Cotton fiber for nonwovens

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ABSTRACT *Compared with the three leading fibers (polyolefins, polyesters, and rayons), very little cotton is currently used in the nonwoven fabrics industry. The objective of a recently initiated project at the Southern Regional Research Center, U.S. Department of Agriculture, has been to investigate cotton-containing nonwoven textiles with properties acceptable for consumer uses. The purpose is more utilization of cotton. Thermal bonding has been selected as the major technique for producing fabric integrity, but other techniques also will be examined. Initial research involved fiber analysis, opening and blending performance, uniformity, and processibility of bleached cottons, with and without lubricant finishes. Fabric properties of calendered cotton and polypropylene blends from an initial trial run also were evaluated.*

KEYWORDS
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Thermal bonding
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According to the National Cotton Council, cotton's percentage share of the total market of competing materials for *all* end-use consumption in the United States was approximately 30% (*1*). This is in sharp contrast to the 4% of cotton consumed in the nonwoven industry (*2*, *3*). The nonwovens market is almost equally divided between disposable (55%) and durable (45%) fabrics. The leading fiber used in the disposable market is polypropylene (*4*, *5*), and the other major fibers are polyester and rayon. The popularity of synthetic fibers in the nonwoven fabrics industry is attributed to low cost, uniformity, ease of processing, and a wide range of properties that include deniers, lengths, and degree of crimp.

The use of cotton fibers in nonwovens has received recent attention due primarily to competitive pricing and the issue of waste disposal (*6*). Waste disposal is of major concern to the synthetic-oriented nonwovens industry. Recycling has been proposed as a viable answer to this problem, and research also has been directed toward making plastics susceptible to biodegradation. This topic was addressed recently by Lichstein (*7*). An advantage of cotton is that it is naturally biodegradable.

It is important for information to be provided on the properties of bleached cotton used for nonwovens. The commercial supply of bleached cotton used in nonwovens currently is produced by a batch process. In an effort to offer the industry a more uniform product, Cotton Inc. (CI) has developed a continuous process for bleaching cotton fibers. The process is not yet used commercially in the United States, but Edward Hall & Sons, United Kingdom, is currently producing bleached cotton using the CI process (*8*).

The objective of the current investigation at the Southern Regional Research Center (SRRC), U.S. Department of Agriculture, was to determine which fiber properties might be used to predict which cottons are best suited for nonwovens. Bleached cottons, with and without lubricant finishes, were evaluated for uniformity, processibility, and quality, as well as for opening and blending performance. Fiber properties were compared with raw (bale) and gray (mechanically cleaned) cotton. The ultimate objective is to investigate cotton-containing products with properties acceptable for consumer uses. In an initial trial run, two cotton and polypropylene (C/PP) blends were prepared and the properties compared with a 100% polypropylene fabric.

Methods and materials

Fabric properties

The following physical tests were performed under standard conditions (65% RH and 21°C) according to American Society for Testing and Materials (ASTM) methods (*9*): air permeability, D-737-75 (reapproved 1980); tearing strength, D-1424-83; breaking strength and elongation (1C-E), D-1682-64 (reapproved 1975); flex abrasion, D-3885-80; and bursting strength, D-3786-87. Stiffness, reported as bending moment, was obtained by the Tinius Olsen method (*10*). For wicking tests, a modified version of

I. Effect of bonding temperature and blend level on breaking strength (machine direction)

Bonding temp., °C	*Force, N* 100% PP	50/50 C/PP	75/25 C/PP
150	12.5	...	...
152.5	20.0	...	...
155	28.0	10.2	...
160	38.3	17.8	10.7
162.5	Stiff	20.0	4.5
165	...	22.2	16.9
167.5	...	Stick	14.7
170	...	...	14.2

II. Analysis of cotton/polypropylene (C/PP) nonwoven fabrics

Nominal blend	*Bonding temp., °C*	*PP found, %*
50/50	155	47.2
C/PP	160	51.6
	162.5	53.8
	165	54.9
75/25	160	32.5
C/PP	162.5	18.4
	165	26.7
	167.5	23.0
	170	25.1

III. Verification of analysis for cotton/polypropylene (C/PP) blends

Nominal blend	*PP known, %*	*PP found, %*
85/15	15.06	15.65
	15.11	15.69
60/40	40.23	40.51
	40.38	40.66
30/70	70.53	70.65
	70.02	70.19

the INDA (Association of the Nonwoven Fabrics Industry) method was used in which samples were immersed 2.54 cm (1 in.), and the times to reach 2 and 3 cm were recorded (*11*).

