CHARACTERIZING SMALL TRASH PARTICLES AND AN ASSESSMENT OF THEIR IMPACT ON TEXTILE OPERATIONS

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Abstract

Since production of air-jet spun yarns began in the early 1980s, it has often been said that sliver cleanliness is of paramount importance in terms of both yarn quality and spinning performance. The target coarse trash percentage in a 50/50 polyester/cotton blend has usually been quoted as 0.05%. In order to achieve this level of sliver cleanliness, however, a textile plant must usually extract a fairly large percentage of waste in the cleaning line and at the card. This, of course, results in economic loss because good fiber is inevitably lost in the waste. In addition, the aggressive cleaning action required places stress on the fiber. This research was conducted to scientifically determine the effects of trash size and trash level in polyester/cotton sliver on air-jet spinning performance and yarn quality.

Two bales of cotton with varying amounts of trash content and trash size distribution were used in the study. For each bale, settings at the fine opener and card licker-in were changed in order to obtain three levels of trash content. Therefore, a total of 6 sliver conditions were created. Sliver from each condition was spun into 34/1 yarn. The total number of stops and the nature of the stops were recorded during spinning. Quality measurements were made on the yarn from each condition.

Results and Discussion

One Russian bale and one Californian bale of cotton were chosen for the study. The two bales were similar with respect to many properties; however, micronaire, elongation, and nep count were different. High Volume Instrument (HVI) and Automated Fiber Information System (AFIS) test results for both bales are provided in Table I.

Approximately 200 pounds of each bale were processed through the cleaning line at the Institute of Textile Technology (ITT). Cotton was hand-fed into a hopper, transported to a fine opener, and fed to a Marzoli card. The three levels of non-lint content were achieved by altering the fine opener grid-bar settings, licker-in mote-knife setup, and card flat-strip speed. The Marzoli CX300 card has two mote knives under the licker-in. An aluminum plate covered the second opening to achieve less waste removal and, thus, less cleaning for four of the six conditions. Details of the opening and carding setups are provided in Table II. Separately, 600 pounds of 0.95 d.p.f. x 1.5 in. Hoechst Celanese L-70 polyester were carded on the Marzoli card. The polyester sliver weight produced was 49 grains per yard. AFIS multidata results for the cotton card sliver are shown in Table III.

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The cotton and polyester slivers were drawframe blended on the ITT's RSB-851 drawframe. The third drawing pass was leveled. The resulting finisher sliver was a 47/53 polyester/cotton blend and 40 grains per yard. Uster test results for the finisher sliver are given in Table IV. Short-term evenness (%CV) values between the two cotton types are different; but, in general, the values within a cotton type are equivalent. Finally, in a 47/53 polyester/cotton blend, the levels of %visible foreign matter for each condition are as follows:

- Russian Cotton
  - Clean → 0.06
  - Medium → 0.08
  - Dirty → 0.13

- Californian Cotton
  - Clean → 0.16
  - Medium → 0.16
  - Dirty → 0.30

Sliver from the six conditions was used to spin 34/1 yarn on ITT's 802H spinning frame. The setup used at spinning is provided in Table V. Yarn was spun on 14 positions for a total of exactly 12 spinning hours per condition. For each stop, a determination was made as to type and cause, if possible. Results of overall spinning stops are shown in Table VI. Finally, yarn from each condition was tested for Mill Quality Control (MQC) properties (three Classimat tests per condition). The results of these tests are provided in Tables VII and VIII.

Statistically, comparisons of mean were performed using the T-test. Analysis of variance (ANOVA) was used to determine the relationship of non-lint components (dust and trash) and spinning performance (red-flags and slub-cuts). All T-test and ANOVA's were processed on SYSTAT software.

The Influence of Non-Lint Content on Spinning Stops

Spinning stop results for the six conditions are depicted graphically in Figure 1. As shown on this graph, red flags increased as finisher sliver %V.F.M. increased.

The influence of finisher sliver %V.F.M. on total red flags and slub cuts is shown in Figures 2 and 3, respectively. Both figures depict a linear increase in stops with an increase in %V.F.M.

