AN INVESTIGATION OF THE EFFECTS OF CLEAN REWORKABLE WASTE ON THE QUALITY OF A 37s 50/50 POLYESTER/COTTON RING SPUN YARN

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Abstract

The following study deals with the ever present problem of waste handling. Clean reworkable waste refers to primarily sliver from piece-ups, roving bobbin strips, and pneumafil. To start, the source and amount of clean reworkable waste produced was studied at a sheeting yarn manufacturing facility. This study yielded an approximate rate and proportion at which clean reworkable waste should be added. It was found that pneumafil accounted for approximately 40% of the total waste while roving bobbin strips made-up about 25%. For the study a 37s 50/50 polyester/cotton yarn was produced using Clemson University laboratory manufacturing equipment. Separate forms of clean reworkable waste were added at 3.5% to the polyester lay down. A blend of the waste forms was added at 3.5%, 7.0% and 10.5%. Testing was performed on the Uster Evenness Tester II, Classimat, Statimat II, and Scott Tester.

Results of the testing found that adding 10.5% of the optimum blend yielded skein break factors, tenacity, elongation, work and major fault values significantly worse than the other waste combinations. The samples with no waste and 3.5% of the optimum blend usually illustrated more desirable results. According to the study, the different individual forms of waste added at 3.5% showed similar results with the exception of the polyester/cotton drawing sliver which generally conveyed worse values.

Introduction

Clean reworkable waste refers to potentially good fibers which have been kicked out of the system. Reasons for fiber waste include mechanical difficulties, quality problems, and piecing-up. These fibers may be recovered and put back into the system. However, the processing to which the fibers have been exposed may have stretched, decrimped, and broken some fibers.

In manufacturing the goal is to produce the required yarn quality at the lowest possible cost. Since a large portion of the yarn cost is due to fibers, it is desirable to use the waste created during production (Putzschler and Wulfhorst). A few issues need to be addressed before considering the use of reworkable waste. One should be aware of the source, or production of waste and how to effectively utilize reworkable waste.

Waste is produced at almost every stage of manufacturing. Generally, waste can be divided into three categories, namely, dirty, clean, and hard. Examples of dirty waste are card flats, blow room waste, and ginning waste. Clean waste refers to sliver, noils, and pneumafil. Finally, hard waste is comprised of twisted roving, yarn and fabric. Dirty, clean, and hard waste each require different preparatory steps for salvaging fibers. For instance, dirty waste requires an opening and cleaning stage while clean waste may require only an opening step. Hard waste needs special opening, or shredding (Binder).

After addressing the issue of waste preparation, the focus turns to how the waste will effect the quality of the yarn. This is the focus of the current study.

Prior studies have dealt mainly with 100% cotton ring spun and open-end rotor yarns with reclaimed fibers from dirty waste. Yarn properties studied were unevenness CV%, thick and thin places, neps, single-end strength, and skein break factor. These studies suggest that adding reclaimed fibers up to 2.5% have no significant effect on a 30s ring spun yarn quality. For 20s rotor yarn the amount of reclaimed fibers which may be added without a significant effect is 5%. Previous studies state that during processing fibers may become decrimped, stretched, and broken. This leads to a loss in cohesion, higher short fiber content, more thick and thin places, and a greater degree of hairiness (Putzschler; Wulfhorst; Yankey).

This project deals with a 50/50 polyester/cotton blend ring spun yarn. The yarn count selected was a 37s with a twist multiplier of 3.7. A production study was performed at a yarn manufacturing facility to determine the sources of clean waste and the rate at which clean waste is produced. The “optimum” blend and percentage of waste added to the polyester lay down for this waste project was calculated from the production study.

Objectives

The objectives of this investigation are:

1. To rank individual types of clean reworkable waste according to their effects on yarn quality and compare them to a control yarn without waste;

2. To compare the yarn quality of the following;

    a. optimum blend at 3.5%, 7%, and 10.5% vs. control with no waste;
    b. optimum blend vs. waste forms added individually;
    c. bale of waste - top layer vs. bottom layer vs. blend of top and bottom layer; and

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d. bale blended by an outside source vs. baled waste vs. control with no waste.

Materials and Methods

Materials

Cotton, polyester, and waste samples were collected from a yarn manufacturing facility. Cotton samples was taken from a 28 bale cotton mix laydown. Pure polyester fibers were collected from the 28 bale polyester mix laydown. The bale of waste used in the investigation was randomly chosen from the warehouse. In addition, clean waste samples were collected at each process.

Processing

Clemson University laboratory equipment was used to manufacture the yarn. The cotton was processed separately through carding. Blending of the cotton and polyester was performed at the first drawing step. The waste was added to the polyester at opening on the conveyor belt behind the hoppers. Carding sliver, drawing sliver, and roving samples were collected for testing Uster CV% in order to track the consistency of the manufacturing processes.