Analysis of cotton and polypropylene blend fabrics

Approximately 1 g of fiber blend was accurately weighed after equilibration under standard conditions. The fibers were added to a beaker equipped with a magnetic stirring bar and containing 100 mL of xylene (b.p. 138-140°C). The beaker was placed on a hot plate and stirrer, and the solution was heated to a vigorous boil. The beaker was equipped with a beaker condenser to maintain a constant volume of solvent. The fibers were heated at the boil for 7 min. The undissolved cotton fibers in the hot solution were filtered through a 40-mL Coors 4 porcelain crucible. The residue fibers were washed two times with hot xylene, two times with cold xylene, and then two times with cold acetone. Slight vacuum was applied after each washing. The residual fibers were thoroughly dried, allowed to equilibrate under standard conditions, and then accurately weighed. The percentage of cotton in the blend was determined from the equation:

% cotton = [wt. of residue (100)]/(original wt. of total fibers).

IV. Physical properties of nonwoven fabrics at optimum bonding temperature (machine direction except as indicated)

	100% PP	*50/50 C/PP*	*75/25 C/PP*
Breaking strength, N	48.5	20.0	14.2
Cross direction	7.6	5.8	1.8
Elongation, %	79.8	28.7	17.0
Abrasion, cycles	165	118	34
Cross direction tear strength, mN	1569	1442	981
Bursting strength, kPa	84.8	73.8	43.4
Stiffness, $N \cdot m \times 10^{-5}$	5.8	7.6	4.3
Air permeability, $[(m^3/s) / m^2] \times 10^{-2}$	182	132	133
Wicking time, s			
To 2 cm	9	6	6
To 3 cm	21	16	16

Fiber analysis

Cotton used in fiber and yarn evaluation came from the same lot, which was supplied by Cotton Inc. Bleached cottons, with and without lubricant finishes, were produced by CI's continuous line in Greenville, S.C. Finishes applied to bleached cottons were butoxyethylstearate (BES) from Stepan Co., Maywood, N.J.; Sonostat 668 from Henkle Co., Charlotte, N.C.; and Dow 1111 silicone from Dow Corning Corp., Greensboro, N.C.* Gray cotton is mechanically cleaned cotton that has not been subjected to wet processing. Raw cotton is cotton taken directly from the bale. Polypropylene (PP) was supplied by Fiber Technical Center, Hercules Inc., Oxford, Ga.

ASTM methods (*9*) were used for Stelometer tensile and elongation, D-1445-75; Fibrograph span length and uniformity ratio, D-1447-83; and Shirley IIC micronaire/fineness/maturity D-3818-79 (reapproved 1984). These tests were run by the International Center for Textile Research and Development (TRC), Lubbock, Tex. The Peyer test, which is a proposed ASTM method, was used to determine mean length and percentage of short fibers (*12*). The number of neps per gram of fiber were counted from a carded single web (*13*).

The shear friction test was performed according to the method described by Cheng and Duckett (*14, 15*). Openness value (OV) was determined according to a modified version of the method described by Szaloki (*16*). Twenty-five grams of each fiber was placed into a 4-L graduated cylinder and the volume determined. The fibers were processed two times through the Spinlab opener and blender and the volumes measured after each pass.