It is obvious when viewing Figures 2 and 3 that the most extreme point 0.30% V.F.M. is outside the practical range of finisher sliver %V.F.M. found in modern MJS plants. Most plants achieve finisher sliver %V.F.M. levels of roughly 0.04% to 0.15%. Therefore Figures 4 and 5 were produced to show the influence of finisher sliver %V.F.M. on spinning stops in a more practical range. A strong relationship still exists between finisher sliver %V.F.M. and red flags. There is an indication that red flags increase significantly when finisher sliver %V.F.M. is higher than approximately 0.10%. However, as shown in Figure 5, slub cuts cannot be predicted from sliver %V.F.M. in this case. The relationship between finisher sliver % V.F.M. and N_2 nozzle chokes is shown in Figure 6.

The Influence of AFIS Trash Size on Spinning Stops

The average trash size contained in the card sliver was calculated manually from the AFIS histogram of trash and dust size and amount. This was necessary because the AFIS report of trash size is the average of trash (>500μ) and dust (<500μ). The results of the manual calculation of trash size are listed in Table III.

The relationship between trash size and red flags and slub cuts is depicted in Figures 7 and 8. It was expected that the size of the trash particles would have a greater influence on spinning performance than indicated. Although

the relationships are not extremely weak, they account for less than half of the stops in spinning.

The Influence of AFIS Dust Count on Spinning Stops

The total dust count in card sliver samples for each condition is reported in Table III. As depicted in Figures 9 and 10, dust (<500μ) count has a great influence on stops (red flags and slub cuts) in air-jet spinning. Considering the size of the jet orifice in the air-jet spinning nozzles (between approximately 0.01 – 0.016 inches), it is not that surprising that dust would cause an interruption to the formation of yarn in an air-jet nozzle. When considering that dust particles are as large as 0.02 inches in size and less, it is quite reasonable to expect dust to deposit in the orifice of the nozzle jets.

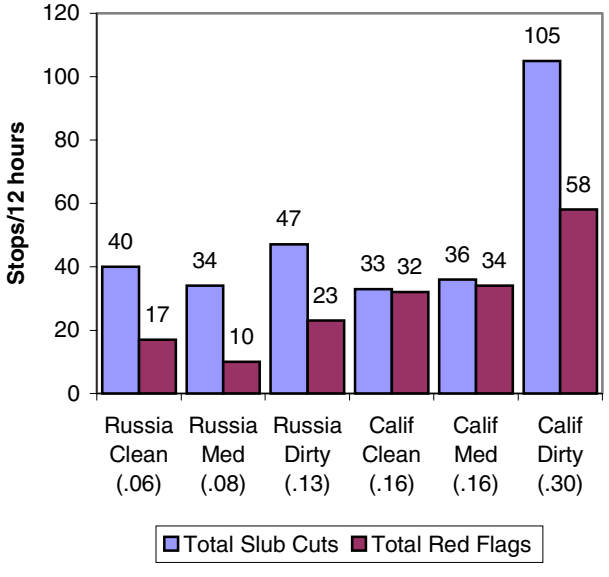
The Influence of Non-Lint Content on Yarn Quality

Complete data sets for all conditions are shown in Tables VII and VIII. It is shown in Table VII that Uster %CV, %CV 1-yard, %CV 3-yard, thicks (+50%), neps (+200%), minors, and long thins increase with increasing finisher sliver %V.F.M. Most of these properties were expected to deteriorate with increasing non-lint content. Tensile properties were generally equivalent for yarn from the three conditions. A few of these relationships are depicted graphically in Figures 11, 12, and 13.

Summary

The following summary statements can be made based on this research:

- Red flags increased significantly with increasing finisher sliver %V.F.M.
- Slub cuts could not be predicted from finisher sliver %V.F.M. within practical %V.F.M. range of 0.06 to 0.13%.
- A relationship exists between finisher sliver %V.F.M. and N_2 nozzle chokes.
- A relationship exists between trash size and spinning stops.
- Dust count has a reasonably strong relationship with red flags and slub cuts.
- Uster %CV, %CV 1-yard, %CV 3-yard, thicks (+50%), neps (+200%), minors, and long thins all increased with increasing %V.F.M. for the Russian cotton.



Note: Finisher Sliver % VFM values are shown in parentheses.

Figure 1. Overall spinning stop results.

