – Anthony, 1983; 59% – Funk and Hardin, 2011). A more complete review of research on electricity use in cotton gins can be found in Hardin and Funk (2011).

Preliminary data from two of the gins monitored in 2010 has been presented (Hardin and Funk, 2011). The gins were more efficient, using 31.6 kWh bale^{-1} and 39.4 kWh bale^{-1}, than the studies cited above, likely because these gins were newer and larger than the average gin. The processing rate was found to be the primary factor affecting electricity use per bale. This result was due to the gins using approximately 70% of the maximum power when idling.

Fuel use at gins has also been investigated by several researchers (Table 1). Fuel use can vary widely between gins and seasons as different weather conditions affect the moisture content of the incoming seed cotton. However, fuel use has decreased over time. Control systems and burner designs have improved significantly, resulting in more efficient drying systems. Management strategies have likely changed, since the importance of avoiding excessive drying in maintaining fiber quality has been emphasized by the cotton industry.

Table 1. Previous surveys of fuel use in gins.

Year	Natural Gas		Propane (LPG)		Location	Source
	m^3 bale^{-1} (ft^3 bale^{-1})	Gins	L bale^{-1} (gal bale^{-1})	Gins		
1960	10.78 (380.8)	28	16.7 (4.4)	20	AR, MO	Holder and McCaskill, 1963
1979	8.83 (312)	122	15.5 (4.1)	96	Mid-South	Griffin, 1980
1987	7.02 (247.8)	124	8.8 (2.3)	93	Mid-South	Anthony, 1988
2007-8	2.32 (81.9)	2	4.0 (1.1)	4	Australia	Ismail et al., 2011

Cost surveys performed by the USDA and the ginners' associations have demonstrated that energy costs are a significant component of a gin's total variable costs (Table 2). Although these surveys indicated a slight decrease in electricity use per bale and fuel use per bale has been declining (Table 1), increasing energy prices resulted in a 29% increase in the nominal cost of energy at gins from 1997 to 2007.

Table 2. Energy costs for US gins.

Year	Electricity Cost ($ bale^{-1})	% Variable Costs	Fuel Cost ($ bale^{-1})	% Variable Costs	Source
1994	3.55	17.5	1.03	5.1	Mayfield et al., 1996
1997	3.40	16.9	1.03	5.1	Mayfield et al., 1999
2001	3.79	19.3	1.26	6.4	Valco et al., 2003
2004	3.56	17.6	1.96	9.7	Valco et al., 2006
2007	3.89	18.0	1.84	8.5	Valco et al., 2009

Significant potential exists for energy efficiency improvements in cotton gins, as electricity use per bale has remained nearly constant for many years and large differences in electricity use exist between gins. While fuel use per bale has declined, energy use has not been a major consideration in gin design. Previous research on gin energy use has relied on one-time measurements of energy parameters (i.e. motor current) or average values acquired from utility bills or periodic meter readings. Furthermore, recent data on fuel use is quite limited, since the cost surveys do not report a quantity used and fuel prices vary widely. Energy use needs to be monitored throughout the season to identify efficient management practices and opportunities for developing new technologies to reduce energy use.

Materials and Methods

Energy Monitoring System

Electrical energy monitoring systems were installed in four saw-type gins during the 2010 ginning season (Table 3). The electrical energy monitoring system, as well as additional instrumentation to estimate fuel use, was installed in gins A and C during the 2011 ginning season. The number of seed cotton cleaners refers to a single line of equipment and includes cylinder-type cleaners, stick machines, and additional extractor-feeders (beyond the extractor-feeder immediately preceding the gin stand). Only gin D had split-stream seed cotton cleaning equipment, following a common first-stage dryer. Gin A had a single lint cleaner behind one gin stand and two lint cleaners behind the other stand, while the other gins had tandem lint cleaning.

Table 3. Monitored gins.

Gin	Region	Primary Harvesting Method	Seed Cotton Cleaners	Gin Stands
A	Mid-South	Picker	3 (2010), 4 (2011)	2
B	Southwest	Stripper	6	3
C	Southeast	Picker	4	2
D	West	Picker	5	3

Motor loads were monitored for motors larger than 11 kW (15 hp) at gins A, B, and C. Power and power factor were also monitored at each motor control center at gins A, B, and C. At gin D, all motor loads were monitored. A voltage measurement taken during operation and the average power factor from the other gins was used to estimate power demand at gin D from motor currents. A more complete description of the electrical energy monitoring system can be found in Hardin and Funk (2011).