Yarn analysis

A nominal 27-mg/m (22/1 yarn count) ring-spun yarn was prepared from various cottons. The performance of

*Names of companies or commercial products are given solely for the purpose of providing information. Their mention does not imply recommendation or endorsement by the U.S. Department of Agriculture to the exclusion of others that also may be suitable.

these fibers was subjectively evaluated for "processibility" during the carding and spinning operations. The following physical tests were conducted according to ASTM methods (*9*): single-end breaking strength and elongation, D-2256-88; evenness test, D-1425-81; skein break, D-1578-88; and yarn grade, D-2255-87.

Opening and blending equipment for uniformity evaluation

The equipment used for opening and blending in uniformity evaluations included:

- Cleaner. SRRC opener/cleaner, which is the same as a Rando cleaner, from Rando Machine Corp., Macedon, N.Y.
- Beater. Fibers Control B-1 Synco blender (61-cm-diameter beater) from Fibers Control Corp., Gaston County, N.C.
- Hopper. Hopper of 46-cm Rando Webber from Rando Machine Corp.
- Batt. Batt from 46-cm Rando Webber from Rando Machine Corp.
- Opener and blender. Spinlab 338 opener/blender from Spinlab Inc., Knoxville, Tenn.
- Lap. Lap prepared on picker from Aldrich Co., Greenville, S.C.
- Card. Whitin Model H equipped with 58-cm-diameter take-up wheel to give a nonwoven batt approximately 46 by 91 cm and 45 g/m^2.

The reflectance reading was obtained with Reflection Meter 670, using Search Unit 610-Y with a green tristimulus filter from Photovolt Co., New York.

Initial investigations

Since synthetic fibers are the current choice of the disposable nonwoven industry, the initial approach in the SRRC project was to introduce cotton as a blend with synthetic fibers. We decided to achieve fabric integrity by thermal bonding with a calender, using a minimum of 50% cotton blended with low melting, fusable, synthetic fibers. Thermal bonding was selected because it was the major technique used by the industry to produce coverstock, the most widely used disposable nonwoven fabric.

As an introduction to the calendering process, the Fiber Technical Center of the Hercules Corp. cooperated in the preparation of two fabric blends on its thermal bonding line. A bleached cotton (C) with BES finish, obtained from Cotton Inc., and polypropylene (PP) T-185, from Hercules, were used to make 50/50 C/PP and 75/25 C/PP blends. Three cards in tandem were used to produce a web weight of approximately 50 g/m^2. Each blend level was run at various bonding temperatures to determine optimum properties. A speed of 508 mm/s (100 ft/min) and a roll pressure of 28 kN/m (160 lb/linear in.) were held constant. The patten on the top engraved roll was Hercules No. 009, which had a 40% bond area.

Table I shows that the more polypropylene fiber present, the lower the bonding temperature needed for maximum strength. This effect appears to be linear for the 100% polypropylene and the 50/50 C/PP blend, but results were somewhat erratic for the 75/25 blend. The 75/25 blend started out with high breaking strength, reached a low at 162.5°C, and then increased again. Because the 75/25 blend was run through the line immediately following the 50/50 blend, we suspected that fibers from the previous run still may have been in the system. If this was true, then the first "75/25" web through, i.e., the one bonded at 160°C, may have contained a percentage of polypropylene greater than 25%.

Olefins, such as polypropylene, are reported to be soluble in hot xylene (*17*). The percentage of polypropylene in the blends therefore was determined by wet analysis, using hot xylene as described in the methods and materials section. Results are shown in **Table II**. The 75/25 C/PP blend at 160°C was found to contain an actual 32.5% polypropylene, instead of the theoretical 25%. A temperature of 162.5°C gave the lowest breaking strength at 18% polypropylene. Only after several hundred yards were processed did the system equilibrate to give the desired 75/25 C/PP blend. A look at the 50/50 blend series shows that the percentage of polypropylene increased during processing. This may indicate that with this equipment, which uses roller cards, polypropylene may be processed preferentially over the cotton fiber. The percentage of synthetic fiber and the bonding temperature both contribute to the strength properties of the fabric. It is not known which has the greater influence within the narrow ranges shown in Table II, but this experiment demonstrates that it is important to know if, in fact, the correct blend levels were obtained.

