THE INFLUENCE OF SEED COAT NEPS IN YARN MANUFACTURING

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Abstract

The ability of the Uster AFIS to classify neps into fiber neps or seed coat neps will make it possible for the yarn spinner to remove seed coat fragments more effectively in the carding process. Replacing traditional card maintenance techniques with the AFIS Process Improvement Chart can substantially reduce repair and replacement costs in the carding department. Prior knowledge of the presence and amount of seed coat neps will allow optimization of process machinery for highest yarn quality.

Introduction

The textile industry is faced with the new and welcome challenge of having to adjust to its significant growing pains. With changes in world trade practices and a shift in consumer attitudes, production levels are challenged and old processes are quickly being rethought. Consumer tastes are changing and the number of middle class consumers is increasing in Asia, Eastern Europe and South America. These con-sumers purchase higher "status" textile products and demand greater selection and quality.

In keeping pace with industry demands, cotton ginning and textile machinery speeds have increased dramatically. Because of these increases, fibers are subjected to more stress. There is less tolerance for error in processing materials. An area of great concern is the presence of seed coat neps. These particles are generated when the fiber is separated from the seed during ginning. Most seed coats have a substantial amount of fibers attached which can make them difficult to remove during processing. Seed coats that remain in the sliver after cleaning and carding can cause yarn faults and breaks and generally reduce the quality of the final product. The objective of this study is to present information on the components in the carding process which affect the removal of seed coat neps and to discuss the actions necessary to achieve those results.

Background

The Advanced Fiber Information System (AFIS) was developed to measure traditional fiber neps (entanglements), oftentimes called mechanical neps. A recent breakthrough development has furthered the technology for classifying neps into two categories: fiber neps and seed coat neps. AFIS Nep Classification is the newest addition to the modular AFIS system providing a more detailed summary of nep type imperfections from ginned cotton through carded and combed sliver.

Seed Coat Nep Detection Method

As illustrated in Figure 1, the fiber individualizer separates the sample into three main components: lint, trash and dust. The lint channel contains fibers, short fibers, mechanical neps and seed coats with fibers attached. The trash channel contains trash, dust, some fiber fragments and very large seed coats with little or no attached fiber. The seed coats which remain with the fiber during opening are termed seed coat neps by the AFIS. These are masses that are most likely to remain with the good fiber during the textile opening, cleaning, carding and combing processes. Large seed coats, termed seed coat fragments, are collected in the trash port of the AFIS and are more easily removed from the fiber. The AFIS Nep Classification module counts and sizes seed coat neps. The classification module is able to identify the distinct electrical waveforms produced by fibers, fiber clumps, seed coat neps, etc. This improved nep module uses a digital signal processor (DSP) to classify all incoming waveforms and to calculate nep size. Figure 2A illustrates a typical nep waveform and the values extracted by the standard nep module. Figure 2B illustrates the same signal analyzed by the DSP system. The DSP system is capable of recording and analyzing all of the information contained in the nep signal, therefore providing better information about the sample characteristics. The classification software compares each sampled waveform to a standard waveform to determine which classification it most resembles. These standard waveforms are based on models of seed coat neps and mechanical neps travelling through the sensor and are verified on numerous simulations using manually introduced fiber neps and seed coat neps.

Seed Coat Neps Influence In Yarn Quality

In a recent trial conducted by Zellweger Uster, it has been determined that fiber neps as measured by the Uster AFIS, contain two types of neps: mechanical neps and seed coat neps. The latter have been determined to cause yarn faults in the range of +200% Imperfection (IPI) value as measured by the Uster evenness tester (UT3), for yarn counts of Ne 30 (20 tex), Ne 22 (27 tex) and Ne 16 (37 tex). In Figure 3, the correlation coefficient r2 between 200% imperfections and count per gram is shown for total neps, fiber neps only and seed coats only. The highest correlation is when only the seed coat neps are considered implying that, for this test, the majority of the +200% imperfections recorded by the UT3 were due to seed coat neps. This is especially true as the yarn count becomes finer (diameter decreases), since it becomes increasingly difficult for the seed coat neps to become hidden in the yarn structure. Figure 4 shows the nep and seed coat nep levels through typical mill processes. The removal efficiency of seed coat neps follows the same pattern that has been

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established in the past for total neps. That is, most seed coat nep removal is accomplished at the card with some additional removal at the comber. Figure 5 illustrates the effect of carding on the size distribution of seed coat neps. Here is plotted the ratio of seed coat neps in the sliver to seed coat neps in mat. From 500 mm to 2200 mm the card is removing about 70%. Toward the smaller size ranges, however, it appears that the ratio is increasing and at the smallest sizes, the number of seed coats may be increasing. This follows from the theory that the card will tend to break up larger seed coats into smaller ones and that the smaller seed coats are difficult (if not impossible) to remove.

