

THE ADVANTAGES OF USING THE CROSTROL TANDEM CARD WITH THE MURATA AIR-JET SPINNING MACHINE

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Abstract

Previous studies have proved that the Tandem Card produces superior quality yarns and fabrics from both Ring and Rotor spinning systems often from inferior raw material. We initiated the following trials to ascertain whether this would apply to Air-Jet spinning also.

Introduction

In today's highly competitive global market manufacturers are increasingly being asked to produce ever higher quality yarns and fabrics at lower and lower costs.

The industry urgently requires systems that will provide this. Both the Murata Air-Jet Spinner and the Crosrol Tandem Card are well known for their cost effectiveness in the production of high quality yarns and slivers. Both companies have been at the leading edge of their respective technologies for some considerable time.

By combining the two systems we hoped that the potential of each would be utilised.

Discussion

We decided to use two cottons namely one of Memphis origin and one of Texas origin, to these we blended three different types of polyester. Finally we spun them into NE 35's for comparison.

Both Single and Tandem Carded cotton slivers were used in the trials.

Memphis cotton was chosen as the benchmark because it is normally used commercially.

The Memphis cotton was classed as being middling (31), 35/32 inches long, the Micronaire was 4.45 and the strength was 26.6 grams per tex.

The Texas cotton was classed as strict low middling (41), 32/32 inches long, the Micronaire was 4.30 and the strength was 28.6 grams per tex.

The Memphis cotton cost 75 cents per pound and the Texas cotton cost 71 cents per pound.

Samples of bale stock were tested on the Uster Multidata AFIS. The results can be seen in Figure 1.

The data shows that the Texas cotton:

Was shorter than the Memphis.
Had a similar diameter.
Contained more dust, trash and foreign matter.

The only parameter that the Texas cotton appeared to be superior in was the short fibre content, it had less.

Both cottons were processed at Crosrol Inc. through the following opening machines under identical conditions.

One Automatic Bale Opener.
One Four Chamber Blender.
One Three Roller Coarse Cleaner.
One Tower Reserve with Pinned Opener
One Tower Reserve with Fine Wired Opener.

Both cards were Chute Fed and ran at 90 pounds per hour, producing a 60 grain sliver.

At 90 pounds per hour the Tandem Card normally reaches its quality plateau. Production rates of 120 pounds per hour or more could probably have been used without much deterioration in sliver quality.

Card waste losses are shown in Figure 2.

The Texas cotton being trashier than the Memphis cotton gave slightly higher card waste losses. The increase being 0.26% for the Single Card and 0.09% for the Tandem.

Naturally the Tandem Card produced more waste than the Single Card did, in fact 0.90% for the Memphis and 0.73% for the Texas. This gave an improved cleaning efficiency of 6.0% for the Memphis and 5.2% for the Texas when compared with single carding.

Looking at the sliver data (Figure 3) it is apparent that for both cottons the Tandem Card sliver had a slightly longer mean length and upper quartile length with a lower short fibre content than the Single Card sliver had.

Trash, dust and visual foreign matter were generally lower in Tandem Carded sliver than in the Single Carded sliver.

Murata obtained three bales of polyester from Dupont, the specifications follow:

Sample "A" was T-90C, 1.2 Denier, 1.5 inch Staple.
Sample "B" was T-90C, 0.9 Denier, 1.25 inch Staple.
Sample "C" was T-90C, 0.9 Denier, 1.5 inch Staple.

These were all carded at Dupont's Hamby Textile Research Facility under identical conditions.

Each polyester was blended with the four cotton samples processed at Crosrol Inc. They were then blended three times on a RSB851 Rieter Drawframe.

The four cotton samples were:

- (1) Single Carded Memphis Cotton.
- (2) Tandem Carded Memphis Cotton.
- (3) Single Carded Texas Cotton.
- (4) Tandem Carded Texas Cotton.

Each finished sliver was spun into NE35's yarn by Murata on their 802-H Machine. The spinning conditions are shown by Figure 4.

The resultant yarns were tested on the Uster Tensojet and the UT3.

The results from Sample (A) are to be found in Figures 5, 6 and 7.

The results from Sample (B) are to be found in Figures 8, 9 and 10.

The results from Sample (C) are to be found in Figures 11, 12 and 13.