Table III confirms the accuracy of the wet method of analysis and shows that it could be used as an indication of the true blend levels. It comes as no great surprise that, as **Table IV** indicates, the properties of cotton fabrics relative to synthetic fabrics are the same for nonwoven fabrics as they are for woven fabrics. That is, the fiber itself contributes greatly to the overall fabric properties. Breaking strength, elongation, abrasion resistance, tear strength, and bursting strength all decrease as the percentage of cotton is increased in C/PP blend fabrics. Stiffness, air permeability, and wicking are the favorable properties for cotton. Stiffness is an indication of fabric hand, air permeability an indication of cover and bulk, and wicking an indication of absorbency. Cotton's other major attributes—comfort and softness—are very real properties but difficult to analyze objectively.

Another technique for imparting fabric integrity is through the hydroentanglement (HE) or spunlaced process. A 50/50 C/PP fabric was prepared on the HE unit at Honeycomb Corp. (*18*). Unlike the fabrics prepared by thermal bonding, in which the C/PP fibers were blended intimately, the polypropylene batt was placed on top of the cotton batt and the two layers were laminated for the HE process. The resulting nonwoven white fabric appeared to be an intimate blend. After preferential dyeing with DuPont identification stain No. 4, however, the lamination process that was used was easily discernible. The top of the fabric did not dye, whereas the bottom portion, containing predominately cotton fibers, dyed a deep green color. This type of fabric offers possibilities for commercial applications to produce fabrics in which the cotton side may be used next to the skin and the polypropylene side exposed to the outer environment as a barrier fabric for added strength and increased protection. A perfect example in which this layered effect could be used is in diaper coverstock. The hydrophilicity of cotton would provide easier wet-through properties, and the hydrophobicity of polypropylene would provide protection against wet-back.

The HE process also allows for the use of 100% cotton fibers, unlike the thermal bonding process, which requires the presence of low-melting synthetic fibers. Because of this advantage for increased utilization of cotton in nonwovens, the HE technique is one that will continue to receive attention.

Fiber and yarn investigation

Opening and blending

Fiber preparation and web formation are two important steps in the production of nonwovens that should not be overlooked. If cotton is to be used in the thermal bonding process, it is important that the low-melting binder fiber be distributed evenly throughout to ensure uniformity of fabric properties. Fibers that are opened properly before blending generally will provide better distribution of fibers in the nonwoven batt.

An attempt was made to determine the degree of "openness" of cotton and polypropylene fibers. The openness values (OV) of polypropylene, gray cotton, and bleached cottons with various lubricant finishes were determined as described in the methods and materials section. A description of fibers and openness values is given in **Table V**. Results show that all the cottons gave greater OVs than polypropylene. Among the cottons, bleached cottons with various finishes gave the highest OVs. Surprisingly, even unfinished bleached cotton gave a greater OV value than the gray cotton. Fiber analysis, discussed later in this section, revealed that this was not due to short fiber content since the percentage of short fibers for all cottons fell within approximately the same range. Greater openness of bleached cottons may be due to repulsive ionic charges between fibers, but this was not determined experimentally and is beyond the scope of this paper.

V. Opening evaluation

Fiber	Description	Volume, cm^3 Unopened	After one opening	After two openings	Openness value after two openings, cm^3/g [a]
Gray cotton	Mechanically cleaned	1400	2000	2000	123
Bleached cotton	No finish	1000	2150	2150	132
Bleached cotton	1% BES[b]	1250	2300	2350	145
Bleached cotton	1% Sonostat 668	950	2200	2500	154
Bleached cotton	0.5% Dow 111 silicone	1200	2200	2350	145
Polypropylene	Type T-185	800	1600	2000	74

[a]Openness value = [(volume, cm^3)(specific gravity)] / (fiber weight, g). Specific gravity for cotton was 1.54 and for polypropylene was 0.93. Each fiber sample weighed 25 g.

[b]Butoxyethylstearate.