The Influence Of Opening, Cleaning, And Carding On Seed Coat Neps

During a separate in-mill trial, the influence of carding on the removal of seed coat neps was investigated. Nine bales were taken from various growth areas, from saw and roller ginned cotton. Each bale was introduced into a modern blow room system producing 4.3 ktex card sliver. Various adjustments were made at the card such as: licker-in to main cylinder, main cylinder to flats and doffer, cylinder speed, and flat speed. In conclusion, it was found that the cylinder speed (card throughput), flat settings and flat speed were the three components which influenced the removal of seed coat neps the most. Trial details are listed below:

Nine bales of upland and pima type cottons were tested first on a Uster High Volume Instrument (HVI 900) in order to obtain a bale profile. (See Figure 6) These bales had ranges of micronaire from 2.7 to 4.9 and strength of 24. 4 to 32.8 grams/tex and length of 1.06" (27mm) to 1.13" (28.7mm).

Each bale was then carded at two carding speeds, 100 lbs/hr (45 kg) and at 120 lbs/hr (54.4 kg). Further, each bale was carded at two different flat speed settings of 5 and 9.75 inches per minute. Finally, each bale was carded at three different flat settings to the main cylinder of 0.008, 0.01 and 0.014 inches. Each setting produced 4.3 ktex sliver. The amount of seed coat neps and traditional fiber neps were investigated in sliver form (Figure 7).

The following graphs indicate the influence of the three card variables on the removal of seed coat neps and traditional neps. The three variables are card throughput (expressed in pounds or kilos per hour), flat speed and flat spacing to the main cylinder (Figures 8, 9, and 10).

Upon further evaluation, data revealed that seed coat nep removal efficiency varied from 44-86% for the nine bales as they were processed with each card setting (Figure 11). The process of opening and cleaning did not affect the removal of seed coat neps as effectively as carding.

Card Optimization of Seed Coat Nep Removal

From the processing conditions evaluated in the previous section, two conditions were chosen with the best and worst seed coat nep removal performance, as follows:

Process A:
Flat spacing 0.008" (.2 mm)
Flat speed 5 in/min (127 mm/min)
Throughput 100 lbs/hr (45.3 kg/hr)

Process B:
Flat spacing 0.014" (.36 mm)
Flat speed 9.75 in/min (247 mm/min)
Throughput 120 lbs/hr (54.4 kg/hr)

A portion of each of the nine bales were processed at settings A and B and three rotor yarns (Nec 10's, 22's, and 30's) and three ring yarns (Nec 22's, 30's, and 40's) were produced. The yarns were then tested on the Uster evenness tester (UT3) and Uster Tensorapid (yarn strength and elongation tester). The differences in seed coat nep levels on the sliver for the two conditions are shown in Figure 12. Overall, the seed coat nep level in card sliver drops approximately 50% while the fiber nep level decreases approximately 65% (Figure 12). The strength of the rotor yarn increases (Figure 13) while the strength of the ring yarn is unchanged for the two processing conditions (Figure 14). The Yarn Appearance Index reveals a substantial improvement in ring yarn quality for condition A in Figure 14. A higher index value indicates better yarn appearance for boarded yarn. Condition A processing also improves the Yarn Appearance Index (ASTM) of the rotor yarns, although not at the same level as the ring yarns.

Applications For Cotton Card Maintenance And Return On Investment

Introduction

The carding department in a spinning mill is the most critical area for maintaining proper process control. The cotton card provides the last opportunity to remove neps and trash in sliver before the spinning process. However, additional removal of neps and trash can be accomplished in the combing process.

Neps in card sliver produce imperfections in carded yarn as measured by the Uster evenness tester (UT3). The number of imperfections in terms of neps (as measured by Uster Tester) and thick places can be directly associated with the neps and seed coat fragments in card sliver. Neps in card and draw frame sliver cannot be detected by only controlling sliver weight and evenness. This is the reason that sliver with acceptable CV% evenness and count variation values may produce unacceptable spinning efficiencies and poor yarn quality.

