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# Evaluating Potential for Cotton Utilization in Alternative Nonwoven Textile Technologies

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**Abstract**

The use of synthetic fiber is increasing, replacing cotton fiber in textile industry. Various nonwoven technologies constitute the fastest growing sector of textiles in both the U.S. and rest of the world. This study evaluates the potential for cotton fiber in nonwoven textiles and analyzes the issues of cotton use in nonwovens, with a focus on potential target markets. Data was collected through an online survey conducted among the nonwoven products producing firms. The study shows that cotton is not being used by most of the nonwoven producing firms, with polypropylene as rayon as the primary substitute fibers. Reasons for using the substitute fibers include price, price volatility, processing costs, etc., of cotton. However, it appears to be potential for cotton, especially in hygiene and other products requiring absorbency.

**Keywords:**

Cotton, nonwovens textiles, technical textile, cotton properties for nonwoven use.

## **Introduction**

Nonwovens are engineered fabrics that are a combination of traditional textiles, paper, and polymers. Nonwoven textile products are largely found in products related to medical and personal care, filters and electronics, clothing/households, padding /laminated, geotextiles, and others. These products are made with natural and man-made materials such as: polypropylene, polyester, nylon, rayon, cotton, wood pulp and blends of these fibers.<sup>1</sup>

Nonwoven textiles are the fastest growing sector of the textile industry. The number of U.S. firms producing nonwovens increased from 29 to 45 between 1998 and 2000.<sup>2</sup> According to the volume growth rate recorded for nonwovens during the period 1990 - 2000, production was estimated to have increased at an annual rate of 5-7% until 2010.<sup>3</sup> According to The European Disposables and Nonwovens Association (EDANA) and The Association of the Nonwoven Fabrics Industry (INDA), production of nonwoven roll goods reached 5.75 million tons globally in 2007, with a market value of \$20.9 billion. Between 2007-2012 the global annual growth rate was estimated to be at 7.9%, with production of 8.41 million tons of nonwovens by 2012.<sup>4</sup>

The major producers of nonwoven products are the United States, Western Europe and Japan. The U.S. is one of the largest producers and exporters of cotton in the world.<sup>5</sup> Despite, their success in cotton export and production; there is decline in domestic use of cotton, which has been a cause for concern in the U.S. cotton industry. Their cotton mill use decreased from 7.2 million bales in 2002 to 3.6 million bales in 2011.<sup>6</sup>

Besides being biodegradable, cotton has desirable characteristics like absorbency behavior, strength, ease of blending, and dyeability. Of primary importance is cotton's comfort

when in contact with the skin. Therefore, cotton is desirable in personal care and hygiene products, medical/surgical supplies, and other products applied to the human body.

This study evaluated the potential for cotton fiber in nonwoven textiles in general and analyzed the issues of cotton use/non-use in nonwovens. The specific objectives were to

1) Assess the characteristics of products, technologies, and firms that use and do not use cotton to obtain information on potential target markets, and

2) Identify the issues that motivate and deter the use of cotton among the nonwoven textile producers.

## **Methods**

An online survey was conducted among a sample of nonwoven textile producing firms. Based on responses, descriptive statistics were calculated to provide insight into the input, products, and technologies of nonwoven firms.

