Influence of cotton content and area density on the properties of cotton thermal-bonded nonwovens

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Absorbency increases and strike through time decreases with increase in cotton content in cotton thermal-bonded nonwovens. In general, cotton shows wet back (rewet) properties similar to that of polypropylene. Tenacity increases with increase in binder fibre concentration but decreases with increase in area density. Bending length increases with binder fibre content and area density.

Keywords: Absorbency, Cotton, Nonwovens, Tensile strength, Thermal bonding, Wet back (rewet) properties

1 Introduction

One of the major end use markets where the nonwovens have established is in the area of health care, personal and hygiene goods. These are light weight materials commonly made by chemical or thermal bonding systems. A sizeable portion of apparel interlining market is served by thermal-bonded fabrics. The largest thermal-bonded carded staple nonwoven market in the United States is coverstock for sanitary products1. In all such products where absorbency is of paramount importance, cotton as a raw material can play a fruitful role. Cotton fibre, because of its superior absorption characteristics and soft feel, is eminently suitable for hygienic and health care applications, such as disposable diapers, coverstocks, wipes and also in interlinings. The ecofriendly character of cotton is of great importance in disposable items and in single use applications. Low micronaire and immature cottons, comber noils and such fibres which pose problems in spinning can be profitably employed for nonwovens. However, cotton has only a modest presence as yet in the nonwoven industry which is dominated by the synthetics. Consumption of bleached cotton in nonwovens was only around 60 mlb in 1991 in the United States2, one of the largest markets for nonwovens.

In the Indian context, use of cotton in nonwovens holds immense scope for product diversification, value addition and increased export. Indepth studies in this area to arrive at optimum conditions will, therefore, be rewarding.

The nonwoven technology offers alternative systems such as chemical bonding or thermal bonding for making cotton light weight nonwovens. Chemical bonding results in the individual fibres being coated with the chemical film, making the resultant fabric stiff and impairing its absorption capacity, thus nullifying the advantages of comfort, absorption and softness desired from cotton3. In contrast, in the thermal bonding process, the binder fibre in cotton nonwovens does not necessarily degrade the desired properties. The thermal bonding system is a clean process with no problem of effluents and is an eco-friendly process.

Moreau4 correlated the physical properties of thermal-bonded cotton/polypropylene nonwovens with bonding temperature and observed that the bonding temperature has a high influence on breaking strength whereas the fabric weight has a significant influence on fabric stiffness. He concluded that in a consumer product, where stiffness and breaking strength are important properties, cotton blends would be equally effective as 100% polypropylene fabrics. Much of the earlier work on coverstocks is based on the premise that the best attributes will be provided by coverstocks with high resistance to wet back and a high strike through rate. Consequently, the hydrophilic synthetic fibres were preferred. Studies by Cottenden et al.5 show that the choice of fibres has negligible effect on skin comfort. The studies were carried out on coverstocks made of viscose and polyester fibres. As the cotton content increases in thermal-bonded nonwovens, discomfort

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sensation related to surface dampness is reduced. This reveals the potential advantages of using cotton in next-to-skin applications. Earlier work at BTRA reveals that absorbency and wicking rate of cotton thermal-bonded nonwovens decrease with the increase in binder fibre content and bonding pressure.

In the present study, investigations have been carried out on the cotton thermal-bonded nonwovens for their absorption, liquid strike through time and wet back characteristics. The influence of cotton content and area density on these functional properties, tensile strength and bending behaviour are also discussed. One of the difficulties in making thermal-bonded nonwovens is the need to import low-melt synthetic fibre from abroad. Therefore, the use of an indigenous polypropylene fibre of normal type as a binder fibre was attempted. This will help to bring down the raw material cost in thermal-bonded nonwovens.

2 Materials and Methods

Bengal Desi (bleached) cotton and indigenous polypropylene fibre having the following specifications were used:

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td></td>
</tr>
<tr>
<td>Mean length, mm</td>
<td>15.4</td>
</tr>
<tr>
<td>Effective length, mm</td>
<td>18.0</td>
</tr>
<tr>
<td>Short fibre, %</td>
<td>8.2</td>
</tr>
<tr>
<td>Bundle strength, g/tex (Stelometer 3 mm)</td>
<td>13.6</td>
</tr>
<tr>
<td>Micronaire</td>
<td>7.2</td>
</tr>
<tr>
<td>Denier</td>
<td>2.11</td>
</tr>
<tr>
<td>Effective length, mm</td>
<td>54.0</td>
</tr>
<tr>
<td>Single fibre</td>
<td>2.7</td>
</tr>
<tr>
<td>Tenacity, g/tex</td>
<td></td>
</tr>
<tr>
<td>Elongation at break, %</td>
<td>119</td>
</tr>
</tbody>
</table>

Binder fibre concentration levels of 10, 20 and 30% were employed and for each concentration level, three area density levels were selected, viz. 40, 55 and 70 g/m². All the nine samples as planned above were prepared by blending the two components prior to carding. The carded batt of required area density was passed through a calender type of thermal-bonding machine. The calenders were plain smooth rollers and were heated by hot oil circulation, maintaining the oil temperature at 185°C. The actual temperature on the rolls was 170°C. Delivery speed of 1 m/min was maintained at a pressure of 42 kPa/cm. The material was given two passages through the calender bonding machine.