New high speed cards have a very high production rate compared to the cards produced just a few years ago. Normal production for a new card is approximately 100 pounds (44 kg) to 175 pounds (80 kg)/ hour. This means a card can produce 2,400 pounds (1065 kg) of sliver in 24 hours. Visual inspection of the card web by the technician has been used to judge the performance of the carding elements such as cylinder wire, flat settings and licker-in cylinder. These visual determinations can be very subjective and lead to unnecessary maintenance and rebuilding. Visual counting of neps is also complicated by trash and seed coat fragments in the card web, new design etc. New designs of cot-ton cards have moved the doffer cylinder very close to the main cylinder. This new design has limited access to the card web.

The Uster AFIS N (neps) instrument allows the spinning mill to quickly test each card sliver to determine the quality level of the sliver being produced. The repeatability and consistency of the AFIS N measurement gives valuable information to the card room technician. This information can be used to establish a detailed maintenance schedule for the carding department. The information provided by the AFIS N instrument can improve yarn quality by reducing the number of imperfections in the yarn such as neps and thick places. Intelligent and timely scheduling of card maintenance can substantially reduce the amount of money and time spent on card rebuilding.

Carding Department Analysis

A line or group of cotton cards do not operate or wear the same throughout the carding department. Because of the mechanical nature of the card design, the components of each card wear differently from one another. This has led to establishing general maintenance and rebuilding schedules based on experience. Typical schedules are shown below. The use of AFIS can produce a more realistic and practical schedule.

Setting Control Limits

The control chart in Figure 22 showing the card number has the AFIS Nep count per gram on the vertical axis with the weekly test results on the horizontal axis. Card sliver should be tested at least weekly, and the results should be posted on the card for that particular week. When the nep levels exceed the upper control limit, the card is then scheduled for maintenance. The upper control limit is established using the following information:

Carding Department avg. nep count/gram

Check all cards at least once per week, for 6 - 8 weeks to determine the card room average

Spinning System, Ring or Rotor

In ring spun yarns fiber neps should be lower than those found in rotor spun yarns for coarse and medium yarn counts. This is due to the way yarn is formed by the two spinning systems. For fine count yarns, the nep levels both ring and rotor systems should be kept to a minimum.

End Product, Knitting or Weaving Yarn

Neps are visually apparent and thus more critical in knit fabric than in finished woven fabric. This is due to the basic fabric construction and finishing techniques.

Uster Evenness Tester (UT3) Nep Count

Compare the counts of yarn neps from the Uster evenness tester to the quality charts in the Uster Statistics book (Uster News Bulletin No. 36). To improve yarn nep count and reach a desired level the nep count in sliver must be reduced to meet this higher quality level.

Nep Removal Efficiency

As the card nep removal efficiency improves, the upper limit on the control chart should be slowly lowered. Experience has shown that the upper limit should level off in 4 to 6 months after a maintenance program has been implemented with the AFIS Nep schedule. There are two methods commonly used to monitor neps in card sliver. One is to use the actual nep count/gram in carded sliver. Another is to use card nep removal efficiency. Removal efficiency (RE) is calculated using the following formula:

$$\frac{\text{Neps in card mat} - \text{neps in card sliver}}{\text{Neps in card mat}} \times 100$$

Neps in card mat are the neps in samples taken from the chute feed or cotton entering the back of the card, either in lap or mat form.

Neps in card sliver are the neps in samples of cotton sliver taken from the sliver can at the front of the card.

Calculating the nep removal efficiency is an excellent method for analyzing individual cards. The efficiency calculation is also useful when comparing various carding elements, such as wire, flats or licker-in cylinders. This efficiency calculation is ideal for evaluating a new design of card cylinder wire. Two cards can be rebuilt, one using new wire of the old design and another using wire of the new design. These two cards can be compared for a 30 day period to determine which wire is best for the mill's own quality requirements. This same procedure can be used to evaluate card flat wire, licker-in cylinders as well as main cylinder and flat speeds.

Reducing Maintenance Costs

Using the information from the AFIS to establish a nep control chart and limits for scheduling maintenance can reduce the overall cost of the carding department. Mill studies have shown that it is possible for some cotton cards to process over two million pounds (900,000 kg) before exceeding the upper limits for nep counts in sliver. Typically, costs for card wire and replacement parts such as flats and licker-in cylinders are one of the largest expense items in the spinning mills machinery maintenance budget. Reduction or elimination of the cylinder grindings can also be accomplished using this nep control chart for scheduling maintenance.