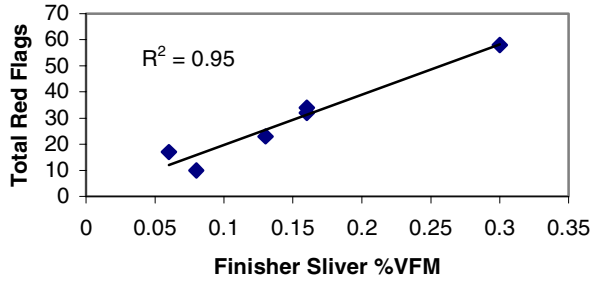


Figure 2. Influence of finisher sliver % V.F.M. on total red flags (all points included).

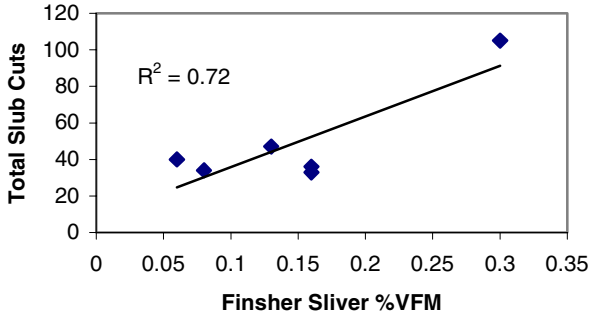


Figure 3. Influence of finisher sliver % V.F.M. on total slub cuts (all points included).

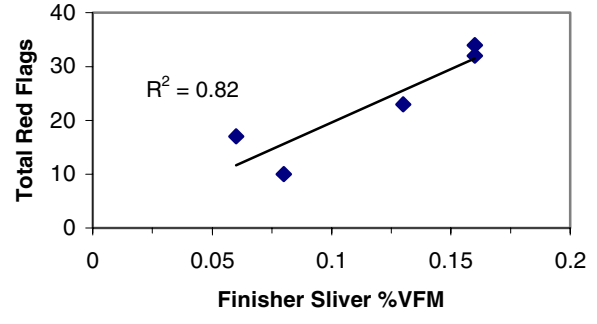


Figure 4. Influence of finisher sliver %V.F.M. on total red flags.

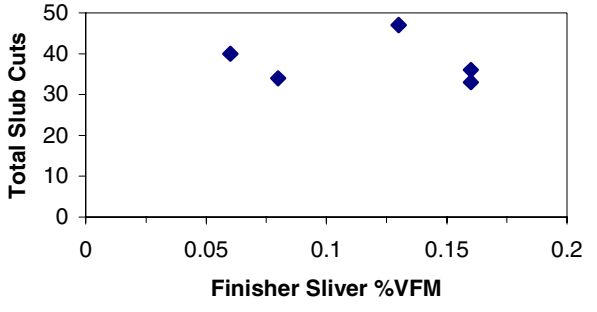


Figure 5. Influence of finisher sliver % V.F.M. on total slub cuts.

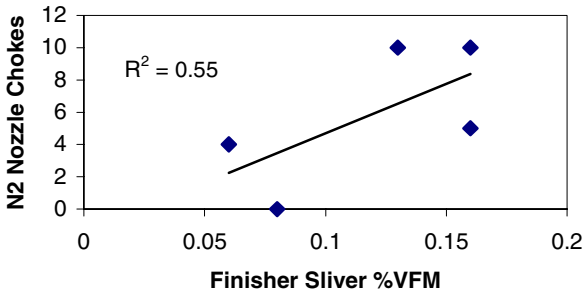


Figure 6. Relationship between finisher sliver %V.F.M. and N_2 nozzle chokes.

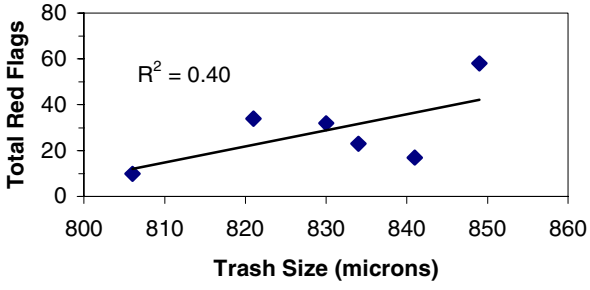


Figure 7. Influence of trash size on total red flags.