Fuel use was estimated based on heat transfer to the conveying air. This method required monitoring of ambient temperature and humidity, the heated air temperature, and the air flow through the burner. A Dwyer RHP-2S11 temperature and humidity transmitter (Michigan City, IN) was installed near the burner inlet to measure ambient parameters. Air velocity was determined by installing s-type pitot tubes (Dwyer 160S-18) in the heated air lines prior to the seed cotton mixpoint and measuring the velocity pressures with a Dwyer 616 pressure transmitter. A minimum of 8.5 duct diameters in length of straight duct were located upstream of the pitot tubes to improve the accuracy of velocity measurements. At both gins, the first stage air stream was split above the burner, requiring two velocity measurements to determine air flow for the first stage drying system.

All temperature measurements in the ducts were made using type J thermocouple probes (Omega NB1-ICIN-18U-12, Stamford, CT). Temperatures were measured immediately after the burner to determine the maximum air temperature, before significant heat loss to the gin environment. Because the pitot tubes were located a significant distance from the burners, additional thermocouple probes were installed approximately two duct diameters downstream from the pitot tubes and used to determine the air density at the pitot tube.

Analysis

The current and power data was analyzed to provide summary data for each gin and identify factors that significantly affected energy use. Total power demand was calculated for each record in the data. Total power use was divided among major gin functions- seed cotton cleaning, ginning, lint cleaning, bale packaging, and materials handling. A local maximum in the bale press pump motor current data indicated that a bale had been pressed. The total and component power used for each bale was calculated by integrating the instantaneous power demand over the length of time required to process the bale. All bales were used to calculate the average electricity use; consequently, the effect of gin downtime was included in this calculation of electricity use.

Periods when the gin was idling - all motors on and no cotton ginned on any stand - were identified. Total and component power demand and power factor were calculated while the gin was idling. The operating efficiency of each gin stand was also determined. Gin stand operating efficiency is the percentage of time the gin stand motor is on that is spent ginning cotton, as opposed to running idle.

The median electrical energy used to start the gin ($E_{starting}$) and the time required ($t_{starting}$) were calculated for each gin. Median values were used because the data was significantly skewed. Average costs for seasonal labor ($C_{seasonal\ labor}$ = \$162 hr^{-1}) and electricity ($C_{electricity}$ = \$0.093 kWh^{-1}) were obtained from surveys (unpublished data, T.D. Valco, USDA-ARS). These variables and the power demand at idle (P_{idle}) were used to estimate a breakeven idling time ($t_{breakeven}$) according to the following equation:

$$E_{starting} * C_{energy} + t_{starting} * C_{seasonal\ labor} = P_{idle} * t_{breakeven} * C_{electricity} \quad (1)$$

The breakeven idling time is the maximum time that gin motors should be left on while no cotton is being ginned. This analysis considered the electricity costs of starting and idling the gin, as well as the additional labor cost due to the extra time needed to restart the gin. Stopping the gin was assumed to require much less time than restarting, and was not considered in the analysis. Dryer fuel savings were also not considered, since fuel use varies with environmental conditions, and some control systems will turn down or shut off burners if the flow of cotton into the gin is stopped.

Models were developed to predict the power required and electricity used to produce a bale. The model was based on the hypothesis that the gin used a specific amount of power when idling, and the additional power required increases linearly with the processing rate. Preliminary data indicated that the power required reached a plateau near the maximum ginning rate, likely because the processing rate calculated from the bale press cycle times varied from the actual ginning rates. For example, actions of the press operator could result in one bale being formed 5 s faster than a subsequent bale, even though the processing rate through other machinery remained unchanged. Due to this plateau, a piecewise model was used with the initial linear region, a transition region to create a smooth function, and the plateau. Additional terms were added to include the effects of gin temperature and the stages of lint cleaning used on power and energy. Nonlinear regression (*PROC NLIN*, SAS 9.2, SAS Institute, Inc., Cary, NC) was used to fit this model to the average total and component power and power factor for each gin.