The following example shows a comparison between traditional maintenance scheduling and the AFIS method of process improvement. This example is based on a single card processing 100% Upland type cotton. The cards are high speed cards at a throughput of 100 lbs/hr (44 kg) for a period of four years. Prices for rebuilding and grinding are typical costs in North America. This same chart can be used for other economic regions by inserting typical costs for that particular area:

Traditional Card Maintenance Schedule

CARDS	REBUILD/YR	REBUILD	TOTAL
30	30	$2,500	$75,000
CARDS	REGRIND/YR	REGRIND	TOTAL
30	60	$250	$5,000

Total Maintenance $90,000

AFIS Maintenance Based On Control Chart

CARDS	REBUILD/YR	REBUILD	TOTAL
30	18	$2,500	$45,000
CARDS	REGRIND/YR	REGRIND	TOTAL
30	21	$250	$5,250

Total Maintenance$50,250

Total savings when using AFIS N is $37,500 per 12 month period.

The savings shown are based on the following guidelines:

- Rebuild only cards that exceed established nep levels.
- All cotton cards do not wear at the same rate.
- Additional savings can be accomplished by reducing the replacement of carding elements such as flats and licker-in cylinders.

Nep Variation In Card Sliver

The variation of neps in sliver from card to card results in maintenance on cards that are producing a good quality sliver. This also means that some cards that are producing off-quality sliver are not scheduled for maintenance at the optimum time. Regularly scheduled testing of card sliver on the AFIS N instrument can provide the necessary information for determining which cards are in need of maintenance. Figure 21 shows the typical variation of a single line of cotton cards.

Figure 21 clearly indicates that some cards have a low nep count and others have a higher than acceptable nep count. This example is quite typical of the nep variation in sliver in a normal carding department. The cotton used in this carding process was a saw ginned American Upland variety.

Application of AFIS Nep Data

In order to assure optimum card efficiency, it is recommended that a process control chart be established for each cotton card. This chart should be kept in a file that records maintenance for each card. A typical chart for a high speed cotton card is shown in Figure 22.

Neps in card sliver will increase over time as the card wire and other components deteriorate. This type of chart applies to any type of card regardless of make, single versus tandem or throughput. Cards operating at slower speeds will generally take a longer time to deteriorate and will produce a sliver with a higher nep count.

Conclusion

The Uster AFIS classifies neps into fiber neps or fiber entanglements and seed coat neps. This breakthrough technology will now make it possible for the cotton yarn spinner to remove seed coats more effectively by the carding process. Reducing neps in sliver reduces the neps and imperfections in yarn and improves fabric appearance. Replacement of traditional card maintenance techniques with the AFIS Process Improvement Chart can substantially reduce the repair and replacement costs in the carding department. Seed coat neps generally cause yarn faults in the range of + 200% Imperfection (IPI) value as measured by the Uster Evenness Tester. Generally, it is found that the adjustment of card flat setting, flat speeds and card throughput influence the removal of seed coat neps the most. The ability to optimize process machinery and to detect unusually higher levels of seed coats neps in cotton will continue to be on the forefront of spinning mills. This technology will allow spinners to become more competitive and to continue to provide higher quality cotton products to consumers.

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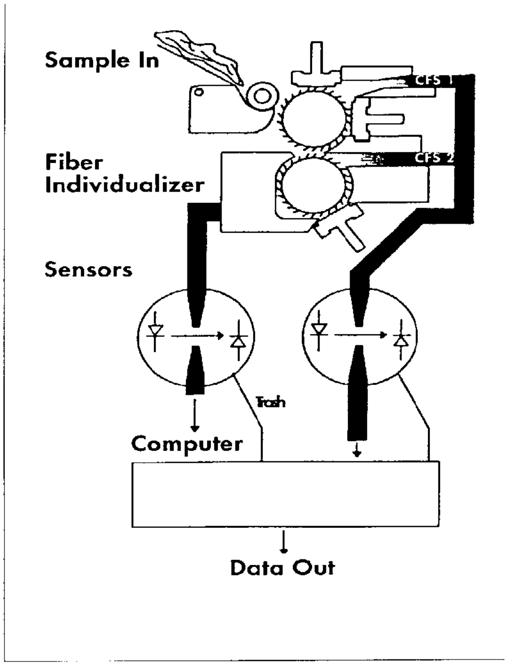


