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SYSTEMS ENGINEERING OF SEED COTTON HANDLING AND GINNING IN TEXAS

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Abstract

The number of cotton gins in the U.S. is decreasing while the number of bales produced remains constant or is increasing slightly. Texas produces and processes approximately five million bales each year with approximately 280 cotton gins, while losing approximately 20 cotton gins per year. An analysis of the number of gins in the state suggests that the reduction is constant and linear with an $R^2 = 0.98$; indicating that by the year 2018, no gins will remain in business. It is likely that more cotton will be processed by existing gins, with associated longer gin seasons, longer transport distances, and larger module storage areas with associated insurance coverage problems. This paper details a systems engineering project to formulate a simulation model to evaluate the engineering and economic impacts of proposed changes in the traditional processes of harvesting, storing in modules, transporting modules to the gin, and ginning of seed cotton. The results of this work indicate that the minimum cost of ginning occurs at around 150% utilization.

Introduction

Cotton production in Texas has been relatively constant for 20 years at three to five million bales of cotton per year. Simpson and Parnell (2004) reported the number of gin facilities in Texas have decreased from 1,400 gins in 1960, to 280 gins in 2003 (Figure 1). Similar trends occurred across the U.S. in most cotton producing states. At some point, this trend of gin closures and consolidations must cease in order for the ginning industry to be able to process three to five million bales of cotton annually. Texas cotton production and ginning in 2004/05 was extraordinary in that over 7.5 million bales were ginned and it is anticipated that over 7.7 million bales will be ginned this year (2005/06). A number of factors played a role in the large amount of Texas cotton produced this past year including irrigation technology advances, timely rainfall, and optimal late growing season temperatures. The high production levels have resulted in longer gin seasons. Some gins on the high plains ginned cotton 24 hours per day from late October until Easter with only two days off.

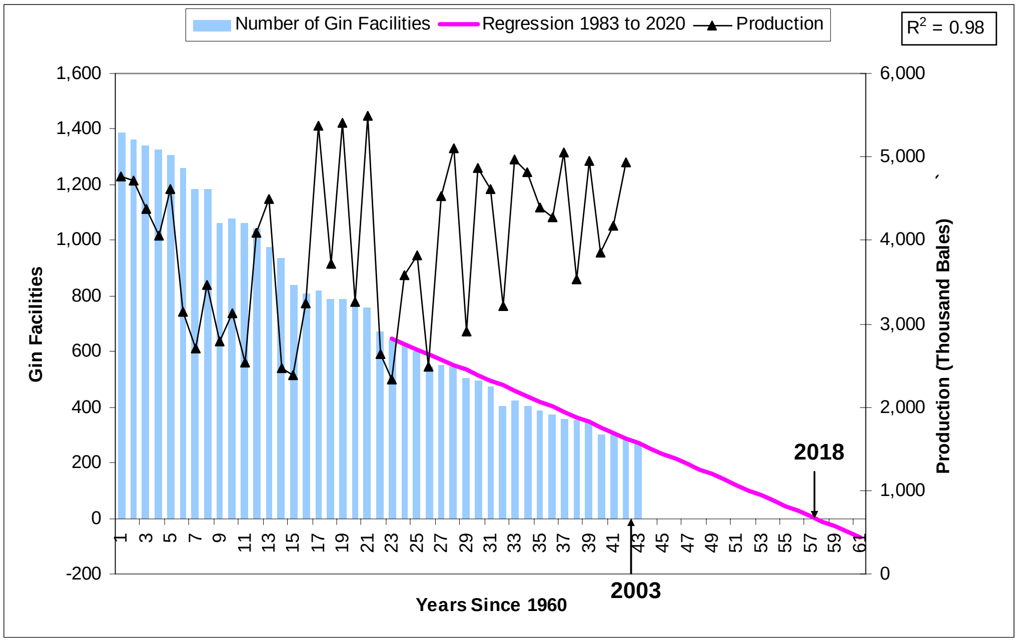

Figure 1: Number of operating gins and cotton production in bales from 1961 through 2003 in Texas (TCGA, 2003).