Management at gin C provided cultivar information, USDA–AMS classing data, and bale weights for the monitored bales. An analysis of variance (*PROC MIXED*) was performed on the processing rate, average power, and electrical energy use per bale. The cultivar and number of stages of lint cleaning were independent variables in the statistical analyses, and bale weights and ambient temperatures were covariates. In the model for power demand, processing rate was also used as a covariate, to account for the lower power required when ginning at less than full capacity. For each combination of cultivar and the number of stages of lint cleaning used, correlations (*PROC CORR*) between classing data and power and energy variables were examined to identify significant relationships.

Fuel use for the first and second stage seed cotton dryers was calculated for each record in the data set. First, vapor pressure and the humidity ratio were calculated from the temperature and relative humidity. Equations given in the ASABE (2010) standard on psychrometric data were used to determine these parameters. The barometric pressure, vapor pressure and the temperature at the pitot tube were used to determine the density of air, according to the ideal gas law.

The mass flow rate of the actual moist air was calculated from the measured velocity pressure, calculated density, and duct diameter. The mass flow rate of the dry air, for use in calculating fuel use was then determined using the humidity ratio. Fuel use was then calculated using the following equation (all listed values are from Henderson et al., 1997):

$$m_{fuel} = \frac{m_a\left(c_{pa}(t_2 - t_1) + H * c_{pv}(t_2 - t_1)\right)}{\eta\left(L - h_{g,0} * W - c_{pv} * t_2 * W\right)} \tag{2}$$

where:

m_{fuel} = mass flow rate of fuel, $kg_{propane}\ s^{-1}$ ($lb_{propane}\ s^{-1}$)
m_a = mass flow rate of dry air, $kg_{dry\ air}\ s^{-1}$ ($lb_{dry\ air}\ s^{-1}$)
c_{pa} = specific heat of air = 1.007 kJ $kg_{dry\ air}^{-1}\ K^{-1}$ (0.2405 Btu $lb^{-1}\ °F^{-1}$)
t_2 = temperature after burner, °C (°F)
t_1 = ambient temperature, °C (°F)
H = ambient humidity ratio, $kg_{H2O}\ kg_{dry\ air}^{-1}$ ($lb_{H2O}\ lb_{dry\ air}^{-1}$)
c_{pv} = specific heat of water vapor = 1.876 kJ $kg_{H2O}^{-1}\ K^{-1}$ (0.4481 Btu $lb^{-1}\ °F^{-1}$)
η = combustion efficiency, assumed to be 95%
L = heat of combustion of fuel, propane = 50,150 kJ $kg_{propane}^{-1}$ (21,560 Btu $lb_{propane}^{-1}$)
$h_{g,0}$ = heat of vaporization of water = 2503 kJ kg_{H2O}^{-1} (1076 Btu lb_{H2O}^{-1})
W = mass of water released per mass of propane burned = 1.634 $kg_{H2O}\ kg_{propane}^{-1}$ (1.634 $lb_{H2O}\ lb_{propane}^{-1}$)

The moisture control section of the Cotton Ginners Handbook (Hughs et al., 1994) provides a similar, but simpler method. The denominator of the equation is approximately the lower heating value of the fuel. Heating the moisture in the ambient air only requires a relatively small quantity of fuel and is ignored in the Cotton Ginners Handbook method. Fuel use per bale was determined by integrating this fuel use over the length of time required to produce the bale. A LPG density of 508 kg m^{-3} (4.24 lb gal^{-1}, Henderson et al., 1997) was used to calculate the volume of fuel used per bale. Correlations between fuel use, processing rate, power demand, and electricity were examined.