Figure 1. AFIS General Schematic

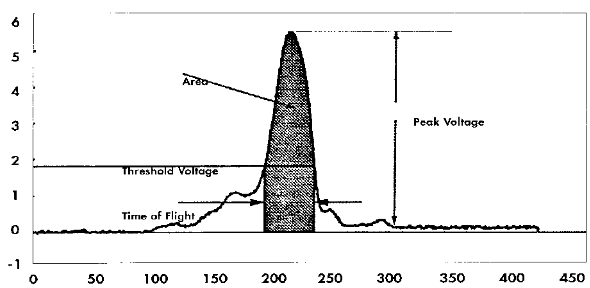


Figure 2a. Nep waveform- lumped waveform parameters

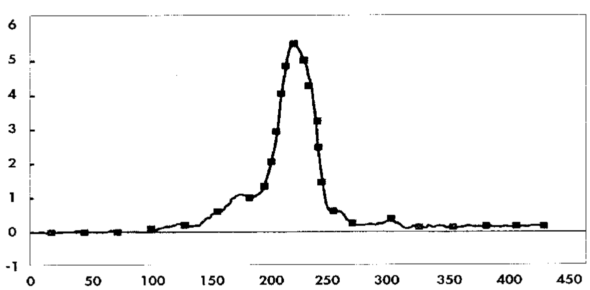


Figure 2b. Nep waveform – digitally sampled waveform

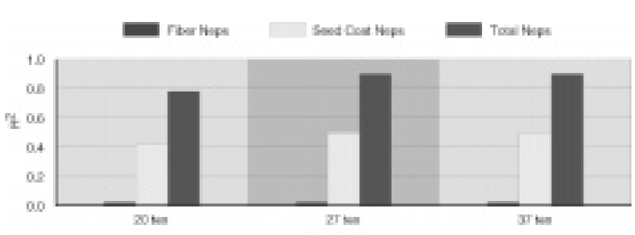


Figure 3. Comparison of standard AFIS-N total neps and AFIS - seed coat neps and seed coat neps to total UT3+200% ring spun yarn imperfections.

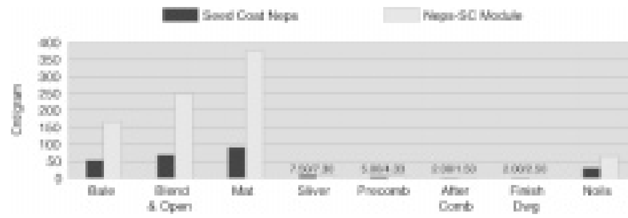


Figure 4. AFIS - seed coat through mill study Plant 2.

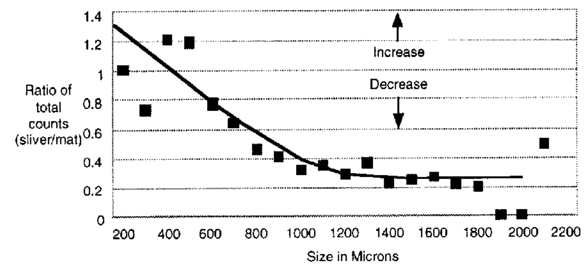
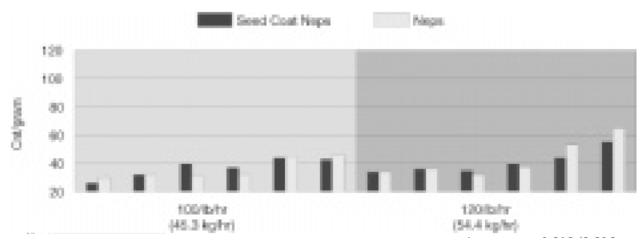


Figure 5. Comparison of seed coat nep size.

Bale	% Area	Cnt	Len (in)	Un	SFI	Str (g/tex)	El%	Mic	Rd	+b
1	0.5	44	1.11	83.3	6.6	32.8	5.7	4.3	75.3	8.7
2	0.7	55	1.13	82.8	7.0	32.3	6.3	3.8	76.2	7.8
3	0.2	19	1.13	84.0	5.5	30.5	6.7	4.5	79.7	7.9
4	0.4	36	1.12	83.5	6.3	32.6	5.4	5.1	75.1	8.9
5	0.8	52	1.07	80.9	10.1	24.4	5.4	4.9	59.5	10.8
6	0.8	64	1.03	79.8	11.9	25.1	7.5	2.8	77.5	8.3
7	0.6	43	1.08	81.6	9.1	25.7	5.1	4.9	64.2	10.0
8	1.0	62	1.06	81.3	9.7	27.5	8.0	3.1	78.7	7.6
9	1.1	87	1.06	78.4	13.3	23.3	7.5	2.7	67.1	8.7

Figure 6. HVI test results



G	0.008	365	9.75	100	4.3±1	0.012/0.015
H	0.008	365	9.75	100	4.3±1	0.020/0.025

Figure 7. Card settings

Figure 8. Bale #1 Throughput Comparison on AFIS.