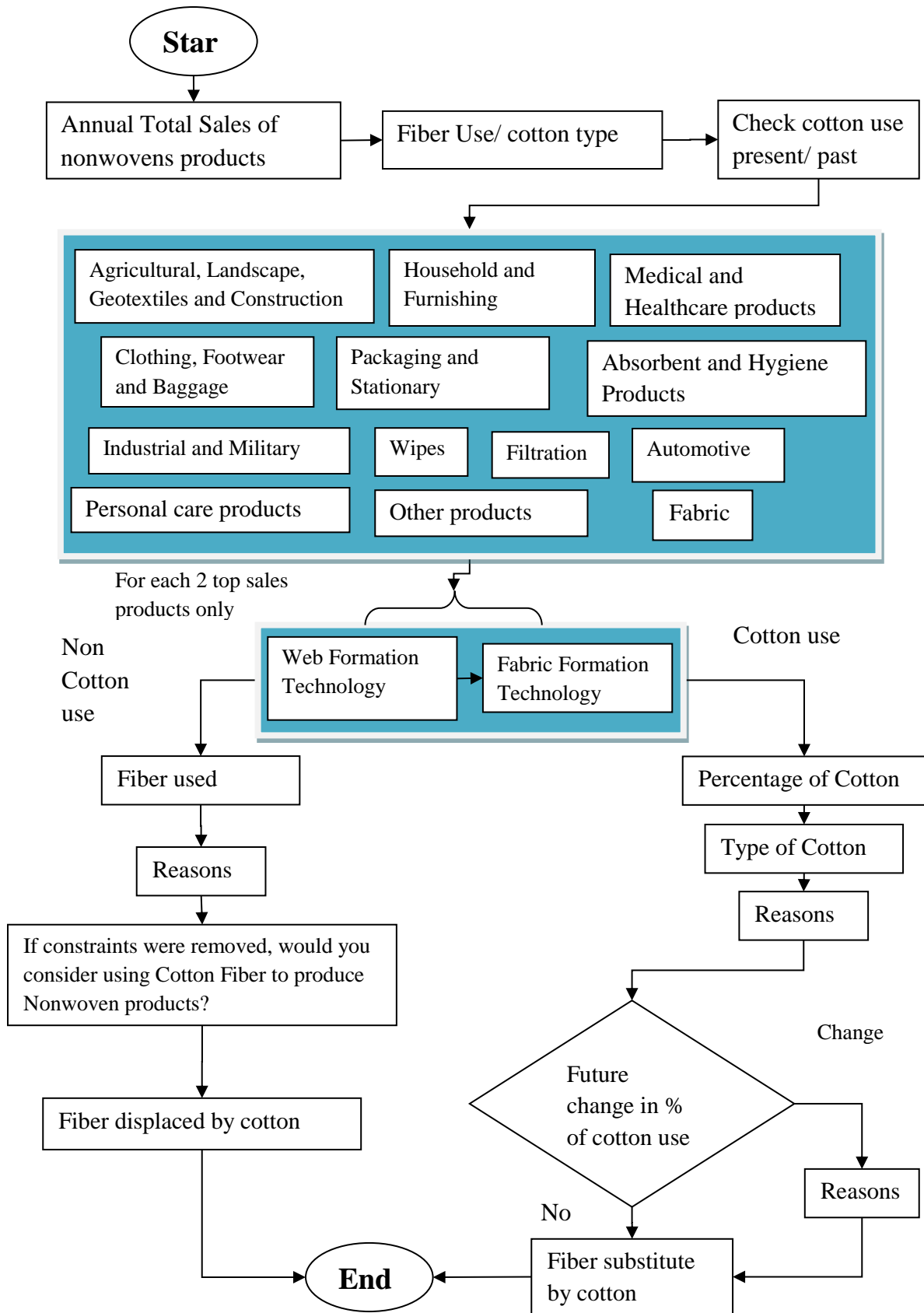
### Survey Design

The questionnaire was designed in consultation with experts who are familiar with the nonwoven textile industry. Contacts were made through an INDA conference and followed up for guidance in designing an internet based questionnaire. All of the questions were designed as multiple choices with single selection or multiple selections. Based on the response of the question, the questionnaire had different branches and multiple levels (the general outline is shown in the flow chart in Figure 1). In some questions, an ‘*others*’ choice with space to specifically answer the question was made available if the choice list did not have a desired selection. Similarly, in some questions, a ‘*don't know*’ choice was made available. Rank order

questions were also included. In ranking questions, respondents were asked to partially rank up to the top three choices from a list. Typically, asking respondents to rank more than three choices results in inefficient responses.<sup>7</sup>

## Questionnaire

The Questionnaire was designed following the outline in Figure 1, starting with the number of years in production of nonwoven products, identifying the fiber used in the production of nonwoven products and the firm's cotton use status (i.e., current "cotton using", "formerly cotton using", and "non-cotton using"). After identifying the firm's cotton use status, different sets of questions were asked for each category of firms (however, the general theme of the question was same). The response from "cotton using" firms was for cotton based nonwoven products, the response from "formerly cotton using" firms was for products they used to produced previously using cotton and the response from "non-cotton using" firms was for products they produce based on other fibers (i.e., except cotton fiber).The questions consisted of identifying the top two highest average sale end-product categories from the list. For each product category, technologies and fiber used in the production was asked. Following the product questions, reasons for using or not using cotton was asked (i.e., different for current "cotton using", "formerly cotton using" and "non-cotton using" firms), in which the respondents were asked to rank the top three reasons among five/six available alternatives. At last, respondents were asked to identify the substitute fiber for cotton and future possibility of cotton use in production of nonwoven textile for that firm.