VI. Uniformity evaluation for cotton/polypropylene (C/PP) batts[a]

Opening method[b]	Blending method[b]	Averages Reflectance[c]	Std. Dev.	%CV[d]
1. C: Spinlab PP: Spinlab (twice)	None[e]	75	6.81	8.96
2. C: card PP: card	Card[f]	76	5.92	7.78
3. C: Spinlab PP: cleaner	Spinlab	81	6.14	7.54
4. C: Spinlab PP: Spinlab (twice)	Spinlab	72	5.28	7.28
5. C/PP: hopper	Hopper	77	4.35	5.61
6. C/PP: hopper	Rando batt	69	3.33	4.81
7. C: cleaner PP: cleaner	Spinlab	67	4.58	6.77
8. C: cleaner PP: cleaner	Beater (once)/lap	71	3.29	4.59
9. C: cleaner PP: cleaner	Beater (twice)/lap	72	2.43	3.35

[a]Batts were 80% bleached cotton/20% black polypropylene, prepared on card, and measuring 46 by 91 cm and 45 g/m².

[b]Methods used to open and blend fibers before carding. See text for equipment description.

[c]Reflectance readings across batt, six each on the top and bottom.

[d]Percent coefficient of variation of reflectance readings.

[e]Fibers not blended. Cotton layered on top of polypropylene to prepare final batt.

[f]Cotton layered on top of polypropylene and then blended on card.

To produce a uniform nonwoven batt, fiber blending experiments were conducted using black-dyed polypropylene as a tracer fiber and blending it with bleached cotton with the Dow finish. Although this is a logical technique for determining the uniformity of blended fibers, information and data on this method could not be found in the literature. Some publications describe various types of equipment used for opening and blending but give no data or proof of uniformity (*16, 19*).

The presence of the dyed polypropylene fiber not only allowed visual inspection of differences but presented an opportunity for objective evaluation with a reflection meter. Uniformity of the carded batts was evaluated by taking several reflection measurements across the width of the batt, both on the top and bottom. An 80/20 C/PP blend generally was used, and the degree of uniformity was determined by the percent coefficient of variation of the reflectance data.

Table VI shows how the percent coefficient of variation and standard deviation of reflectance readings are related to the various methods used in opening and blending the fibers. The high percent coefficient of variation of sample No. 1 indicates the need for blending before carding. Use of the card as a blender (No. 2) gave good vertical blending but did not achieve

VII. Analysis of cotton fibers

Fiber	Micronaire	Fineness, mg/km	Maturity, %	Tenacity, kN · m/kg	Elongation, %	2.5% span length, cm	Uniformity ratio	Mean length, cm	Short fibers, %	Neps per g	Shear friction, H
1. Raw	5.4	242	90.7	169	5.3	2.41	48	1.63	36.5	224	0.7683
2. Gray	5.4	239	92.0	165	5.8	2.34	47	1.58	36.9	329	0.7778
3. Bleached	5.4	233	92.8	176	4.3	2.39	43	1.63	35.5	602	1.8508
4. Bleached	5.3	225	94.4	161	4.5	2.39	46	1.60	36.9	556	1.0979
5. 0.25% BES[a]	5.4	246	88.5	164	5.0	2.41	45	1.52	41.1	810	1.2807
6. 1% BES[a]	5.3	222	95.6	153	5.0	2.52	48	1.58	38.7	495	1.2894
7. 1% Sonostat[a]	5.3	239	89.4	156	5.0	2.39	46	1.63	35.4	674	0.9353
8. 0.5% Dow 1111[a]	5.2	232	90.6	137	4.5	2.46	48	1.58	37.2	643	1.1592

[a]Finish applied to bleached cotton fiber.

uniformity across the width of the batt. This method produced noticeable black and white streaks on the batt. The Spinlab apparatus gave only slight improvement in batt uniformity. Opening and blending in the Rando hopper gave noticeable improvement in percent coefficient of variation. Preparation of a batt on the Rando Webber before carding gave good uniformity but resulted in obvious shorter fibers because of the severe action of the Rando air-laid process. The cleaner proved to be most suitable for opening large quantities of fibers. The cleaner, in combination with the beater and preparation of laps (Nos. 8 and 9), produced the lowest percent coefficient of variation. Fiber damage caused by processing through these various openers and blenders has not been analyzed. For this study, uniformity of the blend was the primary concern.