The Department of Biological and Agricultural Engineering (BAEN) at Texas A&M University is conducting a systems engineering study of seed cotton handling, storage, and ginning. Seed cotton transported from the turn-row to the gin yard is an essential element of seed cotton handling. It is likely to become a larger component of the ginning cost as a result of fewer gin facilities. Producers that once harvested five miles from the nearest gin facility now may be fifty miles or more from the closest operating gin. Gin operators typically pay for the cost of moving cotton to the gin yard unless the distance is beyond their normal service area. In the future, producers may have to pay part, or all, of this transportation cost. New and alternative transport systems may reduce costs while increasing productivity.

Ginning 7 to 7.5 million bales of cotton each year with gin facilities decreasing in number, logically dictates that the annual ginning volume per facility will increase. The normal practice of cotton ginning is to use a first-come-first-serve queuing discipline and gin the cotton as quickly as possible. The practice has evolved from years of having cotton gins near the site where cotton was grown along with relatively small annual gin volumes. Cotton gin processing rates have increased from less than 10 bales per hour (bph) to 60 bph with the possibility of going to 90 bph. Most ginners strive to process producers’ cotton as quickly as possible so that their customers can receive payment. As a result, it is not uncommon for ginners to operate 24 hours per day, seven days per week until they complete ginning their customer’s cotton.

One of the goals of this research effort is to develop a model of ginning costs (fixed and variable) using data from surveys and cooperating Texas gins. Parnell et al. (2005a) reported progress on this goal using data from a survey performed by Valco (2004). Parnell et al. (2005b) also reported progress utilizing three to five years of historical data provided by cooperating Texas gins. This paper reports progress made in the development of a model describing the relationship of ginning costs as a function of percent utilization using three to six years of new and more detailed historical data provided by managers of Texas gins.

The structure of the seed cotton handling, storage, and ginning simulation model was based upon the following priorities and assumptions:

1. It is desirable to maintain the option of producing and ginning cotton at levels of five to seven million bales per year for Texas and 18 to 20 million bales per year nationally.
2. With increases in harvesting speed, it was assumed that producers would want to harvest their cotton crops as quickly as possible and place their cotton in modules or similar seed cotton systems. (Quality losses associated with weathering of cotton in bolls far exceed quality losses with seed cotton in modules.)

3. Affordable insurance would be available to protect the value of the seed cotton stored for either the producer or the ginner.
4. A mathematical model exists that would allow for accurate engineering and economic evaluations of proposed changes in the traditional seed cotton handling, storage, and ginning system.

The ginning rates for the newer gins have progressed to the point that a number of cotton gins can now process 60 bph or one 500-lb bale from the bale press every minute. One ginner has indicated a possible expansion to 90 bph; likely requiring two presses.

Goals and Objectives

The goal of this study is to develop a mathematical (systems) model that can be used by the ginning industry to provide answers to the following questions:

1. How many gins are needed in each production area?
2. Is there a more efficient work schedule for cotton ginning? (Compared to 24 hours per day, seven days per week)
3. Can we "farm out" a portion of the cotton dedicated to one gin that may be exceeding 200% utilization to another having a commitment of less than 100% utilization and provide a more efficient harvesting/ginning system?
4. Is there a process that can be used to partially pay producers for the cotton in modules that may not be ginned for four to six months after harvesting?
5. How far can gins travel to acquire modules for ginning before it is too costly? On what basis will this decision be made?
6. Can we develop an alternative for module mover trucks that will satisfy transportation limitations for axle loading?