Results and Discussion

2010

Electricity use and power factor are shown in Table 4. The average total electricity use per bale was slightly lower than recently reported measured and surveyed values (40.1 kWh $bale^{-1}$, Funk and Hardin, 2011; 42.4 kWh $bale^{-1}$, Valco et al., 2009). The monitored gins had higher processing rates than the survey average, and consequently, were likely more efficient. Electricity use, both total and in all categories, varied significantly between gins. Examining the sources of this variation indicated possible strategies to reduce gin energy use. Gin A used the least energy for seed cotton and lint cleaning. This gin had the fewest cleaning machines installed and bypassed both the stick machine and second stage lint cleaner during the monitoring period. Using only the minimum cleaning necessary to achieve the desired leaf grades will reduce energy use. The electricity used for ginning was similar between gins, except for gin B, which had excess installed ginning capacity. Material handling varied greatly according to the layout of the plant. By using conveyors for trash handling instead of fans, gin C reduced material handling energy requirements significantly. Conversely, gin D had additional fans for an extra stage of drying, and used nearly twice the electricity per bale as gin C.

The measured power factor indicated that some motors in the gins were oversized, since power factor is near 0.85 for fully loaded motors of the sizes typically found at cotton gins. Some utilities may charge a penalty when power factor is in the range measured at these cotton gins.

Table 4. Electricity use and power factor- 2010.

Gin	# Bales	Electricity Use (kWh $bale^{-1}$)						Power Factor
		Seed Cotton Cleaning	Ginning	Lint Cleaning	Bale Packaging	Material Handling	Total	
A	16774	1.3	5.5	1.2	5.2	18.3	31.5	0.753
B	26899	4.0	8.6	2.5	4.6	20.8	40.5	0.789
C	5968	2.2	6.2	2.4	2.5	14.4	27.7	0.830
D	25626	4.0	5.3	3.6	2.9	27.8	43.5	–
Total/Mean	**75262**	**2.9**	**6.4**	**2.4**	**4.4**	**20.3**	**35.8**	**0.791**

The average power required at each gin, while running at maximum capacity and idling, is illustrated in Figure 1. The total power is displayed at the top of each column, and the relative contribution of each gin function is indicated by the proportion of the column with the corresponding color. At the monitored gins, idling required 71% of the power used at maximum capacity. Consequently, idling can significantly increase per bale energy requirements, since large amounts of electricity are used, with no lint produced. Material handling motors used 88% of their maximum power demand at idle, and accounted for 68% of the total power requirements at idle. Centrifugal fans require more power when unloaded, because air flow increases. Eliminating fans will reduce the power demand at idle, as demonstrated by gin C, which used the lowest proportion, 64%, of maximum power at idle. Alternatively, control systems that throttle fan output or reduce fan speed when unloaded will save energy.

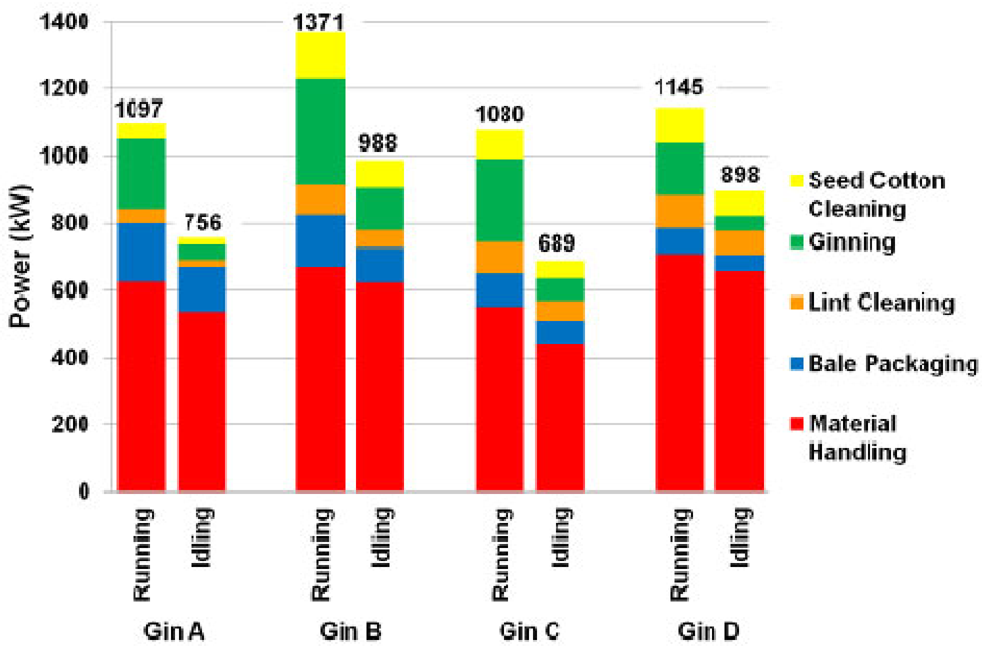

Figure 1. Power used while ginning at maximum capacity and at idle.