Specific processing instructions are listed below:

1. A 60 gr/yd cotton card sliver was produced. This card sliver was used throughout the investigation.

2. Sixteen different combinations of polyester and waste were processed. Those same sixteen combinations were repeated in order to justify the results. The order of the combinations for manufacturing was randomized to help prevent biased results. The following are the sixteen combinations used in the investigation:

a) No waste - control sample
b) 3.5% Baled waste - fiber from the top layer
c) 3.5% Baled waste - fiber from the bottom layer
d) 3.5% Blended baled waste - fibers from the top and bottom layers
e) 3.5% Bale of waste blended by an outside vendor
f) 3.5% Cotton card waste
g) 3.5% Polyester card waste
h) 3.5% Cotton pre-draw sliver
i) 3.5%Polyester/Cotton sliver from breaker draw and finisher draw
j) 3.5% Cotton lapper waste
k) 3.5% Cotton comber waste
l) 3.5% Roving bobbin strips - already opened by fiber supplier
m) 3.5% Spinning pneumafil
n) Optimum blend of waste processed at 3.5%, 7%, and 10.5%. The optimum blend proportions were predetermined as follows:

i.	Cotton card waste	2.5%
ii.	Polyester card waste	2.5%
iii.	Cotton Pre-draw sliver	2.0%
iv.	Polyester/Cotton sliver	15.0%
v.	Cotton lapper waste	3.0%
vi.	Cotton comber waste	13.0%
vii.	Roving bobbin strips	20.0%
viii.	Spinning pneumafil	42.0%

3. Four cans of polyester card sliver and four cans of cotton card sliver were blended at breaker drawing to make a 50/50 blend. A 58 gr/yd breaker sliver was produced. The first 500 yards were run for testing. The remaining yards were divided into eight pads for finisher drawing.

4. During finisher drawing a 56 gr/yd sliver was processed. Approximately 500 yards were run for testing. The remaining yards were divided into nine pads for the roving step.

5. Nine roving bobbins were produced with a hank roving of 1.25. One bobbin was used for testing while the remaining eight continued to the spinning process.

6. Finally a 37s count ring spun yarn was produced. For each trial or fiber combination, eight bobbins were spun to produce 1.5 pounds of yarn.

Testing

Uster II Evenness Tester was employed to test sliver, roving, and yarn (ASTM D1425-89). Neps, thick places, thin places, and CV% were recorded for four packages of yarn for each trial. Other yarn tests performed include skein break on the Scott tester (ASTM D1578-93), yarn linear density (ASTM D1907), twist (ASTM D1422), Statimat II single-end tester, and Classimat II. Eight packages per trial were tested on the Scott Tester and averaged. One hundred breaks per trial were performed on the Statimat and averaged. Finally, on the Classimat II approximately 30,000 yards of yarn were run for each trial. The results were then calculated for 100,000 yards for comparison.

Results and Discussion

For this study it was chosen to place the waste in the polyester lay down. Reasons being that the waste fibers have already been exposed to processing which could have stretched, decrimped, and broken the fibers. These waste fibers are basically clean and further harsh cleaning in the cotton line may damage the fibers further.

When adding waste to a 50/50 blend one should be aware of the blend proportions of the waste. For instance placing 100% cotton waste in the polyester lay down at 3.5% of the final product (2 bales of a 28 bale lay down) may swing the ratio to 46.4% polyester and 53.4% cotton. Meanwhile using the “optimum” blend proportions at 10.5% may yield a finished product with 43.7% polyester and 56.3% cotton. Unless sliver weights are adjusted to compensate for the cotton added to the polyester line, future problems in consistency of product or shade matching may arise.

Statimat testing (Table 1) showed that the polyester/cotton drawing sliver and 10.5% optimum blend combinations yielded significantly worse results for elongation, work, and tenacity. On the other hand, the samples containing 3.5%

of the optimum blend and samples without waste gave better values. Also, waste samples containing 100% polyester waste, namely polyester card waste and baled polyester layer, fared better than the other trials.

For the Classimat testing (Table 2) the Major faults were significantly greater in the 7% and 10.5% optimum blend samples than the 3.5% optimum blend and no waste samples. The pneumafil trial showed the worst major fault values.

The Uster Evenness CV (Table 3) was not significantly different between any of the trials. For thin places, thick places and neps the 3.5% optimum blend performed better than the control mix. However, the 7% and 10.5% optimum blend had a higher number of thin places and neps than the control mix. Results from the polyester waste bale showed the highest number of neps, thin places and thick places.

The skein break factor (Table 4) for the sample without waste and the one with 3.5% optimum blend were significantly better than the rest of the trial results. The lowest break factor was obtained from the 10.5% optimum blend followed by the mix containing polyester/cotton drawing sliver.

Conclusion

As illustrated in this study, adding waste at 10.5% to the lay down may have adverse effects on sheeting yarn quality. Because some forms of waste, namely polyester/cotton drawing sliver and pneumafil, may effect quality different than others, blending the individual forms of waste may help maintain a more consistent quality level.

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Table 1. Average results for Statimat II testing.