Standard test methods were followed for testing the area density, thickness, tensile and bending behaviour. Absorbency and strike through time were tested as per EDANA standards. 7-8 sub-samples were tested for each property for working out an average value. For measuring the strike through time, the nonwoven material was placed over a set of 5 standard filter papers which served as the absorbent. Distilled water (5 cc) was made to flow at a standard rate, and pass through the nonwoven material into the underlying absorbent. The time taken for the passage of water through the nonwoven was taken as the strike through time.

Rewet (wet back) property was tested by slightly modifying the method proposed by Weyerhaeuser and reported by Kevin Hodgson. Distilled water (10 cc) was used instead of synthetic urine (80 cc) proposed in the method. Distilled water was poured at a prescribed rate onto the test specimen which was superimposed on a standard absorbent pad in the liquid strike through tester. The test specimen was then allowed to absorb the liquid for 2 min. Two preweighed filter papers were placed over the point of fluid entry and a one psi (7 kg/100 cm²) weight was applied for 2 min. The filter papers were removed and weighed and the net gain in weight was taken as the rewet value. Rewet property measures the ability of the material to keep the skin of the wearer dry during use.

3 Results and Discussion

3.1 Thickness

The thickness values of thermal-bonded cotton nonwovens, as seen in Fig. 1, are higher at higher area density levels. For the same area density, higher binder fibre content results in a lower level of thickness due to higher number of contact points and compactness of the material.

3.2 Absorbency

Fig. 2 shows the bar chart for absorbency values of
cotton thermal-bonded materials. The absorption increases with the increase in cotton content in the blend.

3.3 Liquid Strike Through Time

Fig. 3 shows the strike through time values. A higher cotton content generally shows a lower strike through time, indicating a faster passage of liquid possibly because of absorption of water in the cotton matrix. A trend towards lower strike through time with higher area density is seen. This could be because of the increase in cotton content with increasing area density and the consequent absorption of liquid during its passage. In the case of 100% polypropylene thermal-bonded material also, an increasing trend in strike through time with area density is noticed since the liquid has to pass through a thicker material with higher weight.

3.4 Rewet (Wet Back) Property

Fig. 4 shows that the rewet property is at a peak with high cotton content and higher level of area density, as seen with 70 g/m² material in 90/10 and 80/20 cotton/polypropylene blends. Under these conditions, the liquid held by the material is likely to be higher and the same is reflected in the wet back properties. Similarly, with 100% polypropylene thermal-bonded materials, rewet increases with the increase in weight of the material as observed for 40 and 70 g/m² polypropylene materials.

It is further seen that the rewet properties are not significantly affected by the type of fibre used, indicating that cotton can be successfully used for coverstock materials. This confirms the conclusions of earlier workers \(^4\) that the choice of fibres has negligible effect on skin comfort.

3.5 Tenacity

The tenacity increases with increase in binder fibre content (Fig. 5) due to increased number of bonding points and decreases with increase in area density. This is because the greater thickness at higher area density levels makes it difficult to obtain optimum bonding conditions throughout the fabric. Heavier webs are thus a limitation in calender type of thermal bonding.

3.6 Bending Length

The cotton nonwovens tend to become stiffer with increase in binder fibre content and weight of material (Fig. 6). The drop in thickness is accompanied by an increase in bending length at higher binder fibre content.

3.7 Statistical Analysis

The results of absorbency, strike through time and rewet properties were subjected to statistical analysis. Analysis of variance was carried out to bring out the
3.7.1 Absorbency

The results of analysis of variance of absorbency data (Table 1) indicate that the cotton content has a predominant influence on the absorbency property. Area density and its interaction with cotton content also have a statistically significant influence on the absorption characteristics of thermal-bonded cotton nonwoven. Density (g/cc) takes into consideration the area density (g/m²) and thickness of the fabric. Density of fabric is found to show a good negative correlation ($-0.87$) with absorbency (Fig. 7), indicating a drop in absorbency with increase in density.

3.7.2 Strike Through Time

The results of analysis of variance of strike through time data (Table 2) indicate that both cotton content and area density significantly influence the strike through time, but their interaction is not significant. This shows that the two factors independently influence the rate of passage of liquid through the material. This is because of the hydrophilic nature of cotton.

3.7.3 Rewet Property

The results of analysis of variance of rewet data (Table 3) show that the wet back property is significantly affected by the cotton content and weight of the material and that their interaction is also significant.

5 Conclusions

5.1 The thickness of cotton thermal-bonded nonwovens decreases while stiffness increases with increase in binder fibre concentration.

5.2 Absorbency increases and strike through time decreases with increase in cotton content in the
thermal-bonded nonwovens. Absorbency increases with decrease in the density of fabric.

5.3 Higher cotton content and higher area density result in higher wet back property. However, in general, cotton shows similar wet back properties as polypropylene and hence can be used for coverstock materials.

5.4 Tenacity increases with increase in binder fibre concentration but decreases with increase in area density.

5.5 Bending length increases with increase in binder fibre content and area density of cotton thermal-bonded nonwovens. However, the binder fibre content has a greater influence than area density on bending length.

Acknowledgement
The authors are grateful to Dr S.M. Betrabet, Director, BTRA, for his keen interest during this study.

References
1 Subhash K B & Dharmadhikary R. Globalisation of the nonwoven industry—Implications for the developing countries, *Proceedings, International Conference on Nonwovens* (The Textile Institute, North India Section, New Delhi) 1992, 1.


Erratum
5 Conclusions should be read as 4 Conclusions and
5.1–5.5 as 4.1–4.5