The 80/20 C/PP ratio presented problems in blending. It was most difficult to distribute the small amount of polypropylene evenly throughout the larger volume of cotton. In spite of this difficulty, average reflectance readings were relatively close among the various methods. Only for No. 3, with an average reflectance reading of 81, did the value appear to be too high. The reading indicates that polypropylene fibers may have been lost during this series of processes. Differences in reflectance may indicate that the 80/20 ratio was not the same for all methods of blending. In some cases, this was confirmed by wet analysis, which showed that an increase of 3% polypropylene decreased the average reflectance reading by 11-13 units.

Fiber properties

Cotton samples were examined for fiber properties, as shown in **Table VII**. The objective was to determine if these properties could be used to predict which cottons might be best suited for use in nonwovens. The properties of micronaire, fineness, and maturity reflect the genetic properties of the cotton. Since these cottons all came from the same lot, there was very little difference in these properties.

Cotton fibers generally are classified as short, medium, long, or very long. The cotton samples of this investigation are classified as short fibers. This is indicated by such properties as 2.5% span length (<2.46 cm); mean length (<1.91 cm); and percentage of short fibers (>35%). These properties, as well as uniformity, tenacity, and elongation, were relatively unaffected by bleaching or finishing. Conversely, the number of neps per gram of fiber and the shear friction data did reflect some differences as a result of processing. Neps, which reflect web quality, increased with processing. Raw cotton gave the fewest neps, followed by gray cotton. All bleached cotton, with and without lubricant finish, produced a greater number of neps. There is no explanation as to why cotton No. 5, with the least amount of finish, gave the greatest number of neps.

The shear friction test is reported to be a good indicator for determining the "processibility" of cotton fibers (*14, 15*). The test is a measurement of the loss of mechanical energy as the fiber assembly is subjected to an oscillatory shear action. The results are reported as H values, a frictional parameter that includes the coefficient of energy dissipation. Raw and gray cotton, which contain natural waxes, gave the least amount of friction. The addition of lubricants to bleached cotton did not reduce the frictional properties to those of raw or gray cotton. Among the finished cottons, the Sonostat finish gave the best frictional properties. Two batches of bleached, unfinished cotton were evaluated. Bleached cotton No. 3 gave the greatest degree of friction, but bleached cotton No. 4 gave an unexplained lower frictional value than three of the finished cottons. However, the results from yarn evaluations shown in **Table VIII** indicate that all finished cottons performed better than the unfinished bleached cottons. It would appear at this stage that shear friction may be used as a guide, but it may be a disputed method for determining processibility. Additional research will be needed to compare shear friction and carding properties for many samples and finishes.

Yarn evaluation

Except for nep count and shear friction, fiber properties alone showed little difference for the fibers studied. Evaluation of fibers in relation to yarn properties provided a good method for determination of relative performance. The processibility of the eight cotton fibers was evaluated subjectively by carding and spinning. The quality of the fibers was compared in terms of yarn properties, as shown in

VIII. Analysis of cotton yarns

	Carding		Spinning		Single end				Skein		
Yarn[a]	*Comments*	*Waste,%*	*Comments*	*Amount, m*	*Breaking strength, mN*	*Tex, mg/m*	*Tenacity, kN·m/kg*	*Elongation,%*	*Breaking strength, N*	*Tenacity, kN·m/kg*	*Yarn grade*
1. Raw	Good	5.2	Good	1143	2628	27.4	95.9	5.1	296	*10614*	C-
2. Gray	Good	4.4	Good	1116	2609	27.9	93.5	5.0	289	*10403*	C
3. Bleached	Difficult	30.7	No yarn	No yarn	...	...	...	...	...	—	...
4. Bleached	Poor	4.8	Many breaks	732	2471	28.9	85.5	4.1	235	*8279*	D+
5. 0.25% BES[b]	Good	3.6	OK; breaks	978	3109	28.1	110.6	5.2	312	*10968*	D
6. 1% BES[b]	Good	4.4	OK; breaks	1097	3020	27.7	109.0	5.1	318	*11329*	C
7. 1% Sonostat[b]	Good	4.6	OK; breaks	1097	2628	27.8	94.5	4.6	262	*9521*	C
8. 0.5% Dow 1111[b]	Good	4.0	Good	1097	3089	28.1	109.9	5.4	320	*11691*	C-

[a]Fibers used to prepare 22/1 ring-spun yarn.
[b]Finish applied to bleached cotton fibers.