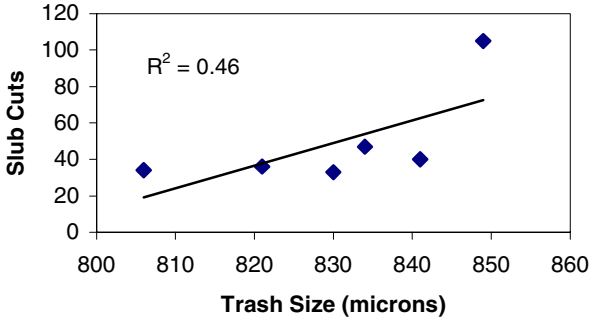


Figure 8. Influence of trash size on slub cuts.

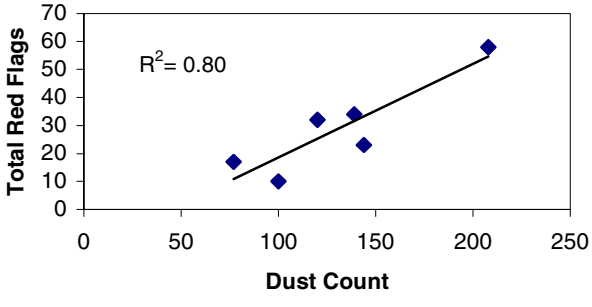


Figure 9. Influence of dust count on total red flags.

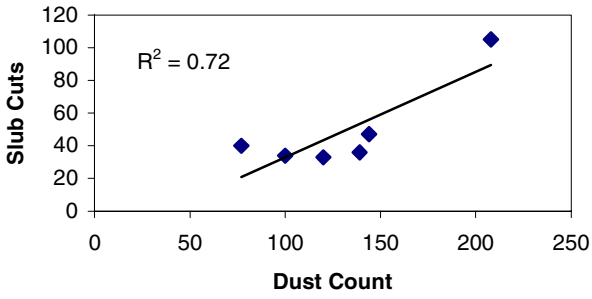


Figure 10. Influence of dust count on slub cuts.

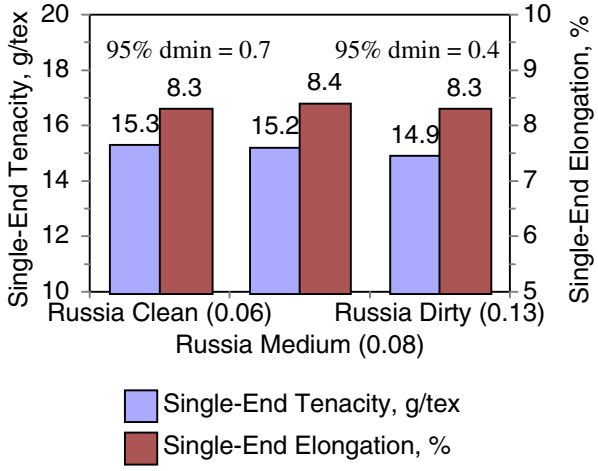


Figure 11. Relationship between finisher sliver % V.F.M. and yarn tensile properties.

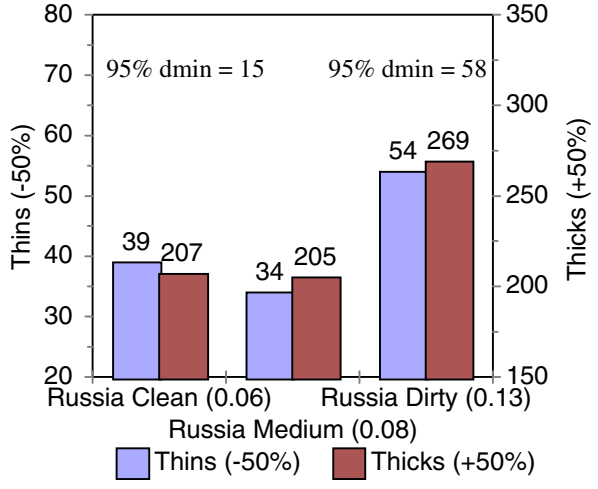


Figure 12. Relationship between finisher sliver %V.F.M. and IPI defects.