Results

Strength (Figure 11)

The single end strength of the Tandem Carded blends were slightly higher than the Single Carded blends for Samples (A) and (B), generally 3.5% higher, however Sample (C) was slightly weaker, generally 0.2% lower.

In most cases the Tandem Carded Texas blends were as strong at 287 meters per minute spinning speed as the Single Carded Memphis blends were at 247 meters per minute, indeed for Sample "A" the Tandem Carded Texas blend had the highest work to break of the whole sub-set.

Elongation (Figure 11)

The Tandem Carded blends usually had lower elongations than the single blends.

Uster CV% (Figure 11)

The Tandem blends always had better Uster CV%, being from 0.4% to 1.2% lower.

IPI (Figure 10)

The yarn IPI's were always superior with the Tandem blends ranging from 7.2% to 29.9% lower.

Costings

Amortation

A reasonable period for a modern card would seem to be 10 years, although cards will produce good sliver well in excess of this.

If we assume a 160 hour working week and that there are 50 working weeks in the year then the write off period would be 80,000 hours.

If we then use the production rate as used in the trial then the overall production in that period would be 7,200,000 pounds.

A typical selling price for a Single Card is 55,000 USD and for a Tandem is 90,000 USD.

The capital cost per pound of sliver produced therefore would be: $55,000/7,200,000 = 0.75$ cents/lb. for a Single Card. $90,000/7,200,000 = 1.25$ cents/lb. for a Tandem Card.

Power Consumption

The power consumption of a Single Card is 6.5 KW/HR.

The power consumption of a Tandem Card is 11.0 KW/HR.

Cost of electricity in the USA was 3.7 cents/KW/HR.

The cost of power to produce one pound of sliver therefore is:

For the Single Card = $(6.5) (3.7)/90 = 0.27$ cents/lb.

For the Tandem Card = $(11.0) (3.7)/90 = 0.45$ cents/lb.

Cost of Air Extraction

The amount of air extracted from the Single Card was 4420 cubic meters per minute and for the Tandem was 8840 cubic meters per minute.

This required 1.27 KW/HR and 2.54 KW/HR. of power respectively. Therefore cost of air for the Single was $(1.27) (3.7)/90 = 0.05$ cents/lb., and the cost of air for the Tandem was $(2.54) (3.7)/90 = 0.10$ cents/lb.

Maintenance

A major factor in card maintenance is the cost of the wire. Wire life is considerably longer on the Tandem Card than on a Single Card, for that reason the cost is not double.

Overall cost of maintaining a Single Card is 1.13 cents/lb.

Overall cost of maintaining a Tandem Card is 1.50 cents/lb.

Cost of Card Waste

The waste losses experienced in the trial are shown in Figure 3. You will see that the total waste losses in

processing the Texas cotton was 2.84% and 3.57% for the Single and Tandem Card respectively.

The waste losses on the Memphis were 2.58% and 3.48% respectively.

Therefore the cost of waste per pound of sliver produced was:

- 2.02 cents/lb. For Single Carded Texas Cotton.
- 2.53 cents/lb. For Tandem Carded Texas Cotton.
- 1.94 cents/lb. For Single Carded Memphis Cotton.
- 2.61 cents/lb. For Tandem Carded Memphis Cotton.

Total Cost (in cents per pound of sliver produced)

	Single Card	Tandem Card
Capital Costs	0.75	1.25
Power Consumption	0.27	0.45
Air Consumption	0.05	0.1
Maintenance Costs	1.13	1.5
Sub Total	2.2	3.3

	Texas	Memphis	Texas	Memphis
Cost of Waste	2.02	1.94	2.53	2.61
Totals	4.22	4.14	5.83	5.91
Extra Tandem Costs			1.61	1.77

Total Yarn Costs in Air Jet Spinning are:

At 247 meters/minute at 95% efficiency = 111.1 cents/lb of yarn produced.

At 260 meters/minute at 95% efficiency = 110.5 cents/lb of yarn produced.

At 247 meters/minute at 95% efficiency = 109.9 cents/lb of yarn produced.

At 287 meters/minute at 95% efficiency = 109.4 cents/lb of yarn produced.

Conclusions

The trials show that yarn produced from the Tandem Carded Texas blends matched the quality of the yarn produced from the Single Carded Memphis blends.