**Figure 1.** Flow chart for structure of the questionnaire

## Survey Administration

'*Survey Monkey*', an online survey-conducting platform was used to conduct the survey. The questionnaire was coded on '*Survey Monkey*' and pre-tested by six different individuals to estimate the time of completion and understandability of the questions. On average, it took 10-15 minutes for an individual to complete the questionnaire and the questions were understood well by the respondents.

Rodman Publishing is one of the leading sources of information regarding the global nonwoven industry; it also publishes a magazine that is widely recognized among nonwoven textiles producers called *Nonwoven Industry Magazine*. They identified two groups of nonwoven producing firms (i.e., roll goods manufactures and end products manufacturers). The same questionnaire was sent to both groups of industries. Rodman Publishing launched the survey among its global subscriber list of *Nonwoven Industry Magazine* using *Survey Monkey* on Feb. 8, 2012 and a reminder was sent on March 7, 2012. The survey was closed on April 5, 2012.

## Survey Response and Data

The total valid response received from the survey as of closing date was 245, consisting of 118 end products manufacturers and 127 roll goods manufacturers. In total 762 respondents opened the survey, resulting in 32.15% complete survey response rate. On average, respondents had been in the nonwoven products production business for 26 years. Multiple responses from the same named firms were observed, 58 respondents self-identified their firms among which 19 of them were distinct. The multiple responses from same name firms do not indicate the duplication of responses. This is due to the presence of subsidiaries located all over the world, which may produce different kinds of products. Because products produced by the roll goods



manufacturers are inputs used in the end-product manufacturers, this paper only focuses on the responses from the end product manufacturers.

## Results and Discussion

### Fiber Used

According to the responses, more than fifty percent of firms are classified as “non-cotton using” firms and thirty percent are classified as current “cotton using” firms. Most of the respondents used polypropylene (76.33%) and polyester (75.51%) as raw materials to produce nonwoven products (Table 1). These results indicate that most of the nonwoven products are produced using synthetic fibers compare to cotton.

Cotton fiber is used in combination with other fibers or only a part of a product is made using cotton fiber. By 2012, polypropylene demand from nonwoven textile was estimated to be 160 million tonnes, which is 21% higher than 2007.<sup>4</sup> The consumption of polyester was expected to grow at 6.1% per year until 2012.<sup>4</sup>

**Table 1.** Response for fiber used in production of nonwoven products from total survey

Fiber used in production of nonwoven products	<sup>a</sup> Percentage response (%)
Polypropylene	76.33
Polyester	75.51
Rayon	43.67
Cotton	31.02
Polyamide	30.20
Others	30.61
Acrylic	25.31

<sup>a</sup> Total percentage may not add to 100%

Among the respondents, 31% currently used cotton fiber to produce nonwoven products. These current “cotton using” firms were asked to identify the percentage of types of cotton fiber<sup>1</sup> they used in production. A weighted average was calculated among the percentage use responses for the types of cotton fiber. The weighted average was calculated in two steps. First, the average percentage of each type of cotton was calculated. Secondly, the weighted average of each type of cotton was calculated by multiplying the response rate for the corresponding average percentages across all respondents and dividing by the total number of responses. The proportion of the total cotton used for virgin cotton, waste cotton, and reclaimed cotton was 69.84%, 19.37% and 10.79%, respectively. The availability of waste cotton and reclaimed cotton is typically small and inconsistent. . Sawhney and Condon estimated that 2% of nonwoven products consist of cotton fiber.<sup>8</sup> Further, INDA estimated that 35,000-40,000 tons of cotton would be consumed in nonwoven textiles in 2012.<sup>4</sup> Given this projection, specific cotton fiber consumption may comprise 28,000 tons of virgin cotton, 7,600 tons of waste cotton and 4,400 tons of reclaimed cotton based on the responses in this study

## Nonwoven Products

Absorbent and hygienic products, wipes, and medical and healthcare products are the fastest growing market segments in nonwoven textiles.<sup>4</sup> Most of the respondents that are either “cotton using” or “non-cotton using” focus their production on these products as shown in Table 2. The fibers used in these products have similar properties to cotton: high absorbent capacity and easy handling for sanitation purposes. According to the survey responses, absorbent and hygienic products were most frequently produced using polypropylene, filtration products were