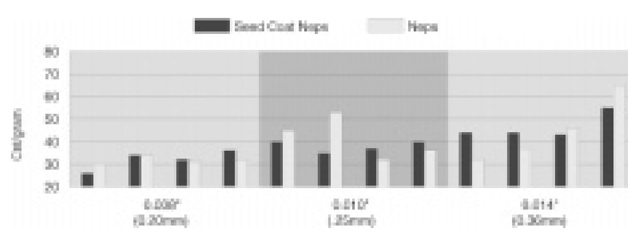


Figure 9. Bale #1 Flat Setting on AFIS.

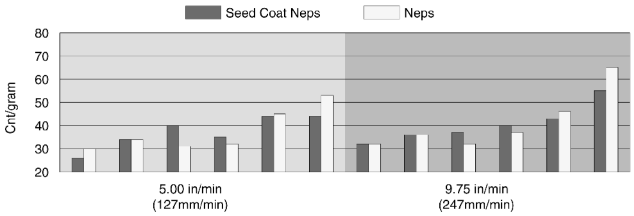


Figure 10. Bale #1 Flat Speed.

Bale ID#	SCN/Bale (Neps/gram)	1st Cleaner (Neps/gram)	Card mat (Neps/gram)	Card Sliver (Neps/gram)	Nep Removal Efficiency
Bale 1	69	75	72	40	44
Bale 2	64	76	81	44	45
Bale 3	36	44	51	20	61
Bale 4	62	50	72	22	69
Bale 5	38	57	77	11	86
Bale 6	63	56	65	28	57
Bale 7	46	68	65	16	75
Bale 8	46	57	55	15	73
Bale 9	40	42	44	10	77

Figure 11. Seed coat removal efficiency tested on AFIS

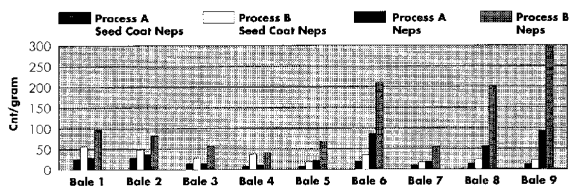


Figure 12. Seed coat neps per gram sliver sample

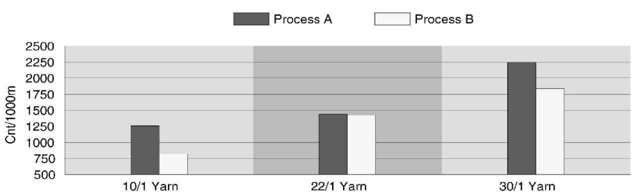


Figure 13a. UT3 - Neps (+140%) for three open-end yarn types (per 1000m).

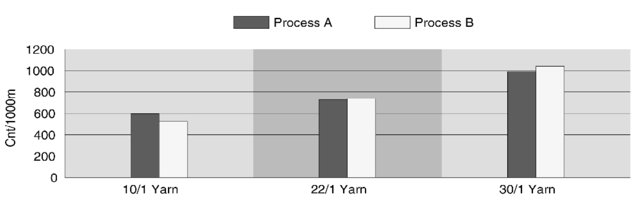


Figure 13b - Thick places (+35%) for three open-end yarn types.

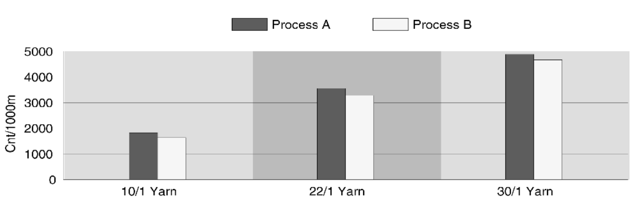


Figure 13c. UT3 - Thin places (-30%) for three open-end yarn types.

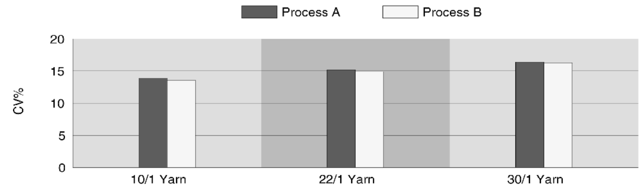


Figure 13d. CV% (Evenness), fr three open-end yarn types.