Remember that the Texas cotton cost 71 cents per pound and the Memphis cotton cost 75 cents per pound. A saving in this trial of 2 cents per pound (remember we are producing a 50/50 blend).

The carding costs of Tandem Carding the Texas cotton was 5.83 cents per pound of sliver and 4.14 cents per pound of sliver the Single Carded Memphis. As the yarn produced was a 50/50 blend this results in a net cost of 0.85 cents per pound.

Spinning benefits could be as high as 1.70 cents per pound (111.1 - 109.4) because as we have seen the Tandem Carded Texas blend yarn spun at 287 meters per minute matched the Single Carded Memphis blend yarns spun at 247 meters per minute for quality.

At best a net benefit of some 2.85 cents per pound of yarn could be realised (2.00+1.70-0.85). This is a significant saving in anyones language.

Since this work was completed both companies have made significant improvements to their machines in both productivity and quality which should enhance the findings of this study even further.

We are actively engaged in further studies which we hope will demonstrate that by maximising the potentials of both our machines a higher proportion of cotton may be commercially spun on the Murata Air-Jet Spinner.

Figures and Tables

Figure 1

Cotton	Memphis	Texas
D(n) (um)	14	14.1
L(w) (in)	0.87	0.85
SFC(w) (%)	15.3	13
UQL(w) (in)	1.1	1.05
DUST (Cnt/g)	609	817
TRASH (Cnt/g)	125	141
VFM (Cnt/g)	2.29	2.92

Raw Cotton Data - AFIS

Figure 2

Texas Cotton		Single MK5 Card
Takerin Droppings		1.44%
Flat Strips		1.40%
Total Waste		2.84%
Cleaning Efficiency		87.9%

Texas Cotton		Tandem Mk5 Card
Takerin Droppings		2.03%
Breaker Flat Strips		0.82%
Finisher Flat Strips		0.72%
Total Waste		3.57%
Cleaning Efficiency		93.1%

Memphis Cotton		Single Mk5 Card
Takerin Droppings		1.25%
Flat Strips		1.33%
Total Waste		2.58%
Cleaning Efficiency		85.4%

Memphis Cotton		Tandem Mk5 Card
Takerin Droppings		1.88%
Breaker Flat Strips		0.86%
Finisher Flat Strips		0.74%
Total Waste		3.48%
Cleaning Efficiency		91.4%

Waste Analysis

Figure 3

Sliver	Single Card		Tandem Card	
	Memphis	Texas	Memphis	Texas
L(w) (in)	0.83	0.84	0.84	0.85
SFC(w) (%)	17.1	14.7	16.9	14
UQL(w) (in)	1.06	1.05	1.07	1.05
DUST (Cnt/g)	293	263	109	119
TRASH (Cnt/g)	15	17	17	10
VFM (Cnt/g)	0.32	0.33	0.26	0.2

Sliver Data - AFIS

Figure 4

Test Details:
 Customer Crosrol/MOA
 MJS x
 End Use Weave
 Machine Type 902/M
 Yarn CL 35/1
 Blend 58/50
 4 Line x
 Sliver Gm/Yd 40
 Wax No

Test No	1	2	3	4	5	6
Speed	247	-	-	260	-	-
Total Draft Ratio	166	-	-	-	-	-
Main Draft Ratio	40	-	-	-	-	-
Feed Ratio	0.98	-	-	-	-	-
Take-Up Ratio	0.98	-	-	-	-	-
Condensor	3	-	-	-	-	-
Distance HI - FR	39	-	-	-	-	-
H1 Air Pressure	2	2.5	3	2	2.5	3
H2 Air Pressure	5	-	-	-	-	-
Type Nozzle N1	H-3	-	-	-	-	-
Twist Controller	H-3	-	-	-	-	-
Type Nozzle N2	H-3	-	-	-	-	-
N2 Guide	H-3	-	-	-	-	-
Apron Spring (Kg)	3	-	-	-	-	-
Side Plate	36-36	-	-	-	-	-
Cradle Pressure	20-22x3	-	-	-	-	-
Front Top Cots	J490-s	-	-	-	-	-
Tensor Bar	2.88	-	-	-	-	-
Test No	7	8	9	10	11	12
Speed	274	-	-	287	-	-
Total Draft Ratio	-	-	-	-	-	-
Main Draft Ratio	-	-	-	-	-	-
Feed Ratio	-	-	-	-	-	-
Take-Up Ratio	-	-	-	-	-	-
Condensor	-	-	-	-	-	-
Distance HI - FR	-	-	-	-	-	-
H1 Air Pressure	2	2.5	3	2	2.5	3
H2 Air Pressure	-	-	-	-	-	-
Type Nozzle N1	-	-	-	-	-	-
Twist Controller	-	-	-	-	-	-
Type Nozzle N2	-	-	-	-	-	-
N2 Guide	-	-	-	-	-	-
Apron Spring (Kg)	-	-	-	-	-	-
Side Plate	-	-	-	-	-	-
Cradle Pressure	-	-	-	-	-	-
Front Top Cots	-	-	-	-	-	-
Tensor Bar	-	-	-	-	-	-