Trial	E (%)	F (g)	W (cm*g)	T (g/den)
No Waste	10.80	324.92	345.29	2.20
Cotton Card Waste	10.51	326.61	340.05	2.18
Polyester Card Waste	10.59	329.77	351.75	2.24
Pre-Draw Waste	10.29	340.68	325.59	2.31
Lapper Waste	10.38	322.38	327.39	2.16
Comber Waste	10.40	317.94	330.28	2.15
P/C Drawing Sliver Waste	10.13	295.85	305.08	2.02
Bobbin Strips	10.49	318.35	334.73	2.14
Pneumafil	10.64	320.08	336.39	2.18
3.5% Optimum Blend	10.49	326.55	341.20	2.21
7% Optimum Blend	10.60	323.95	334.85	2.17
10.5% Optimum Blend	7.15	297.97	282.70	2.04
Baled Waste - Pneumafil Layer	10.39	313.60	325.66	2.17
Baled Waste - Polyester Layer	10.66	329.72	355.43	2.22
Baled Waste - Blended Layers	10.51	314.26	331.64	2.17
Baled Waste - Outside Vendor	10.59	326.96	344.28	2.19

E: Elongation; F: Force; W: Work to Rupture; T: Tenacity.

Table 2. Average results for the Classimat II testing expressed as faults per 100,000 yards.

Trial	Short Thick			Thin				
	Major	Total	A-1	H-1	H-2	I-1	I-2	E,F,G
No Waste	10.0	2018	1475	949	22.7	5.5	1.3	10.9
Cotton Card Waste	9.2	2036	1517	967	4.6	9.3	1.6	7.7
Polyester Card Waste	19.6	2006	1425	806	1.4	7.4	3.0	9.1
Pre-Draw Waste	29.6	1953	1374	1145	50.9	59.9	55.4	35.4
Lapper Waste	15.4	2072	1482	964	29.4	93.0	72.2	15.7
Comber Waste	27.0	2114	1427	941	33.0	73.4	55.3	7.8
P/C Drawing Sliver Waste	32.1	2550	1753	1211	38.3	33.0	18.2	14.7
Bobbin Strips	18.7	2255	1555	981	6.3	7.7	1.6	16.5
Pneumafil	48.1	2746	1822	1102	7.7	13.8	7.7	13.8
3.5% Optimum Blend	6.3	1877	1344	972	46.8	74.1	58.1	48.4
7% Optimum Blend	17.5	2420	1799	1042	9.6	11.2	9.6	8.0
10.5% Optimum Blend	13.0	1950	1444	1162	76.4	94.4	75.7	13.0
Baled Waste-Pneumafil Layer	11.3	2017	1490	970	69.9	112.7	86.5	9.6
Baled Waste-Polyester Layer	3.3	2143	1543	1090	3.3	6.7	3.3	13.3
Baled Waste-Blended Layers	6.6	1944	1421	813	1.6	3.3	1.6	9.7
Baled Waste-Outside Vendor	9.4	1906	1334	934	68.8	115.6	96.9	9.4

Table 3. Average results for the Uster Evenness testing.

Trial	Avg. CV	Avg. Thin	Avg. Thick	Avg. Neps
No Waste	20.53	329	1171	1779
Cotton Card Waste	20.63	338	1202	1842
Polyester Card Waste	19.76	269	1044	1840
Pre-Draw Waste	20.07	324	1107	1886
Lapper Waste	20.35	350	1167	1895
Comber Waste	20.17	312	1109	1802
P/C Drawing Sliver Waste	20.50	346	1134	1919
Bobbin Strips	20.67	396	1177	1962
Pneumafil	20.50	381	1178	1815
3.5% Optimum Blend	20.06	309	1095	1714
7% Optimum Blend	20.43	348	1077	1835
10.5% Optimum Blend	20.47	343	1080	1823
Baled Waste - Pneumafil Layer	20.59	399	1221	1941
Baled Waste - Polyester Layer	21.10	494	1332	2134
Baled Waste - Blended Layers	20.23	358	1131	1851
Baled Waste - Outside Vendor	20.38	377	1168	1926

Table 4. Average results for the Skein Break test using the Scott Tester.

Trial	Avg. Skein Break Factor	% CV
No Waste	2945	2.50
Cotton Card Waste	2877	3.00
Polyester Card Waste	2854	3.26
Pre-Draw Waste	2841	2.53
Lapper Waste	2833	3.49
Comber Waste	2816	3.11
P/C Drawing Sliver Waste	2782	5.25
Bobbin Strips	2896	3.68
Pneumafil	2820	2.41
3.5% Optimum Blend	2923	3.63
7% Optimum Blend	2875	3.35
10.5% Optimum Blend	2673	2.76
Baled Waste - Pneumafil Layer	2835	2.43
Baled Waste - Polyester Layer	2845	4.52
Baled Waste - Blended Layers	2861	2.51
Baled Waste - Outside Vendor	2859	3.69