Procedure

Three data sets have been used in this study. Data set #1 was used for the paper presented last year at the Beltwide (Parnell et al., 2005a). These data were the results of the survey performed by Dr. Tommy Valco with assistance from Kelley Green (Valco, 2004) that included cost data from a large number of cotton gins primarily in Texas. The focus of the cost data was on variable costs. Data set #2 was multiyear data from four gins and was the basis for a paper presented at the ASAE meeting in Tampa Florida last summer (Parnell et al., 2005b). The data included fixed and variable cost associated with operating gins described as follows:

- 60 bph gin processing stripper cotton (three years of data: 2002, 2003, and 2004);
- 30 bph gin processing stripper cotton (two years of data: 2002 and 2004);
- 25 bph gin processing picked cotton (five years of data: 2000, 2001, 2002, 2003, and 2004); and
- 25 bph roller gin processing picked Pima cotton (five years of data: 2000, 2001, 2002, 2003, and 2004).

Data set #3 included three to six years of variable and fixed cost for gins described as follows:

- 40 bph gin processing stripper cotton;
- 20 bph gin processing stripper cotton; and
- 60 bph gin processing picker cotton.

[Data set #3 was acquired relatively late this year and there was insufficient time to fully analyze these data for this paper. In addition, a more recent ginning survey data set similar to data set #1 has been obtained and will be incorporated into future reports (Valco, 2006).]

Variable costs include bagging and ties, repairs and maintenance, drying, electricity, and labor. Variable costs increase or decrease with the number of bales ginned. Fixed costs include depreciation, annual loan payment, and management. Fixed costs were assumed to be independent of the number of bales ginned and were estimated for all of the gins.

The concept of using percent utilization (%U) as an independent variable was first defined by Fuller et al. (1993) and was described by Parnell et al. (2005a; 2005b) as it pertains to this research effort. For modeling purposes, %U allowed for comparing economic and engineering data for cotton gins with different processing rates. %U is calculated using equation 1.

$$\%U = 0.8 \times GR \times 1000 \quad \text{(Eq. 1)}$$

Where GR= ginning rate (bph).

Results

Data from set #1 were divided into five categories: less than 10 bph, 10-15 bph, 15-25 bph, 25-35 bph, and greater than 35 bph. Tables 1 and 2 are typical of the results using data set #1. For the gins listed, the total cost per bale ranged from $178 at 18%U to $32 at 121%U. It was assumed in these analyses that the variable cost per bale (VCPB) versus %U was constant and that fixed cost per bale (FCPB) versus %U decreased from high values for low %U to a minimum value and subsequently increased. Total cost per bale (TCPB) would likely follow the same pattern as (FCPB). (Figures 2, 3, and 4.)

Table 1. Summary of results for 8 of the gins in the 10-15 bph category. The ginning rates and bales per season were given in the data set. The hours per season and %U were calculated.

Gin	Rated Ginning Rate (bph)	Bales per Season	Estimated Hours Per Season	Utilization (%)
1	10	1,412	177	18
2	12	14,471	1507	151
3	12	5,404	563	56
4	14	10,934	976	98
11	12	9,187	957	96
12	12	11,459	1194	119
13	11	6,436	731	73
14	12	3,095	322	32

Table 2. Summary of fixed and variable costs per bale for the gins shown in table 1.

Gin	Fixed Cost ($/bale)	Variable Cost ($/bale)	Total Cost ($/bale)	Utilization (%)
1	$156.93	$20.89	178	18
2	$20.44	$22.57	43	151
3	$49.29	$20.55	70	56
4	$28.91	$23.04	52	98
11	$30.33	$19.54	50	96
12	$24.96	$19.11	44	119
13	$39.44	$16.15	56	73
14	$83.64	$37.12	121	32