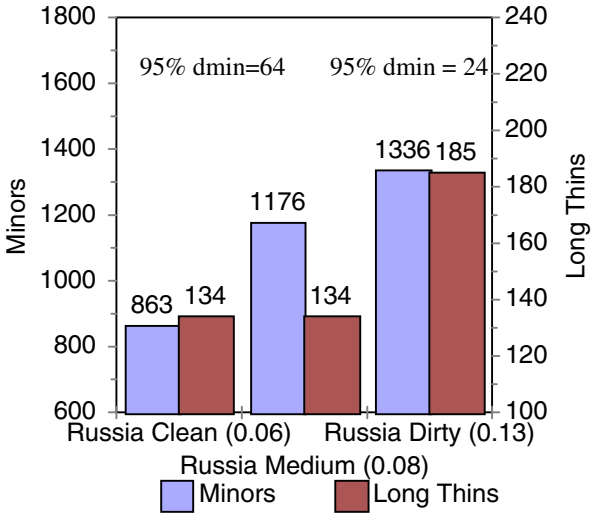


Figure 13. Relationship between finisher sliver %V.F.M. and Classimat defects.

Table 1. HVI and AFIS results for Russian and Californian cottons.

Property	Russian	Californian
HVI:		
Micronaire	4.7	4.0
U.H.M.L., (inches)	1.12	1.15
U.I.	83.9	82.9
Tenacity, (g/tex)	31.1	31.0
Elongation, (%)	8.0	6.0
Rd	78.1	76.6
+b	9.7	8.1
Grade	21	31
Leaf	2	4
AFIS:		
Neps/gram	178	309
Mean Length, (inches)	0.97	0.98
U.Q.L., (inches)	1.17	1.18
Fiber < ½-inch, (%)	7.2	7.1
%V.F.M.	0.93	1.19
Trash Size, (μ*)	800	833
Dust Count/g	305	371

*Manually calculated from AFIS histograms.

Table II. Opening line and carding setup for cleaning cotton.

Parameter/	Russian Cotton			Californian Cotton		
Setting	Clean	Med	Dirty	Clean	Med	Dirty
F.O. Grid Bars	Open	Closed	Closed	Open	Closed	Closed
Lickerin Mote						
Knife No. 1	Open	Open	Open	Open	Open	Open
Knife No. 2	Open	Closed	Closed	Open	Closed	Closed
Flat Strip Speed						
Inches/min.	6	6	Stopped	6	6	Stopped
Waste, %	6.5	4.9	2.4	5.7	4.4	2.5
Sliver Wt., gr/yd	53	53	53	53	53	53

Table III. AFIS MULTIDATA Results for card sliver.

		AFIS L&D, by weight					
Lot I.D.	Neps/ Gram	UQL. In.	SFC %	% VFM	Trash Size, μm*	Dust Ct./ Gram	Trash Ct./ Gram
Russian Cotton:							
Clean	80	1.17	6.3	0.12	841	77	6
Med	85	1.17	6.7	0.15	806	100	7
Dirty	82	1.17	6.5	0.25	834	144	12
Calif Cotton:							
Clean	225	1.19	5.9	0.31	830	120	19
Med	181	1.18	5.9	0.31	821	139	20
Dirty	191	1.18	6.3	0.56	849	208	34

*Manually calculated from AFIS histograms.

Table IV. Evenness Results for finisher sliver.

Lot ID	%CV	%CV, 1-Yard	%CV, 3-Yard
Russian Cotton:			
Clean	4.04	1.00	0.83
Medium	4.34	1.06	0.82
Dirty	4.24	0.83	0.53
Calif Cotton:			
Clean	4.63	0.98	0.61
Medium	4.69	1.06	0.65
Dirty	4.79	0.94	0.55

Table V. MJS Setup for trash strudy.

Machine Parameter	Setting
Spinning Speed, (m/min.)	260
Total Draft	168
Main Draft	50
Feed Ratio	0.98
Take-up Ratio	0.99
Condensor Size, (mm)	3
N_1 Pressure, ($kg/cm^{2)}$	2.5
N_2 Pressure, ($kg/cm^{2)}$	5.0
Slub Setting	2.0 cm, + 120%
Thicks	0.35
Thins	- 35%
Room Temperature, °F	75
Room %RH	43

Table VI. Overall spinning stops results.