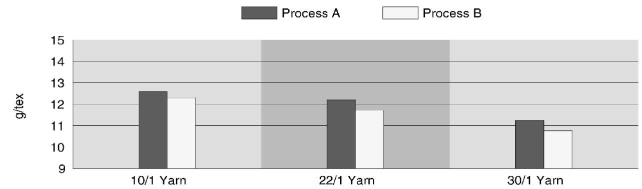


Figure 13e. Yarn Strength for three open-end yarn types.

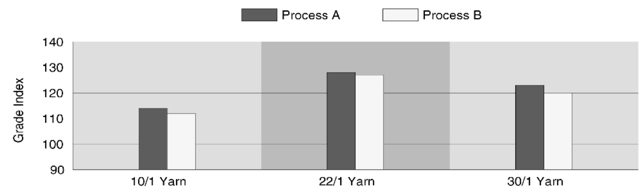


Figure 13f. Grade index for three open-end yarn types (yarn appearance index)

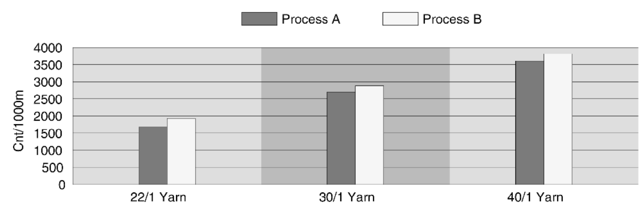


Figure 14a. UT3 - Neps (+140% for three ring yarn types (per 1000m).

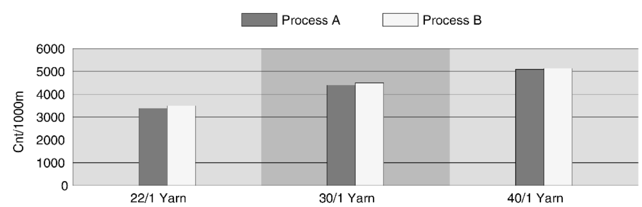


Figure 14b. UT3 - Thick places (+35%) for three ring yarn types.

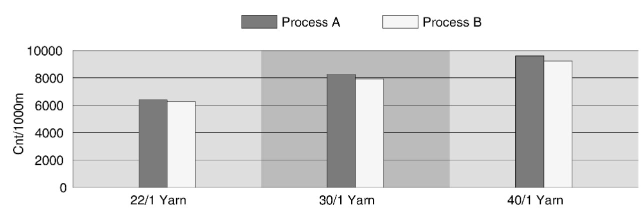


Figure 14c. UT3 - Thin places (-30%) for three ring yarn types.

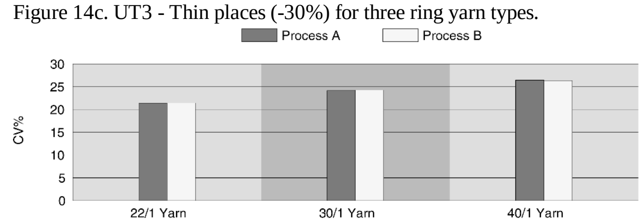


Figure 14d. CV% (Evenness), for three ring yarn types per bale.

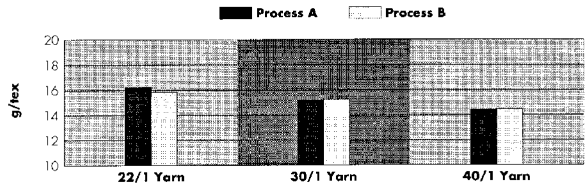


Figure 14e. Yarn Strength for three ring yarn types (g/tex).

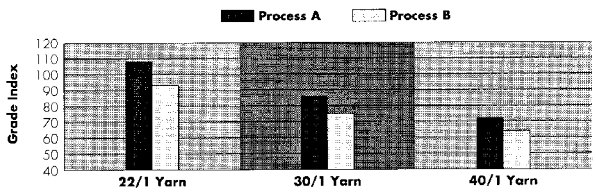


Figure 14f. Grade index for three ring yarn types (yarn appearance index).

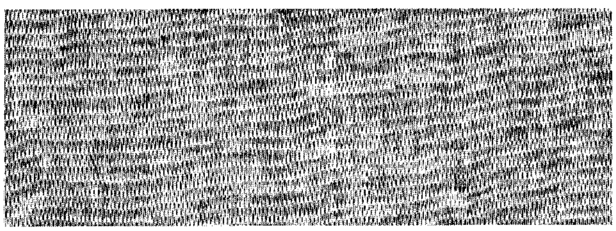


Figure 15. Bale 7 (ID#0840842) Process A (0.008) 9 seed coat neps per gram.