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<sup>1</sup> Three types of cotton were considered in this study i.e. virgin, waste and reclaimed cotton. Definition of each was provided in survey.

produced using polyester, and wipes were produced using rayon. There has been an increased use of polypropylene in durable products such as geotextiles, automotive carpeting, coating substrates, indoor/outdoor carpeting, blankets, upholstered furnishings and bedding.<sup>4</sup> From the survey, 38.46% of the total absorbent and hygiene products responses came from current “cotton using” and “formerly cotton using” firms, while 58.97% from “non-cotton using” firms. Similarly, among the total responses for wipes and medical and healthcare products, 44.83% and 55.56% used cotton, and 55.17 % and 40% used non-cotton fiber, respectively. Hygiene product consumption was 1.41 million tons, equivalent to 27% of total nonwoven production in 2007, and it was estimated that by 2012 its share of total nonwoven production would be 29%.<sup>4</sup>

**Table 2.** End-product manufacturing firm’s response for nonwoven products

Nonwoven products produced (n=156 <sup>a</sup> )	Percentage response (%)
Absorbent and Hygiene Products	25.00
Wipes	18.59
Medical and Healthcare products	16.03
Filtration	12.18
Household and Furnishing	5.77
Industrial and Military	5.77
Fabrics	4.49
Personal care products	3.85
Automotive	3.21
Agricultural, Landscape, Geotextiles and Construction	2.56
Clothing, Footwear and Baggage	1.92
Other products	0.64
Packaging and Stationery	0.00

<sup>a</sup> including Primary and secondary products

## Technologies Used

Carding, spunlaid, and airlaid were the most frequently used web formation technologies (Table 3), while thermal bonding, hydroentanglement, and chemical were the most frequently use web bonding technologies (Table 4) among end product manufacturers. About 53% of the respondents used carding to produce cotton based products, while 46.81% used it to produce

non-cotton based products. Similarly, 33.33% used thermal bonding for cotton based nonwoven product, while 66.67% used it to produce non-cotton based products. About, 42% of the respondent used hydroentanglement to produce cotton based products, while 58.33% used it to produce non-cotton based products. To produce cotton based nonwoven products, carding and hydroentangle are the most frequently use technologies in the sample. Its use is growing due to the introduction of spunlaid technology to China and India, which are the growing nonwoven producing countries. In 2008, nonwoven products produced using spunlaid and carding was 46% and 43%, respectively.<sup>4</sup> The developments in hydroentangle technology and the increase in production of wipes could increase cotton consumption for the production of nonwoven products in personal care and hygiene category.<sup>4</sup>

**Table 3.** End-product manufacturers response for web formation technology

Web Forming Technology (n=156 <sup>a</sup> )	Percentage response (%)
Carded	30.13
Spunlaid (Spunbonded)	24.36
Airlaid	21.79
Meltblown	14.1
Other(co-form, spunlace)	5.13
Wetlaid	4.49

<sup>a</sup> including Primary and secondary products.

**Table 4.** End product manufacturers responses for web bonding technology

Web bonding Technology (n=156*)	Percentage response (%)
Thermal Bonding	30.77
Hydroentanglement (Spunlaced)	23.08
Chemical Bonding	18.59
Needlepunching	15.38
Other(co-form, laminating, hydrogen bonding)	7.05
Stitch bonding	5.13

\*including Primary and secondary products

Current “cotton using” and “formerly cotton using” firms both provided the requested information regarding the cotton based nonwoven products and technology used in those products. Some specific nonwoven products and technologies could be identified from the responses of the nonwoven producing firms that offer some opportunities for cotton fiber. Cotton based medical and healthcare products were produced using spunlaid (40%), and thermal (26.67%) technologies. Absorbent and hygiene products that did not use cotton fiber were produced using polypropylene fibers (70.83%) with spunlaid (45.83%) and thermal (50%) technologies. Both types of products used similar technology and cotton has the potential to be substituted for polypropylene. The reverse is also implying that polypropylene present a significant threat to cotton use in nonwoven products.