Spinning Conditions for Crosrol Tests

Figure 5

Sliver Evenness (%CV)

	Uster CV%	1Yd.Uster CV%
Single Texas	3.48	0.91
Tandem Texas	3.35	0.8
Single Memphis	3.91	0.8
Tandem Memphis	3.51	1.06

Average Single End Strength (grams)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	260	269	259	259
Test 2	263	273	260	263
Test 3	265	272	258	264
Test 4	261	272	258	261
Test 5	267	273	256	262
Test 6	284	270	255	260
Test 7	263	270	257	258
Test 8	258	269	252	256
Test 9	252	266	248	253
Test 10	259	268	247	254
Test 11	244	261	238	248
Test 12	232	249	227	242

PO1 Break (grams)

(0,1 Percentile)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	171	181	168	161
Test 2	158	164	142	173
Test 3	172	166	-	166
Test 4	153	179	159	80
Test 5	162	172	152	162
Test 6	156	153	147	154
Test 7	164	170	144	154
Test 8	150	174	149	154
Test 9	137	153	142	138
Test 10	147	174	134	151
Test 11	121	167	137	143
Test 12	135	124	116	116

CV% of Break (Overall)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	10.8	10.7	11.3	11.2
Test 2	11.4	10.9	11.9	10.8
Test 3	11.4	11	12.2	11.6
Test 4	11.8	10.5	11.5	11.4
Test 5	12.1	11.1	12.4	11.3
Test 6	12.5	11.7	12.6	11.7
Test 7	11.5	10.9	12	11.2
Test 8	13	11.2	12.5	11.7
Test 9	13.5	12.1	13.3	12.4
Test 10	13.3	11.2	13.1	11.9
Test 11	14.6	12.4	14.1	12.8
Test 12	14.6	13.7	14.4	14.1

**Crosrol/MOA Carding Test Yarn Properties
(Cottons Blended with 1.2 x 1.5 “Item A” Polyester)**

Figure 6

CV% of Break (Between Packages)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	2.4	1.4	1.4	1.5
Test 2	1.1	1	0.9	1.5
Test 3	0.7	0.8	1.3	0.8
Test 4	2.1	1.1	1.2	1.4
Test 5	1.7	1.1	0.9	0.8
Test 6	0.9	0.9	1.2	1.2
Test 7	0.9	0.8	1.2	0.6
Test 8	1.2	0.9	0.4	0.7
Test 9	1.5	0.4	0.8	0.4
Test 10	2.4	1.2	1.8	0.5
Test 11	2.7	1.8	2.4	2
Test 12	2.3	2.3	2.6	2.8

Elongation %

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	5.9	5.9	5.9	6
Test 2	6	6.1	6.2	6.2
Test 3	6.2	6.2	6.3	6.5
Test 4	6.2	6.3	6.1	6.1
Test 5	6.9	6.5	6.4	6.4
Test 6	6.9	6.6	6.8	6.8
Test 7	6.4	6.5	6.6	6.3
Test 8	6.7	6.9	6.8	6.6
Test 9	7.1	7.1	7.1	6.8
Test 10	7.2	6.8	7	6.6
Test 11	7.5	7.4	7.5	7.2
Test 12	8.1	7.8	8	7.6

Work to Break (gm x cm)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	416	433	418	423
Test 2	431	451	433	441
Test 3	445	460	437	457
Test 4	434	458	430	429
Test 5	478	471	443	449
Test 6	479	477	461	469
Test 7	452	466	450	438
Test 8	458	486	456	451
Test 9	465	491	461	459
Test 10	476	474	447	447
Test 11	462	494	453	460
Test 12	454	487	446	463