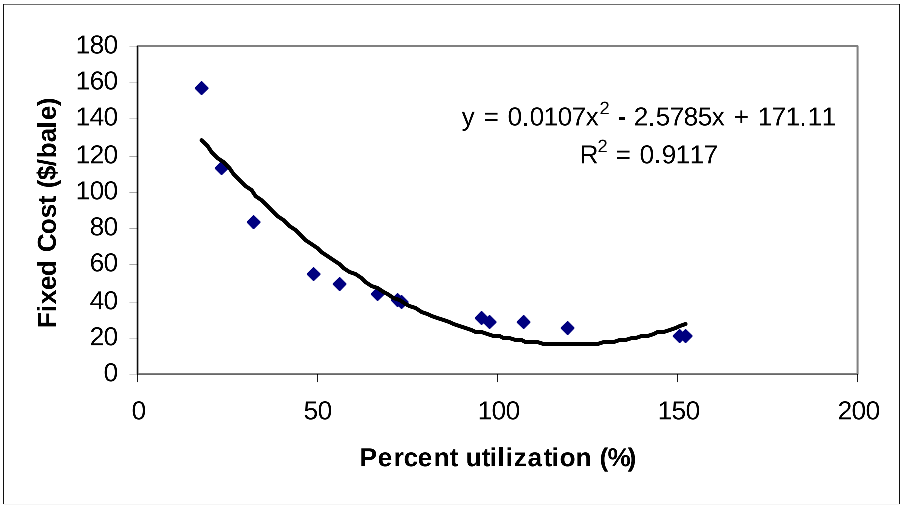

Figure 2. Fixed cost per bale versus percent utilization for all gins in the 10-15 bph category from the 2002 cotton gin survey.

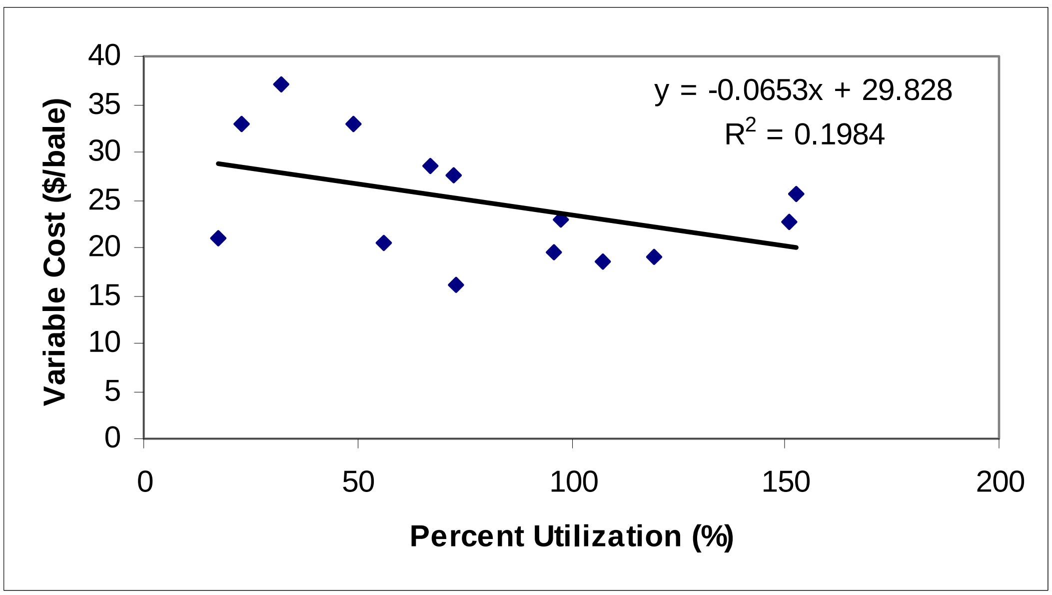

Figure 3. Variable cost per bale versus percent utilization for all gins in the 10-15 bph category from the 2002 cotton gin survey.

