OUR EXPERIENCE IN PROCESSING A PRE-CLEANED GREIGE COTTON LINT FOR CERTAIN NONWOVEN BASE MATERIALS

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Abstract

Traditionally bleached cotton has been used for the production of nonwoven fabrics. One primary reason for this scenario was that there was no greige cotton fiber alternative that would meet the required cotton cleanliness needs of the nonwovens manufacturers. However, today, there are several versions of pre-cleaned greige cotton fibers commercially available, which efficiently can meet the stated needs of existing nonwovens roll goods manufacturers. In other words, no cotton cleaning equipment is needed for production of cotton-based nonwovens, using these pre-cleaned cottons. Furthermore, a pre-cleaned cotton also has the advantage of more efficient web production compared to that of a bleached cotton.

This presentation will show in detail how a pre-cleaned cotton can be efficiently used in the needlepunch and hydroentanglement nonwovens production systems to produce nonwoven base fabrics for certain end-use applications. The properties of the fibers and fabrics processed in this study will also be discussed. Notably, the test data have revealed that some of the greige cotton's natural waxes (heavy hydrocarbons) are also removed during hydroentangling of the (greige) cotton web at a certain hydraulic energy level, which, in turn, makes the nonwoven fabric partly hydrophilic (without the fabric bleaching), which obviously could eliminate the need for cotton fiber or fabric scouring and bleaching for some nonwoven materials and end-use products.

Introduction

Traditionally, mostly bleached cotton ginning byproducts (such as motes and linters) and textile processing wastes (such as comber noils, etc.) have been used, generally in blend with manufactured staple fibers, such as polypropylene, polyester, rayon, etc., to produce nonwoven fabric structures for certain medical, hygienic/wiping, and other end-use products that are attractively marketed and sold with the popular cotton logo™ 

Today, very little, if any, regular (classical) *greige* or even bleached cotton *lint* is used by the U.S. nonwovens manufacturing conglomerates. The main reason, among several others, for this scenario of lack of cotton lint use in nonwovens is that almost all nonwovens roll-goods manufacturers historically and most predominantly use manufactured fibers, which are clean, pure white, stable in supply, consistent in quality, and generally less costly than the *bleached cotton lint*. Furthermore, the classical virgin raw/greige cotton always has some non-lint foreign content, such as the plant debris, seed coat fragments, trash and dust, which must be removed in processing the fiber, especially for certain quality end-use products and applications. However, most nonwovens goods manufacturers today do not have the needed cotton opening, cleaning and carding capabilities to properly process a run-of-the mill, greige raw cotton. Obviously, the possibility of contaminating the existing nonwovens production lines with the greige/raw cotton's non-lint content and particularly its off-white (*grey*) color (compared to the pure white color of the manufactured fibers) remains a serious concern of the nonwovens industry and, consequently, a strong challenge in the development of cotton-based nonwovens.

Fortunately, several quality versions of *mechanically pre-cleaned greige cotton* that is free of the classical non-lint content have recently been made commercially available. Based on our now reasonably sufficient experience in processing these pre-cleaned, non-bleached, greige cotton lints, we believe that they can meet needs of existing nonwovens roll-goods manufacturers of certain products. In other words, no conventional cotton cleaning equipment is needed for production of cotton-based nonwovens, using these pre-cleaned cottons – some of which may even have their inherent "whiteness" acceptable for certain end-use products. Based on the research thus far conducted, it appears that there may be several nonwoven end-use products that could use significant amounts of pre-cleaned

cotton lint that requires no commercial bleaching in its fiber form and, depending on the end-use product, even in its fabric form. Furthermore, a pre-cleaned greige cotton fiber, because of its natural waxes (lubricants) still present/intact, also offers a significant advantage of more efficient mechanical processing (in carding for web production) compared to that of a bleached cotton fiber.