Table VIII. All but the unfinished bleached cottons carded well. The percentage of waste lost in carding was essentially the same for all samples except No. 3, which was very difficult to card. As shown in the table, this bleached cotton was more difficult to process than bleached cotton No. 4. Number 3 was such a problem that yarn could not be spun from it. Number 4 produced many breaks in spinning, and only 800 yards of yarn could be processed. Raw and gray cottons were the easiest to spin. Finished cottons Nos. 5, 6, and 7 gave a few breaks during the second sliver drawing or spinning.

Single-end and skein breaks showed that finished cotton Nos. 5, 6, and 8 gave the greatest values. These samples also had the greatest tenacity, a property that normalizes each sample to compensate for differences in yarn weight. Bleached cotton No. 4 gave the lowest strength values. Yarn grade, which is a measure of yarn appearance, and evenness, which is a measure of nonuniformity, reveal that all of the cottons were not suitable for yarn preparation. Fibers used in yarn preparation generally should produce a yarn grade no worse than B+ and a coefficient of variation of approximately 18%. The neps, as well as thin and thick places in these yarns, were also exceptionally high. Again, bleached cotton No. 4 was the worst in these categories. As shown in fiber analysis, cotton No. 5 also gave a very high nep count, indicating that a low percentage of finish may not be sufficient for improving the processibility of bleached cotton.

Summary

Prospects for increased use of cotton fiber in the nonwovens fabric industry are encouraging. There is a need for research on cotton nonwoven fabrics to evaluate fabric properties and report technical data. Such is the objective of the project initiated at the Southern Regional Research Center.

In initial experiments, thermally bonded cotton and polypropylene blended fabrics were compared with a 100% polypropylene fabric. Results showed that strength properties decreased as the amount of cotton increased. However, the blended fabrics with higher amounts of cotton showed less stiffness, a greater cover factor, and faster wicking. Opening and blending evaluations also were conducted. Results indicated that preparation of the most uniform batt was obtained when cotton and polypropylene fibers were opened separately in a Rando opener and cleaner, blended in a beater box, and then formed into a lap before carding to deliver the batt.

Other experiments were conducted to determine the relative quality and processibility of eight cotton samples. Bleached cottons with and without lubricant finishes gave a greater number of neps and greater fiber friction in the nonwoven web than did raw or gray cotton. This indicates that bleached cottons were more readily damaged by processing and demonstrates a need for improved lubricants that will match the performance of the natural waxes in raw or gray cotton. Evaluation of yarns prepared from the eight fibers showed more dramatic differences in properties. In general, yarns from bleached cotton without a lubricant finish were the most difficult to process and were poorer in quality. The lubricant-treated bleached cottons (Nos. 5-8) performed better in every category than did the unfinished bleached cotton (No. 4). Strength properties of yarns from finished cottons were even better than raw (No. 1) and gray (No. 2) cottons. This undoubtedly is caused by greater fiber friction, which also is responsible for poorer processibility (carding and spinning) of the finished cottons when compared with raw and gray cottons.

Cotton's major attributes of comfort, hand, absorbency, biodegradability, and consumer appeal will be fully exploited in future research.□

IX. Analysis of cotton yarns

Uster evenness test			
%CV	*Thin*	*Thick*	*Neps*
25.5	1208	1808	280
26.7	1528	2112	360
...	...	...	...
36.1	5360	4000	904
34.0	4040	3184	768
29.9	1984	2072	208
29.9	2624	2536	296
30.7	2648	2488	372

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