Uster CV %

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	17.2	16.24	17.94	17.13
Test 2	17.3	16.65	18.3	17.37
Test 3	17.82	16.8	18.11	17.55
Test 4	17.64	16.42	18.4	17.67
Test 5	17.5	16.39	18.58	17.76
Test 6	17.67	16.85	18.5	17.42
Test 7	17.67	16.38	18.92	17.66
Test 8	17.9	16.56	18.8	17.87
Test 9	17.99	16.6	19.21	17.96
Test 10	18.09	16.74	18.96	17.89
Test 11	18.32	16.82	19.44	18.35
Test 12	18.6	17.07	19.45	18.48

**Crosrol/MOA Carding Test Yarn Properties
(Cottons blended with 1.2 x 1.5" Item "A" Polyester)**

Figure 7

Total Imperfections / 1000 vds.

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	715	538	1102	980
Test 2	816	724	1317	1100
Test 3	982	734	1298	1146
Test 4	894	670	1436	1158
Test 5	791	651	1524	1271
Test 6	888	701	1431	1055
Test 7	939	642	1494	1235
Test 8	1057	675	1762	1314
Test 9	1171	775	1931	1329
Test 10	1243	786	1779	1398
Test 11	1378	885	2119	1617
Test 12	1532	1001	2214	1647

Uster 1 yd. CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	7.46	6.54	7.59	6.63
Test 2	7.62	6.63	7.86	6.66
Test 3	7.87	6.71	7.51	6.8
Test 4	7.7	6.54	7.73	6.86
Test 5	7.78	6.52	7.87	6.83
Test 6	7.92	6.57	7.72	6.74
Test 7	7.59	6.53	8.14	6.81
Test 8	7.75	6.61	7.67	7.04
Test 9	7.56	6.42	7.89	6.91
Test 10	7.61	6.47	7.92	6.84
Test 11	7.61	6.35	7.96	7.08
Test 12	7.62	6.38	7.78	7.02

Uster 3 yd. CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	4.75	3.87	4.83	4.14
Test 2	4.86	3.94	4.82	4.06
Test 3	5.03	4.03	4.64	4.1
Test 4	5	3.88	4.7	4.12
Test 5	4.99	3.88	4.72	4.06
Test 6	4.99	3.81	4.74	4.14
Test 7	4.66	3.94	5.13	4.13
Test 8	4.85	3.99	4.72	4.18
Test 9	4.75	3.79	4.9	4.2
Test 10	4.78	3.91	5.06	4.32
Test 11	4.68	3.86	4.89	4.32
Test 12	4.67	3.89	4.83	4.34

Uster 10 yd. CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	2.63	2.04	2.72	2.05
Test 2	2.9	1.99	2.51	2.13
Test 3	2.84	2.16	2.48	2.01
Test 4	2.87	1.82	2.81	2.05
Test 5	2.92	2.05	2.56	2.22
Test 6	2.93	1.89	2.6	2.09
Test 7	2.6	2.04	2.82	2.24
Test 8	2.7	2.08	2.76	2.3
Test 9	2.7	1.94	2.47	2.14
Test 10	2.69	2.08	2.99	2.42
Test 11	2.5	2.02	2.7	2.43
Test 12	2.68	1.96	2.5	2.2

**Crosrol / MOA Carding Test Yarn Properties
(Cottons blended with 1.2 x 1.5" Item "A" Polyester)**

Figure 8

Sliver Evenness (% CV)

	Uster CV%	1 yd.Uster CV%
Single Texas	3.5	0.83
Tandem Texas	3.2	0.61
Single Memphis	3.59	0.87
Tandem Memphis	3.33	0.88

Average Single End Strength (grams)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	270	273	268	280
Test 2	276	282	273	283
Test 3	277	283	273	283
Test 4	268	277	274	282
Test 5	270	282	266	281
Test 6	270	280	261	277
Test 7	272	278	264	278
Test 8	269	278	255	270
Test 9	260	270	248	255
Test 10	266	275	254	260
Test 11	254	267	242	252
Test 12	236	248	227	236