Gin stand operating efficiency, the proportion of time each gin stand motor was on that was actually spent ginning cotton, is shown in Table 5. Gin stands were numbered in the direction of movement by the distributor conveyor, so that the first stand was farthest from the overflow. Previous research indicated that the gin operating efficiency was 84% (Watson and Holder, 1964). Significant improvements in gin technology have likely contributed to this increase. Replacing trailers with modules and improved feed controls have resulted in more consistent feeding of cotton into gin plants. However, at all gins, the least efficient stand was the final stand before the overflow. Furthermore, the third stand at gin D was often ginning at less than full capacity. To maximize processing rate and minimize energy use, all gin stands need to be kept fully loaded.

Table 5. Gin stand operating efficiency.

Gin	Stand # 1	Stand # 2	Stand # 3	Mean
A	95.00%	93.25%	–	94.13%
B	90.26%	90.86%	88.88%	90.00%
C	96.15%	94.68%	–	95.42%
D	91.54%	91.66%	77.95%	87.05%

A common concern for gin managers is determining if the gin should be shut down or left idling for minor maintenance or repair. The median energy used and times required to start the gins, along with the calculated breakeven idling time are shown in Table 6. For all gins, the average power required during startup is less than the power used at idle; consequently, if only electricity use was considered, the breakeven idling time would be less than the startup time. Despite greater power required over several seconds when starting a motor, the average power for the entire gin is less during startup because motors are turned on sequentially. However, the time required to start the gin has a significant impact on cost.

Table 6. Energy and time required to start gins and estimated breakeven idling time.

Gin	Starting Energy (kWh)	Startup Time (s)	Breakeven Idling Time (s)
A	23.6	185	553
B	19.6	197.5	455
C	41.2	260	891
D	68.7	370	993
Mean	**38.3**	**253.1**	**723.0**

While 12 min can be used as an initial estimate, gin managers should determine the appropriate values to use in equation 1 for their gin. Costs, particularly for labor, vary widely between gins. Automating the gin's startup and shutdown sequence may reduce the time and cost. Therefore, the resulting breakeven idling time would be shorter.

Significant differences existed between cultivars in electricity use per bale, processing rate, and average power demand at gin C (Table 7). Although there were differences in power demand between cultivars, these differences were not practically significant. This result was expected because the gin stand feed controls are designed to maintain constant amperage on the gin stand motor. The variation in electricity use was primarily due to differences in processing rate between cultivars. No significant correlation was observed between classing data and electricity use or processing rate.

Table 7. Electricity use, processing rate, and power demand of different cultivars at gin C.

Cultivar	# Bales	Energy (kWh Bale^{-1})	Processing Rate (Bales hr^{-1})	Power (kW)
FM 1740 B2R	392	25.5a	42.1a	1053a
DG 2570 B2RF	1153	26.0b	41.3b	1056a
PHY 375 WR	1895	26.2c	41.1c	1061b
ST 4498 B2R	321	26.9d	39.9d	1064b

Means in a column followed by the same letter are not significantly different at the 5% probability level.

Average power demand and electricity use per bale were predicted based on processing rate, gin temperature, and stages of lint cleaning used (Figure 2). The model for power demand had R^2 values of 0.698, 0.721, 0.557, and 0.301 for gins A-D, respectively. Measurement error was higher at gin D because the data sampling interval was longer and power factor had to be estimated. Furthermore, there was less variation due to processing rate, since the idling power was a larger proportion of the power demand at maximum capacity. At all gins, nearly all variation in electricity use per bale was explained by differences in processing rate.