% FFM Type of Stop	Russia Clean (0.06)	Russia Med (0.08)	Russia Dirty (0.13)	Calif. Clean (0.16)	Calif. Med (0.16)	Calif. Dirty (0.30)
Slub Cuts, No.	40	34	47	33	36	105
Spun-In	32	27	29	29	30	91
Fly	2	3	11	4	6	8
Stem	6	4	7	0	0	6
Red Flags, No.	17	10	23	32	34	58
Roll Laps	2	0	0	7	8	24
N_1 Chokes	0	2	1	5	0	3
N_2 Chokes	4	0	10	10	5	13
Quality Cuts	9	5	7	7	20	10
Unknown	2	3	5	3	1	8
Total Stops	57	44	70	65	70	163

Table VII. MQC Summary for Russian cotton conditions.

Property	Russia Clean	Russia Med	Russia Dirty	95% Conf. Limit	Sign. Diff?
Yarn Count	34.1	34.1	34.7	--	No
Yarn Count (%V_b)	0.7	0.6	1.1	--	No
Skein Strength, lbs.	69.9	70.2	67.2	4.4	No
Skein Strength (%V_b)	5.1	5.0	7.1	--	No
S-End Strength, grams	264.5	262.9	253.9	12.0	No
S-End Strength (%V_o)	9.2	10.9	11.5	--	Yes
S-End Tenacity, g/tex	15.3	15.2	14.9	0.7	No
S-End Elongation, %	8.3	8.4	8.3	0.4	No
S-End Elongation (%V_b)	5.3	4.2	4.3	--	No
%CV	15.89	15.89	16.43	0.35	Yes
%CV (%V_b)	1.3	1.6	2.7	--	Yes
%CV, 1-Yard	5.96	6.07	6.28	0.16	Yes
%CV, 3-Yard	4.14	4.24	4.40	0.16	Yes
%CV, 10-Yard	2.47	2.59	2.70	0.21	Yes
%CV, 50-Yard	1.08	1.02	1.06	0.20	No
Thin Places (-50%)	39	34	54	15	Yes
Thick Places (+50%)	207	205	269	58	Yes
Neps (+200%)	348	347	438	81	Yes
Classimat Minors	862.9	1175.9	1335.6	64.1	Yes
Classimat Majors	0.9	1.8	4.0	2.9	Yes
Long, Thick Places	0.0	0.6	1.8	1.7	Yes
Long, Thin Places	134.4	134.4	184.7	23.5	Yes
Uster, Hairiness	5.20	5.27	5.24	0.28	No

Table VIII. MQC Summary for California cotton conditions.

Property	Calif. Clean	Calif. Medium	Calif. Dirty	95% Conf Limit	Sign Diff ?
Yarn Count	33.5	33.8	33.5	--	No
Yarn Count (%V_b)	0.9	1.4	0.7	--	No
Skein Strength, lbs.	74.4	70.4	72.8	2.7	Yes
Skein Strength (%V_b)	3.2	3.5	3.5	--	No
S-End Strength, grams	262.7	260.3	264.1	10.0	No
S-End Strength (%V_o)	9.6	10.4	9.4	--	No
S-End Tenacity, g/tex	14.9	14.9	15.0	0.6	No
S-End Elongation, %	7.4	7.6	7.6	0.4	No
S-End Elongation (%V_b)	5.2	3.3	6.2	--	Yes
%CV	15.98	16.54	16.11	0.33	Yes
%CV, 1-Yard	6.36	6.98	6.95	0.24	Yes
%CV. 3-Yard	4.60	5.15	5.16	0.25	Yes
%CV, 10-Yard	2.97	3.52	3.58	0.35	Yes
%CV, 50-Yard	1.61	1.69	1.76	0.34	No
Thin Places (-50%)	26	34	22	8	Yes
Thick Places (+50%)	261	287	270	58	No
Neps (+200%)	455	517	456	78	No
Classimat Minors	2421.9	1455.7	2076.3	85.1	Yes
Classimat Majors	6.7	1.8	3.6	3.8	Yes
Long, Thick Places	1.9	4.0	2.7	3.2	No
Long, Thin Places	255.4	240.8	308.5	31.3	Yes
Uster Hariness	5.02	5.26	5.23	0.20	Yes