Although several research-cum-production trials with both *classic* and *pre-cleaned* greige cottons have been satisfactorily conducted on a pilot plant scale to produce a variety of nonwoven substrates and fabrics, this particular article mainly describes how a mechanically pre-cleaned cotton generally was processed at the Center to develop certain needlepunched and hydroentangled nonwoven base materials of 100% non-bleached cotton content for certain end-use applications, such as household quilts and crafts, throw blankets, furnishing, wipes, and the like. The properties of the pre-cleaned cotton and certain nonwoven materials made thereof are also discussed. Notably, the hydroentangled greige cotton fabrics made under certain processing conditions are highly wettable and sufficiently absorbent, as indicated by the water Drop Tests. Also, based on the preliminary test data gathered on the fabrics' wax content before and after certain levels of specific hydroentanglement energy, it seems that most of the greige cotton's natural waxes (long-chain hydrocarbons) can be removed during the hydroentanglement process. This is a significant milestone in the use of greige (generally hydrophobic) cotton, since, depending on the input energy level (which is considerably dependent on the water pressure/force), the "hydroentangling" technology can make a greige cotton-based nonwoven fabric partly or even completely hydrophilic and hence absorbent without the traditional fiber/fabric scouring. This, in turn, can even facilitate the fabric bleaching, if at all required since most nonwovens, unlike the traditional cotton textiles, really do not require the conventional bleaching, dyeing and/or any special chemical finishing. In conclusion, we believe that a mechanically pre-cleaned greige (non-bleached) cotton may eliminate the need for not only the traditional fiber cleaning but also the fiber/fabric scouring and bleaching as well, for certain nonwoven base materials for certain end-use products and applications.

Materials and Methods

A 480-lb bale of mechanically pre-cleaned and pressed (UltraClean®) cotton was selected for the investigative study. The cotton was tested for its fiber characteristics and quality, using AFIS system. Although the supplied cotton visually was observed to be exceptionally very clean and its AFIS test information also supported the visual observation that it, compared to a classical, regular cotton, had very little non-lint foreign matter (trash content) and that it probably did not require the conventional cotton cleaning and carding (with revolving flats). However, it still had to be thoroughly opened up for processing. Furthermore, since a USDA-procured nonwovens card (with no "revolving flats") still had not been installed in the textile pilot plant at the Center, it was a convenient option to let the supplied clean fiber still pass and process through the existing cotton fiber preparatory system/line and determine if the preparatory system/line indeed contributed to any further "cleaning" of the cotton. Hence, the supplied cotton fiber was normally opened (and, say, cleaned) through a commercial hopper, a step cleaner, and a vertical fine opener before being chute fed to a modified 1-m wide commercial cotton tandem card capable of delivering a web of ~ 12 g/m^2 density. The fiber quality and especially its cleanliness, as indicated by its non-lint trash content, were purposely determined 1) at the chute-feed condenser, i.e., prior to the carding action and its impact on the fiber characteristics, quality and especially cleanliness (due to removal of trash, if any) and 2) also after the carding to particularly assess if the cotton card (with its revolving flats) indeed had actually done (i.e., contributed to) any additional cleaning of the so-called *already (pre) cleaned* cotton.

The card output web (~12 g/m^2), crosslapped 20 times by the carriage, was uninterruptedly fed onto a horizontally moving apron. The crosslapped output was continuously fed onto to a faster-moving inclined apron that, in turn, fed the material to a pre-needling, needlepunch machine (loom) to produce the resulting batt/substrate of a nominal weight density of 75 g/m^2, with a needling density of 125 punches/square centimeter. Five portions of this pre-needled substrate were subsequently hydroentangled (also at SRRC) , all with a constant pre-wetting pressure of 50 bar, but with five different entangling pressures of 90, 100, 110, 120 and 125 bar, thus producing five premium quality wiping materials (fabrics) of 70 g/m^2 nominal weight. The entangling of the fibrous materials was affected via two (2) high-pressure heads, both applying the same impacting pressure -- one on the material supported by a "forming belt" and the other on the material supported on a perforated drum. The fabrics were tested for their typical mechanical and physical properties, including the wet-ability (absorbency) and the fatty matter content (hexane extraction).

Results and Conclusions

Table I shows test results of the various samples collected at different stages of the fiber processing *(i.e., from the bale (control); opening/cleaning (from the chute); and carding (from the carded web)).* As seen, the trash and dust counts of the samples at the three different stages are very low compared to what we generally see in a similar processing of a typical raw (greige) cotton. This shows that UltraClean® cotton indeed is very clean, does not contain the usual non-lint (foreign) matter of a regular raw cotton bale, and thus may not require traditional cotton cleaning that is generally done for a typical run-of-the-mill regular cotton bale.