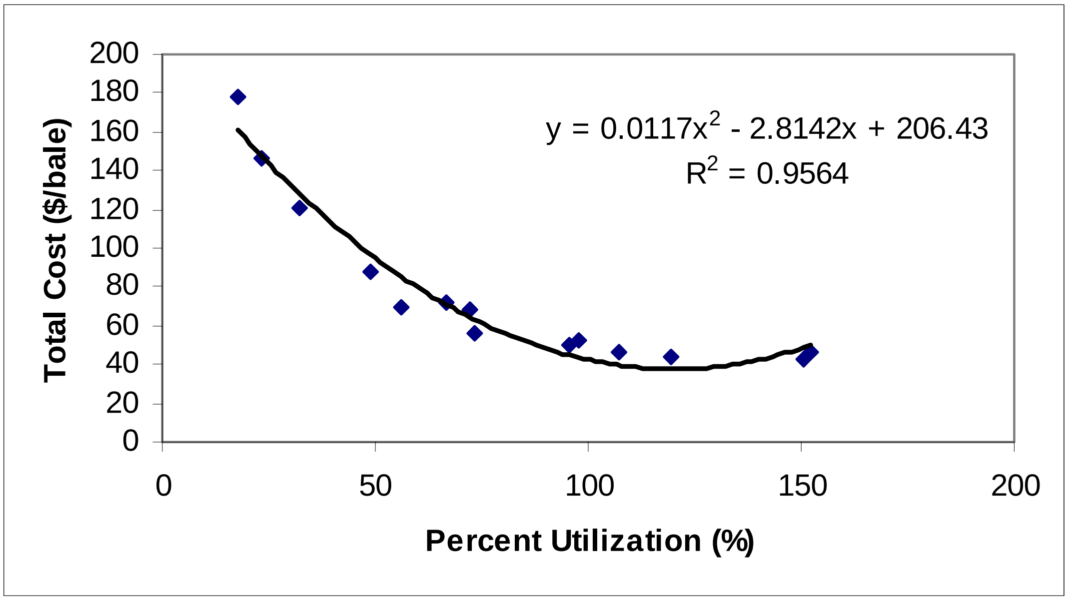

Figure 4. Total cost per bale versus percent utilization for all gins in the 10-15 bph category from the 2002 cotton gin survey.

As a result of these analyses, it was determined that the total cost of ginning was approximately $50 per bale at 100%U (using the combined dataset of the financial data for all gin sizes) and that a model could be used for cost of ginning (equation 2).

$$TCPB = VCPB + FCPB \qquad \text{(Eq. 2)}$$

Where TCPB = total cost per bale ($/bale),
VCPB = variable cost per bale ($/bale), and
FCPB = fixed cost per bale ($/bale).

Table 3 shows the results of regression analyses to fit a second order quadratic equation to the FCPB versus %U data for the different gin size categories. Equation 3 may be used to calculate the fixed cost per bale for any rated ginning capacity. Equation 3 was developed from a regression analysis performed on all of the available data.

Table 3. Results of fitting the fixed cost per bale (y) as a function of percent utilization (x) for each of the gin size categories to a second order quadratic equation: $y=ax^2+bx+c$. The coefficient of determination (R^2) is included for each rated ginning size range. The "All Gins Combined" row represents the regression results of combining the datasets from all of the gin sizes.

Rated Gin Size (bph)	Number of gins in survey	a	b	c	R^2
<10	11	0.0045	-1.32	108	0.94
10-15	14	0.0107	-2.58	171	0.91
15-25	21	0.0017	-0.677	81.6	0.95
25-35	14	0.0024	-0.861	91.3	0.91
>35	7	0.0014	-0.52	67.1	0.99
All Gins Combined		0.00414	-1.1916	103.8	0.94

$$FCPB = 0.00414 \times (\%U)^2 - 1.192 \times (\%U) + 104 \qquad \text{(Eq. 3)}$$

Table 4 shows the results of regression analyses to fit a linear equation to the VCPB versus %U data for the different size categories. Equation 4 may be used to calculate the variable cost per bale for any size gin. Equation 4 was developed from a linear regression analysis performed on all of the available data.

Table 4. Results of fitting the variable cost per bale (y) as a function of percent utilization (x) for each of the gin size categories to a linear equation: y=ax+b. Note that it is assumed that the variable cost per bale should be constant as a function of percent utilization. None of the R^2 values are significant at the 0.05 level of significance indicating that the variable cost of ginning was independent of percent utilization.