P 0.1 Break (grams)
(0.1 Percentile)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	186	188	177	196
Test 2	183	195	170	184
Test 3	171	180	177	182
Test 4	180	186	182	188
Test 5	171	180	159	167
Test 6	160	179	156	171
Test 7	179	178	147	170
Test 8	171	170	148	161
Test 9	136	169	139	150
Test 10	158	162	136	155
Test 11	137	157	101	143
Test 12	131	142	187	133

CV% of Break (Overall)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	10.3	9.8	10.2	10.4
Test 2	10.3	9.9	10.7	10.4
Test 3	10.9	10.2	11.1	10.8
Test 4	10.1	10.1	10.7	11
Test 5	10.7	10.2	12	10.6
Test 6	11.3	10.7	12.8	11
Test 7	10.6	10.3	12.3	10.5
Test 8	11.5	10.4	14	12
Test 9	13	11.8	14.6	13.3
Test 10	11.7	11.2	14.2	13
Test 11	13.5	12.4	15.1	14.1
Test 12	13.4	13.7	14	14.5

Crosrol / MOA Carding Test Yarn Properties
(Cottons blended with 0.9 x 1.25" Item "B" Polyester)

Figure 9

CV% of Break (Between Packages)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	3.5	2.3	1.6	1.1
Test 2	2.2	1.7	1.1	1.4
Test 3	1.9	0.6	1.2	0.2
Test 4	2.4	2.2	1.1	1.6
Test 5	0.9	0.8	2.6	0.9
Test 6	0.8	1.2	2.7	1.1
Test 7	1.1	1.2	2.7	1.9
Test 8	1.1	1.4	4.7	3.1
Test 9	2.9	2.2	4.7	4.1
Test 10	1.4	2	3.9	3.4
Test 11	2.8	2.8	4	4.5
Test 12	2.8	4.2	4	5.2

Elongation %

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	6.1	6.3	6.3	6.1
Test 2	6.3	6.4	6.6	6.4
Test 3	6.5	6.5	6.9	6.7
Test 4	6.6	6.5	6.8	6.6
Test 5	7.6	6.8	7.2	7
Test 6	7.6	7.2	7.5	7.3
Test 7	7	6.9	7.3	7.1
Test 8	7.4	7.3	7.9	7.6
Test 9	8.1	7.8	8.6	8.3
Test 10	7.5	7.1	7.9	7.8
Test 11	8.2	7.8	8.5	8.4
Test 12	9	8.7	9.1	9

Work to Break (gf x cm)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	420	435	430	443
Test 2	445	461	458	466
Test 3	459	469	477	482
Test 4	439	451	467	475
Test 5	469	478	474	493
Test 6	488	492	482	502
Test 7	465	472	472	489
Test 8	479	489	477	500
Test 9	487	497	488	452
Test 10	472	474	471	479
Test 11	474	489	466	480
Test 12	460	476	444	460

Uster CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	15.74	15.22	16.15	15.96
Test 2	15.81	15.44	16.3	16.15
Test 3	16.02	15.5	16.45	16.25
Test 4	15.88	15.36	16.28	16.3
Test 5	16.08	15.48	16.6	16.1
Test 6	16.34	15.5	16.74	16.34
Test 7	15.88	15.01	16.96	16.28
Test 8	16.07	15.69	17.07	16.4
Test 9	16.28	15.56	17	16.86
Test 10	16.1	15.67	17.22	16.76
Test 11	16.44	15.95	17.68	17.05
Test 12	17.08	16.18	18.27	17.39

Crosrol / MOA Carding Test Yarn Properties
(Cottons blended with 0.9 x 1.25" Item "B" Polyester)

Figure 10

Total Imperfections / 1000 yds.

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	488	432	695	674
Test 2	552	482	764	745
Test 3	578	526	843	840
Test 4	584	505	764	855
Test 5	667	547	844	782
Test 6	751	546	951	871
Test 7	650	626	1048	876
Test 8	711	666	1137	962
Test 9	811	621	1092	1188
Test 10	776	721	1218	1116
Test 11	929	794	1454	1312
Test 12	1151	882	1685	1371

Uster 1 yd. CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	5.73	5.13	5.99	5.45
Test 2	5.55	5.26	6.08	5.57
Test 3	5.79	5.14	5.83	5.83
Test 4	5.79	5.04	5.82	5.52
Test 5	5.84	5.08	6.04	5.45
Test 6	5.94	5.09	6.05	5.57
Test 7	5.67	5.14	6.11	5.51
Test 8	5.67	5.13	6.12	5.56
Test 9	5.76	5.02	5.89	5.46
Test 10	5.66	5.06	5.99	5.54
Test 11	5.69	5.24	6.17	5.44
Test 12	5.97	5.19	6.54	5.72