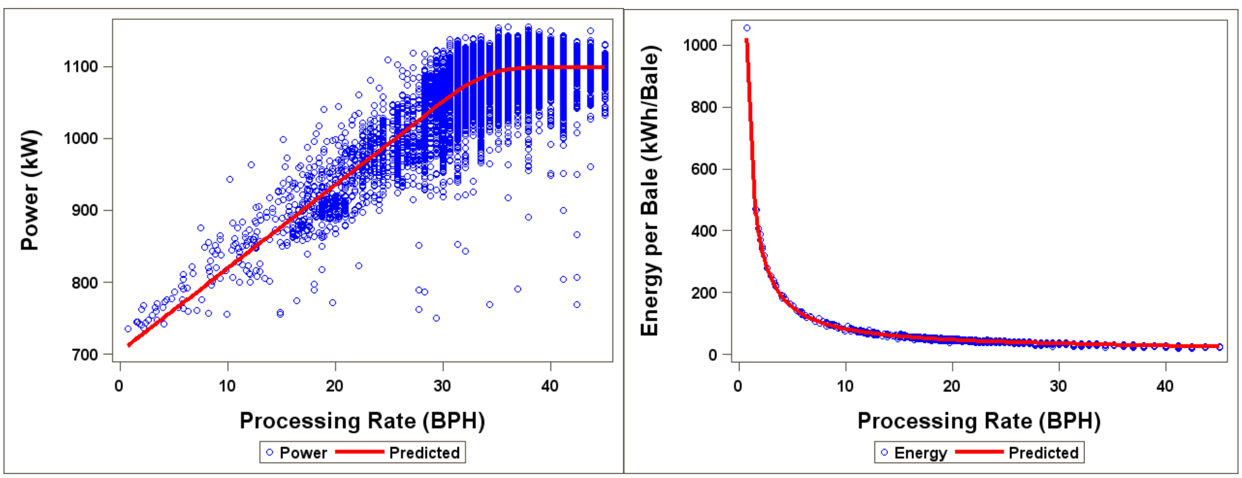

Figure 2. Effect of processing rate on average power demand and electricity use per bale at gin A, 2010. Model parameters: idling power = 717 kW, maximum power = 1111 kW, end of initial linear region = 30.34 bales hr^{-1}, start of plateau = 37.78 bales hr^{-1}

2011

Electricity and fuel use are shown in Table 8. Both gins showed slight declines in electricity use from 2010. Gin A modified their trash handling system, reducing the energy needed for material handling. Gin C increased bale press capacity, which resulted in a 3 bales hr^{-1} increase in processing rate, and decreased electricity use per bale. Fuel use per bale for both gins was significantly lower than reported in past research. However, both gins experienced relatively dry weather during monitoring. Furthermore, fuel used by the humid air restoration systems has not been determined. This component likely accounts for a significant portion of fuel use in dry weather.

Table 8. Electricity and fuel use- 2011.

Gin	# Bales	Electricity (kWh bale^{-1})	Dryer Fuel- LPG L bale^{-1} (gal bale^{-1})	
			1st Stage	2nd Stage
A	15131	29.4	1.44 (0.38)	Not used
C	19670	25.9	1.64 (0.43)	0.35 (0.09)

The model of power demand at gin A for 2011, is shown in Figure 3. The model explained 79% of the variation at gin A and 66% at gin B. The 2010 and 2011 models are similar for both gins.

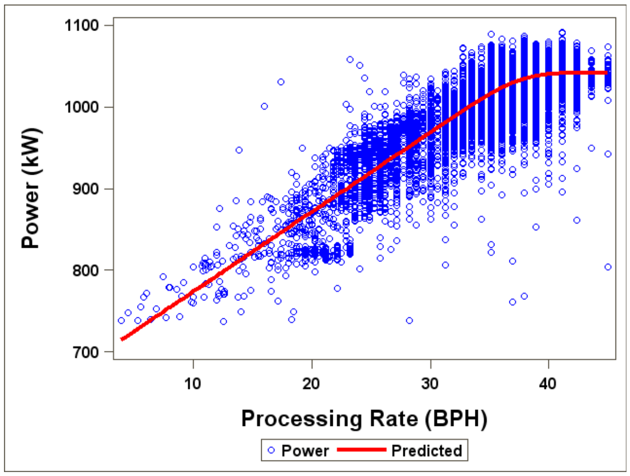

Figure 3. Power and processing rate at gin A, 2011. Model parameters: idling power = 717 kW, maximum power = 1082 kW, end of initial linear region = 33.70 bales hr^{-1}, start of plateau = 41.41 bales hr^{-1}

Fuel use was much more variable than electricity use, since fuel consumption was adjusted based on the moisture content of the incoming seed cotton and environmental conditions (Figure 4). Similar patterns were observed in the fuel consumption of the other monitored drying systems, with higher fuel use observed at lower processing rates. At gin A, the correlation between the first stage dryer fuel use and processing rate was -0.46. The correlation between the processing rate at gin C and fuel use was also significant for both the first stage dryer (-0.24) and the second stage dryer (-0.20).