Gin size (bph)	Number of gins in survey	a	b	R^2
<10	11	-0.0056	25.8	6 E -06*
10-15	14	0.0653	29.8	0.1984*
15-25	21	0.0018	20.3	0.0004*
25-35	14	-0.0021	21	0.0008*
>35	7	-0.0359	20.9	0.038*
All Gins Combined		0.0047	23.56	0.0475*

***R^2 values not significant at the 0.05 level of significance.**

$$VCPB = 0.0047 \times (\%U) + 23.6 \qquad \text{(Eq. 4)}$$

Plots of FCPB and VCPB calculated from equations 3 and 4 and the resulting TCPB obtained by adding FCPB and VCPB are shown in figure 4. The TCPG curve indicates that the minimum cost of ginning cotton occurs near 150%U. More recent data including the 2004/2005 ginning seasons suggest that the minimum cost of ginning occurs closer to 200%U.

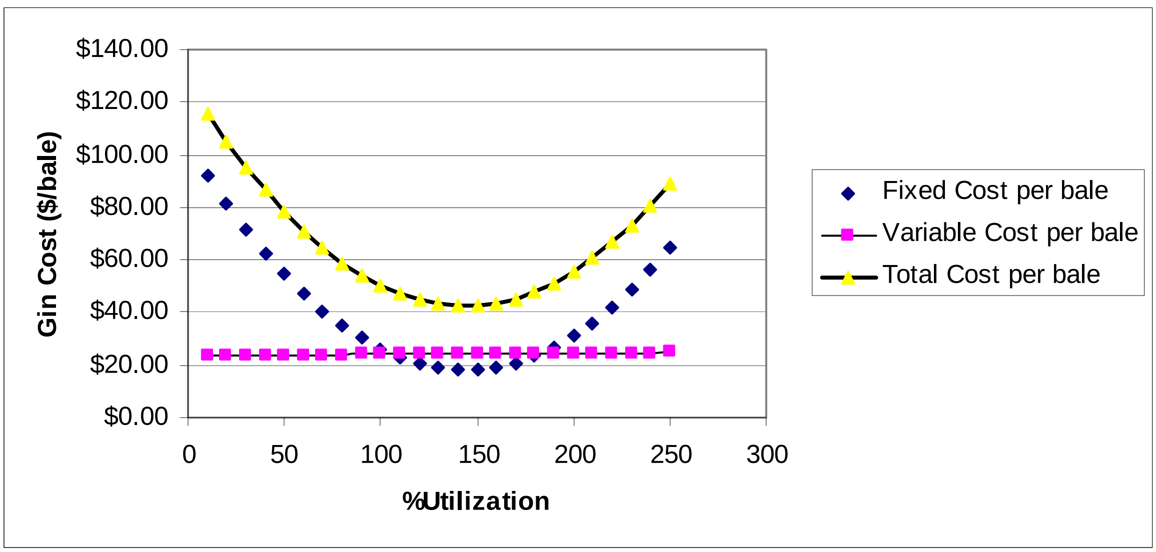

Figure 4. Fixed, variable and total cost per bale results using the equations obtained by averaging the coefficients of the curve fitting shown in tables 3 and 4.

Conclusions

Three datasets were used in the analysis presented here to determine the variable, fixed and total cost per bale of ginning seed cotton at several different size gins. Gins processing both stripper and picker harvested cotton were considered in the analysis. In addition, both saw and roller type gins were included in the analysis. The results of the work presented indicate that the variable cost per bale follows a linear trend with an almost zero slope over the range of percent utilization analyzed. This result indicates that the variable costs of ginning are independent of percent utilization. Fixed cost per bale was shown to follow a second order quadratic trend over the range of percent utilization analyzed. Combining the fixed and variable cost relationships yielded a relationship for the total cost of ginning as a function of percent utilization. The results indicate that the total cost of ginning is minimized at approximately 150% utilization.

Future Plans

We are in the process of using what we have learned working with data set #1 to analyze data sets #2 and #3 with the goal of determining the percent utilization for which the minimum cost of ginning occurs. Dr. Valco has recently shared the new 2005 cotton ginning survey results that will be included as data set #4. In addition, data that will include the 2005/2006 ginning season will be obtained from additional cooperators. A new method for calculating downtime using the electric power consumption in units of kilowatt-hours per bale has been developed and will be utilized in future analyses.

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