Uster 3 yd. CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	3.58	3.33	3.79	3.39
Test 2	3.36	3.23	3.78	3.44
Test 3	3.53	3.24	3.6	3.6
Test 4	3.57	3.16	3.52	3.5
Test 5	3.54	3.15	3.72	3.43
Test 6	3.64	3.15	3.8	3.5
Test 7	3.61	3.25	3.72	3.46
Test 8	3.48	3.18	3.8	3.41
Test 9	3.44	3.7	3.71	3.38
Test 10	3.62	3.14	3.86	3.48
Test 11	3.51	3.2	3.88	3.29
Test 12	3.81	3.26	4.16	3.53

Uster 10 yd. CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	1.98	1.78	2.02	1.94
Test 2	1.74	1.65	2	1.78
Test 3	1.91	1.81	1.91	1.91
Test 4	1.78	1.82	1.92	1.89
Test 5	1.88	1.69	2.02	1.93
Test 6	1.97	1.7	2.03	1.74
Test 7	1.84	1.7	2.09	2.01
Test 8	1.92	1.66	2.1	1.9
Test 9	1.85	1.61	2.14	1.85
Test 10	1.93	1.65	2.15	1.9
Test 11	1.96	1.68	2.06	1.79
Test 12	2.12	1.72	2.34	1.95

Crosrol/ MOA Carding Test Yarn Properties
(Cottons blended with 0.9 x 1.25" Item "B" Polyester)

Figure 11

Sliver Evenness (% CV)

	Uster CV%	1 yd. Uster CV%
Single Texas	3.91	1
Tandem Texas	3.67	0.76
Single Memphis	4.22	1.01
Tandem Memphis	3.72	1

Average Single End Strength (grams)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	293	281	279	276
Test 2	296	294	286	282
Test 3	296	296	290	285
Test 4	296	293	288	283
Test 5	295	281	282	282
Test 6	291	289	280	281
Test 7	294	290	280	279
Test 8	289	287	278	277
Test 9	278	279	274	277
Test 10	282	286	275	277
Test 11	272	275	268	271
Test 12	261	266	260	264

P 0.1 Break (grams)
(0.1 percentile)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	202	198	193	194
Test 2	198	202	194	189
Test 3	198	198	190	196
Test 4	203	201	200	195
Test 5	195	197	183	194
Test 6	183	189	181	192
Test 7	195	195	182	190
Test 8	181	183	175	174
Test 9	172	180	176	176
Test 10	173	183	170	182
Test 11	183	171	173	176
Test 12	136	154	136	189

CV% of Break (Overall)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	10.1	9.8	9.9	9.8
Test 2	10.3	10.2	10.3	10.1
Test 3	10.6	10.3	10.7	10.3
Test 4	10.1	10.1	10.3	9.9
Test 5	10.4	10.4	10.9	10.4
Test 6	10.9	10.5	10.9	10.6
Test 7	10.4	10.3	10.8	10.3
Test 8	11	10.9	11.2	10.8
Test 9	12.1	11.4	11.6	11.6
Test 10	11.5	10.9	11.5	11.1
Test 11	12.5	12.1	12.1	11.6
Test 12	12.8	12.5	12.4	11.9

Work to Break (gf x cm)

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	545	538	508	485
Test 2	589	559	550	515
Test 3	585	579	572	538
Test 4	584	561	552	525
Test 5	599	588	551	546
Test 6	608	582	565	559
Test 7	587	589	550	539
Test 8	602	583	570	553
Test 9	605	583	582	578
Test 10	590	582	568	566
Test 11	595	591	574	572
Test 12	590	584	572	570

**Crosrol / MOA Carding Test Yarn Properties
(Cottons blended with 0.9 x 1.5" Item "C" Polyester)****Figure 12****CV% of Break (Between Packages)**