#### Substitute Fiber for Cotton

Most of the respondents considered rayon a substitute fiber for cotton, followed by polyester and polypropylene (Table 5). About, 62% of current “cotton using” and “formerly cotton using” firms consider rayon a primary substitute fiber for cotton, compared to 48.44% of “non-cotton using” firms. The responses for substitute fibers were similar among roll goods manufacturers and end products manufacturers. Among the rayon fiber respondents, the most frequently produced products were absorbent and hygiene products, using carding and hydroentangle technologies. Rayon is an artificial fiber made from cellulose. The fiber characteristic of rayon is similar to the cotton fiber and cotton fiber properties are a primary reason for use in nonwoven products. Due to these reasons, rayon is being considered as a substitute for cotton.

**Table 5.** Total survey response for substitute fiber

Substitute fiber (n=245)	Percentage response (%)
Rayon	54.69
Polyester	19.59
Polypropylene	18.78
Other	4.08
Acrylic	2.04
Polyamide	0.82

### Reason for Using and Not Using Cotton

The “natural” characteristic is a primary reason for firm use of cotton. Marketing features were the most frequently cited reason to use cotton in the production of nonwoven products (Table 6). Cotton being natural fiber, possibility of producing high price products, consumer demand etc., are some of the marketing feature that come using cotton fiber. In addition, physical properties of cotton fiber, such as its melting temperature, absorbency, and density, are also significant reasons for “cotton using” firms to choose cotton as their production fiber. Further, these are also the reason for some firms to increase the quantity of cotton use in their future production, mostly due to marketing features. Most of the respondents did not want to change the quantity of cotton they are use in the production of nonwoven products.

The most frequently cited reason for ending the use of cotton was higher production costs compared to substitute fibers (Table 6). This is due to the higher price of cotton fiber and further processing requirements for cotton (i.e., filtration cost of trash contained in cotton fiber). Other reasons, such as a change in consumer demand for cotton based nonwoven products and price volatility of cotton fiber has caused some to shift from being “cotton using” to a “non-cotton using” firm. The availability of less expensive products made from artificial fibers may have reduced the demand of cotton- based nonwoven products. Further, these are also the reason for

some “cotton using” firms to decrease their future use of cotton fiber. Among the formerly “cotton using” firms, 29% have prospects of considering cotton use in the future. The marketing properties and physical properties of cotton fiber were the major reasons for these firms to consider using cotton fiber again. This response was also similar to those firms currently using cotton and those who tend to increase cotton use.

The majority of the “non-cotton using” firms indicated that they did not produce products that could use cotton (Table 6). Otherwise, the most frequently cited reason was the higher production cost compared to substitute fibers for cotton, which was also the major reason for firms to shift from cotton to “non-cotton using” firms. Other reasons include cotton incompatibility with the products and technologies of the firm, and relative price volatility of cotton fiber. Further, synthetic fiber is gaining on cotton fiber in terms of performance, which may lead to synthetic fiber based products that are similar to cotton based products. Among the “non-cotton using” firms, 46% were willing to use cotton if all constraints were removed.

**Table 6.** Responses from firms regarding reasons for different cotton use status

Reason for Using cotton (n=76)	Reason for stop using cotton (n=41)	Reason for not using cotton (n=128)
Marketing features (27.33%)	Change in production cost (23.83%)	Don't produce products (27.00%)
Physical properties (22.67%)	Change in demand (18.50%)	Production cost (21.50%)
Price advantage (16.67%)	Price Volatility (13.33%)	Change in demand (10.17%)
Reliable source (14.00%)	Introduction of new fiber (10.50%)	Others (8.83%)
Others (3.67%)	Difficulty in procurement (10.00%)	Price volatility of cotton (8.50%)
	Others (9.50%)	Difficulty in procurement (6.50%)

Note: Total percentage may not add to 100%, Weight average of the top 3 rank order choices was calculated  
 $Weight\ average = (Rank1 * 3 + rank2 * 2 + Rank1 * 1) / 6$

## **Conclusions**

Cotton fiber has potential to increase its market share in different nonwoven target products. Nonwovens where cotton could be used are absorbent and hygienic products, medical/surgical and health care products, personal care products, and wipes. Cotton has the required fiber properties (such as absorbency, ease of handling for end products user, disposability, and sanitation value) to produce these products. It is technically feasible to use cotton in nonwoven textiles, but economic constraints (such as price volatility and processing costs for impurities) impede its use. Cotton's price volatility interferes with firms' ability to plan for the long term, while impurities present in raw cotton fiber places technological constraints on its uses, increasing the cost of production. These issues should be addressed to be able to increase the use of cotton in nonwoven textile.

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