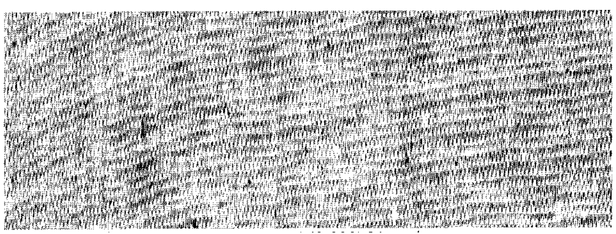


Figure 16. Bale 1 (ID# 1645403) Prcess A (0.008) 26 seed coat neps per gram.

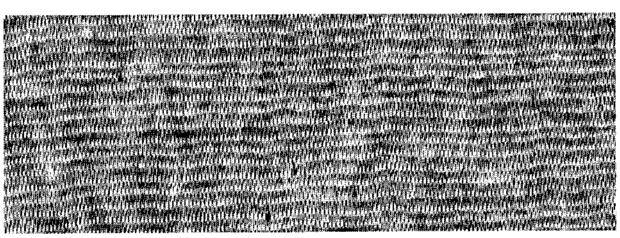


Figure 17. Bale #2 (ID#1645515) Process A (0.008) 29 seed coat neps per gram.

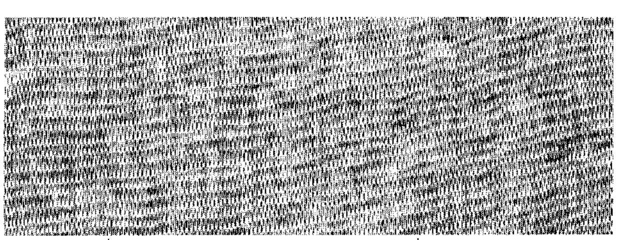


Figure 18. Bale 7 (ID#0840842) Process B (0.014) 17 seed coat neps per gram.

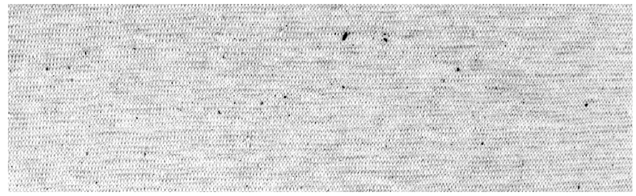


Figure 19. Bale 1 (ID#1645403) Process B. (0.014) 56 seed coat neps per gram.

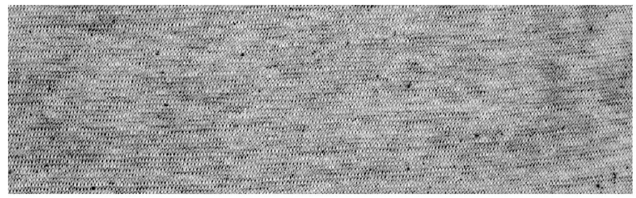


Figure 20. Bale 2 (ID# 1645515) Prcess B (0.014) 49 seed coat neps per gram.

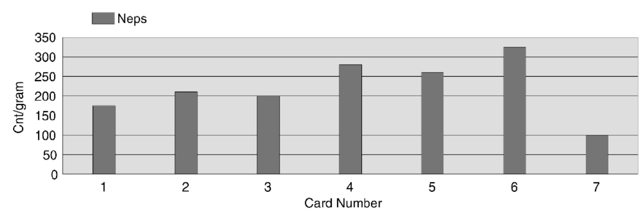


Figure 21. Differences in card sliver.

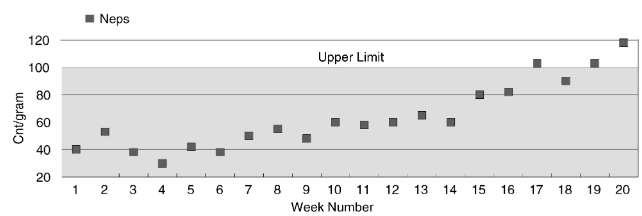


Figure 22. Process Improvement for card #12.

Operation	Typical Maintenance Schedule
Grinding	
a. Cylinder wire and flats	6 months or 500,000 lbs (225,000 kg)
Rebuilding	
a. replace cylinder wire and flats	1 year or 1 million lbs. (450,000 kg)
Licker-in Cylinder	
a. replace	6 months or 500,000 lbs. (225,000 kg)
Flats	
a. replace	6 months or 500,000 lbs (225,000 kg)
b. grind	3 months or 250,000 lbs (125,000 kg)