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	1.6	1.5	0.5	1.4
Test 2	1.3	0.8	0.7	1.4
Test 3	0.7	0.9	0.4	1.2
Test 4	1.1	1	0.5	1.2
Test 5	0.6	0.7	0.5	0.7
Test 6	1.3	0.7	0.9	1.1
Test 7	0.7	1.1	1.8	1.1
Test 8	2.1	1.5	2.2	1.3
Test 9	4.4	3.5	4	3.4
Test 10	3.2	1.8	3.5	3.2
Test 11	4.8	4.7	4.7	4.5
Test 12	3.6	4.7	3.9	4.2

Uster CV %

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	17.06	16.48	17.69	16.99
Test 2	17.12	16.6	17.86	17.28
Test 3	17.59	16.84	17.98	17.35
Test 4	17.32	16.85	18.28	17.26
Test 5	17.65	17.2	18.53	17.04
Test 6	17.68	17.1	18.54	17.34
Test 7	18.05	17.54	19.92	17.52
Test 8	18	17.54	18.93	17.52
Test 9	18.4	17.7	18.68	17.72
Test 10	18.2	17.82	19.06	17.92
Test 11	18.22	18.05	19.32	18.07
Test 12	18.77	18.28	19.35	18.16

**Crosrol / MOA Carding Test Yarn Properties
(Cottons blended with 0.9 x 1.5" Item "C" Polyester)****Figure 13****Total Imperfections / 1000 yds.****Elongation %**

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	6.6	6.5	6.4	6.2
Test 2	6.8	6.7	6.8	6.4
Test 3	6.9	6.9	7	6.7
Test 4	7	6.6	6.8	6.5
Test 5	7.2	6.8	6.8	6.9
Test 6	7.4	7.1	7.1	7.1
Test 7	7.1	6.9	6.9	6.9
Test 8	7.5	7.2	7.3	7.1
Test 9	7.9	7.5	7.7	7.5
Test 10	7.6	7.3	7.4	7.4
Test 11	8.1	7.9	7.8	7.7
Test 12	8.5	8.2	8.2	8

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	939	828	1188	987
Test 2	1010	916	1313	1122
Test 3	1197	976	1391	1177
Test 4	1145	968	1548	1174
Test 5	1274	1173	1679	1111
Test 6	1339	1162	1707	1244
Test 7	1477	1273	1858	1269
Test 8	1477	1321	1947	1348
Test 9	1746	1441	1819	1366
Test 10	1592	1547	1934	1557
Test 11	1738	1646	2227	1610
Test 12	2022	1785	2333	1747

Uster 1 vd. CV %

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	7.23	6.53	7.33	8.64
Test 2	7.07	6.44	7.31	8.77
Test 3	7.34	6.58	7.38	6.68
Test 4	7.1	6.73	7.44	6.5
Test 5	7.22	6.63	7.57	6.43
Test 6	7.04	6.52	7.48	6.74
Test 7	7.3	6.75	7.55	6.05
Test 8	7.14	6.62	7.5	6.55
Test 9	7.27	6.64	7.5	6.86
Test 10	7.35	6.74	7.6	6.6
Test 11	7.17	6.7	7.57	6.73
Test 12	7.13	6.68	7.44	6.64

Uster 10 vd. CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	2.45	1.94	2.44	2.27
Test 2	2.12	2.02	2.38	2.17
Test 3	2.31	2.09	2.3	2.12
Test 4	2.21	2.09	2.38	2.12
Test 5	2.15	2.11	2.49	2.14
Test 6	2.14	1.95	2.46	2.31
Test 7	2.16	2.06	2.6	2.19
Test 8	2.18	2.08	2.54	2.1
Test 9	2.22	2.1	2.35	2.2
Test 10	2.32	2.31	2.47	2.26
Test 11	2.18	2.22	2.3	2.14
Test 12	2.1	2.03	2.47	2.18

Uster 3 vd. CV%

	Single Texas	Tandem Texas	Single Memphis	Tandem Memphis
Test 1	4.22	4	4.58	4.09
Test 2	4.45	3.92	4.48	3.97
Test 3	4.62	4.03	4.3	3.94
Test 4	4.28	4.21	4.55	4.03
Test 5	4.3	4.1	4.59	4.06
Test 6	4.22	3.91	4.54	4.12
Test 7	4.42	4.1	4.6	4.06
Test 8	4.25	4.07	4.54	4
Test 9	4.36	4	4.42	4
Test 10	4.55	4.24	4.53	4.1
Test 11	4.25	4.04	4.45	3.98
Test 12	4.27	3.99	4.52	4.05