Table I. Tested properties of a premium UltraClean®cotton at different stages of processing and a comparable regular cotton.

AFIS Testing	**From UC® Bale***	**From Chute**	**Carded Web**	**From Typical Cotton Bale***
Mean length – *n*-based (cm)	1.85	1.91	1.88	2.03
Mean length – *wt.*-based (cm)	2.34	2.36	2.34	2.46
Shortfiber content–*wt.*-based (%)	11.5	10.6	11.3	8.5
Nep count (/g)	167	348	52	238
Trash count (/g)	2	0	0	169
Dust count (/g)	24	11	9	846

*Although a cotton sample from a bale generally is characterized by HVI, we, *for sake of maintaining consistency in a comparative study*, have tested all the cotton samples, Table I, using AFIS system. However, the cotton samples taken from the bales were thoroughly opened manually, while ensuring that no trash from the selected samples was lost.

Table II shows the tested properties of the nonwoven fabrics produced on the hydroentanglement system, using the five different high hydraulic (water) pressures. As seen, the fabrics have satisfactory properties for premium quality, personal-care wipes. However, the most interesting observation here is that all the fabrics seem to be absorbent based on the water Drop Test. Depending on the magnitude of the high water jet pressure deployed in the hydroentanglement system, the (greige) cotton's inherent (natural) fatty substances/waxes (and perhaps, to some extent, pectin, as well) were removed as shown in the Table. The removal of the hydrophobic waxes (long-chain hydrocarbons) enabled the greige cotton fabrics become readily wickable/wettable without the usual scouring process. Furthermore, the color of the fabrics made with this particular bale of UC cotton was "off white," i.e., nearly white, considering that no bleaching of the fiber or fabric was involved either. These are significant revelations of the research conducted on a pre-cleaned cotton, which should encourage the nonwovens manufacturers to consider use of greige (non-bleached) cotton in their existing facilities that generally do not have the cotton cleaning equipment. However, there may be some other issues and concerns that may need to be addressed, especially in the area of purification of effluent water for recycling in any hydroentanglement system of manufacturing nonwovens. Figures 1 and 2 show rolls of the nonwoven fabrics made with the pre-cleaned (UC) greige cotton.

Table II. Tested Properties of the Hydroentangled Cotton Nonwoven Fabrics.

HE fabrics	**Weight** ***(g/m²)***	**Thckns.** ***(mm)***	**Drop Test** ***(sec)***	**MD Tensile** ***(N)***	**MD Elong** ***(%)***	**CD Tensile** ***(N)***	**CD Elong** ***(%)***	**Wax (hexane) Extraction** ***(% removed)***
A (90)	70.2	0.64	60 +	83.7	36.60	94.0	54.20	61.0
Stdv		0.04		5.9	1.55	4.9	2.85	
B (100)	70.6	0.61	26.9	100.9	34.00	101.7	55.53	69.0
Stdv		0.02		5.4	1.49	4.9	2.02	
C (110)	68.2	0.60	11.7	97.7	28.73	97.9	56.67	61.0
Stdv		0.03		1.5	1.19	12.5	2.87	
D (120)	67.7	0.60	6.6	111.9	22.87	95.1	59.27	62.0
Stdv		0.03		1.9	2.43	12.0	4.66	
E (125)	68.8	0.55	<1.0	120.8	18.07	96.8	51.07	90.0
Stdv		0.02		4.3	2.02	6.7	3.43	

Figure 1. Rolls of pre-cleaned greige cotton needlepunched substrates produced at the Center.

Figure 2. Rolls of Hydroentangled cotton nonwovens produced at the Center.

In conclusion, a mechanically pre-cleaned (greige) cotton may be a viable option for the existing nonwovens manufacturers (most of whom do not have the cotton cleaning/carding equipment) to introduce cotton into their products. However, it may be noted that the water of the HE system at the Center was not recycled in the study presented here. Therefore, the "effects" of hydroentangling raw/greige cotton on the filtration and purification of the system's effluents for recycling the water (as customary for industrial hydroentanglement applications) were not assessed in this study.

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Notes

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