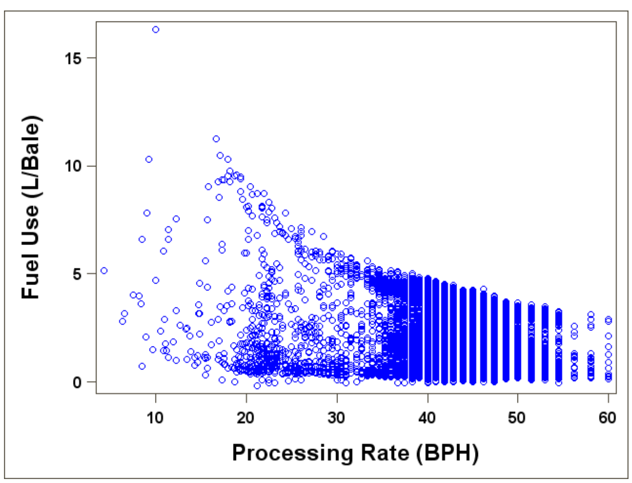

Figure 4. First stage dryer fuel use and processing rate at gin C, 2011.

Higher moisture content seed cotton will decrease the ginning rate and increase fuel consumption. However, other factors that decrease processing rate may also increase fuel consumption. As the processing rate decreases, the air flow rate through the conveying fans actually increases due to lower resistance. Due to the lower processing rate and higher air flow rate, significantly more conveying air would be used per bale at low processing rates. Because a greater volume of air is used, more heat would be lost in the exhaust air.

Conclusions

The monitored gins, with an average electricity use of 35.8 kWh bale^{-1} in 2010, were more efficient than gins examined in past surveys. A wide variation in electricity use, from 27.7 to 43.5 kWh bale^{-1}, was observed between gins, primarily due to different equipment and layouts. Material handling accounted for 56% of the electrical energy used in 2010. Replacing fans with mechanical conveying systems can result in significant energy savings. Bypassing cleaning equipment that is not needed to achieve desired leaf grades can also reduce electricity use.

Gins required 71% of the maximum power demand when idle; therefore, gin managers should avoid downtime. If downtime will exceed a certain length, the breakeven idling time, the gin should be shutdown. The average breakeven idling time was calculated to be 12 min; however, costs will vary by gin, and managers should only use this figure as a guideline. The average gin stand operating efficiency was 92%, but the last stand was the least efficient at all gins and often operated at less than full capacity. Cultivar had a significant effect on electricity use per bale due to differences in the processing rate of different cultivars.

The two gins that were monitored in 2011, used slightly less electrical energy per bale than in 2010, as a result of plant modifications. LPG use in the first stage drying systems was 1.44 (0.38) and 1.64 L bale^{-1} (0.43 gal bale^{-1}). Fuel consumption at the gin that added heat in the second stage drying system was 0.35 L bale^{-1} (0.09 gal bale^{-1}). Both fuel and electricity use per bale decreased with increasing processing rate. Operating all equipment at maximum capacity as much as possible is critical in reducing gin energy use. To maximize processing rate and minimize fuel use, seed cotton must be properly stored so that cotton enters the gin at a suitable moisture content.

Future Work

The full analysis performed in 2010, will be repeated on the electrical data from the 2011 season to allow a more in-depth comparison of electricity use during the two seasons. Additional data was also collected to estimate fuel consumption by the humid air moisture restoration systems at the two gins in 2011. Heat losses from the drying systems to the gin environment will also be determined, since thermocouples were installed at multiple locations in the ducts. Data will also be analyzed to identify other factors affecting electricity and fuel use. Monitoring of gin energy use will be continued during the 2012 ginning season.

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Disclaimer

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