KEYNOTE ADDRESS: NEW DEVELOPMENTS IN NONWOVENS FOR HYGIENE AND APPAREL PRODUCTS

Larry C. Wadsworth, Professor and Senior Executive Technology and Marketing, Textiles and Nonwovens Development Center (TANDEC)
The University of Tennessee, Knoxville

Abstract

The nonwovens industry has traditionally been the most dynamic of the textile sector and there is every reason to believe that this growth will continue. However, the catalyst for this growth is innovation. The industry goes through different phases of innovation. For the past decade, advances in equipment, particularly in melt blowing, spunbonding, hyroentanglement, air laying and high speed carding have driven this growth. Yet, it now appears that product innovations will be the accelerator. Towards this end, University of Tennessee (UT) scientists are also actively developing composites. Examples include spunbond (SB)/melt blown (MB), known as SM, and SB/MB/SB (SMS) laminates, which are enhanced by using bicomponent MB PP/PE webs. New cotton-based nonwovens have been developed at UT with sponsorship from Cotton Incorporated. These include cotton-surfaced SB composites, and laminates of SB and MB webs with the promise of marrying air laying equipment with the SB and MB processes.

Spunbond Developments

A strong market demand for finer denier SB nonwovens which have greater cover factor (i.e. greater uniformity and barrier performance) at lighter basis weight is driving the development of unique SB processes. About 15 years ago, Reifenhäuser GmbH & Company, Troisdorf, Germany, produced the first “turnkey” SB production lines. These Reicofil® 1 lines, produced fabrics in widths up to 3.2 meters with a filament size of 3.5 denier. Their second generation, Reicofil® 2, was available in the early 1990’s at widths up to 4.2 meters, and with an average filament size of 2.5 denier. By 1997, Reifenhäuser was selling a significant number of their third generation Reicofil 3 lines capable of producing SB PP with filament sizes of 1.0 to 1.5 denier. Within the last two years, Reicofil® composite lines have been installed with SMMS spinning heads capable of fabric production speeds of 500 m/min. Such a line was successfully started up in 1998 in the Czech Republic at Pegas. The introduction of only 3-10 g/m^2 of MB PP notably improves the already high barrier and cover performance of the Reicofil 3 SB fabrics, making them even more ideal as cover stock for diapers and sanitary napkins, as well as for medical drapes and gown and for many other industrial, household and consumer products in the weight range of 15 g/m^2 or greater.

Kobelco, a division of Kobe Steel, Ltd, Japan, has started marketing turnkey SB lines that have the flexibility to produce fine denier PP or PET SB nonwovens (Morimoto, 1999). The new Kobelco SB lines are reported to be capable of S, SS, SSS, SMS, and SMMS production with a plant capacity of 12,000 tons/year. The filament sizes range from 0.7 to 10 denier with PP spinning speeds of 3,500 m/min and PET spinning speeds of 5,000 m/min. The maximum production width is 5.2 m, and basis weights of 8 to 150 g/m2 are possible. The maximum web speed is stated to be 500 m/min. In 1998, Kobelco (Morimoto, 1999) provided a commercial PP/PE bicomponent line in Japan for producing diaper top sheet and it was noted that the trend to fine denier SB is continuing and that Kobelco SB lines are now producing 1.0-1.2 denier PP fabric for diaper use. In 1998, Kobelco and Accurate Products Company began a joint venture in the production and marketing of SMS lines with Accurate Products providing the MB component.

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Ason has obtained process patents primarily pertaining to the adjustable distance between the spin plate to the aspirator (fiber attenuator), which allows them to achieve different fiber diameters, depending on the upward and downward movement of the attenuator. Furthermore, the vertical height of the web collector belt can be raised or lowered to obtain optimal web formation (Lu, 1998).

JM Laboratories has entered into supply agreements with both Hills, Inc. of West Melbourne, Florida and Nippon Kodoshi Corporation (NKK) of Japan in which Hills will provide the bicomponent spin beams and Nippon the spunbond drawing jets. The Nonwovens Cooperative Research Center (NCRC) at North Carolina State University is installing a 20-inch pilot line from JM Laboratories, which will have a SB and a MB spinning beam, with both beams having bicomponent fiber capability. The line is expected to be in operation by March 2001 and will have side-by-side, core-sheath and other types of bicomponent configurations available (Batra, 2000).

Melt Blowing Developments

For the past few years there has been a growing interest and increased production of bicomponent (bico) SB nonwovens, particularly with a PP core for good mechanical properties and a PE sheath for softness and greater ease in thermal bonding. More recently, core/sheath (Berger, 1997) and side-by-side (Zhang,et.al., 1999) MB nonwovens have been developed and appear to be on the verge of commercialization. The first trials of the new Reicofil® Bico fiber (side-by-side geometry) 24-inch MB line at TANDEC were made during the machine start-up by Reifenhäuser in March 1999. Reifenhäuser is funding a three-year research program on bico fiber technology with the principal investigators being Drs. Dong Zhang, Qin (Christine) Sun, and Larry Wadsworth. Much of this work has been presented at Insight 99, TAPPI/INDA INTC 2000, and recent TANDEC Conferences (Zhang, et. al., 1999, Wadsworth, et. al., 1999a, Wadsworth, et.al., 1999b, Zhang, et. al., 2000, and Wadsworth et. al., 1999c).

MB bico nonwovens made of PP/PE offer the advantages of better softness and greater ease of bonding to films or SB nonwovens composed of PP or PE (Wadsworth, et. al., 1999c). Furthermore, the side-by-side bico polymer pairs PP/PET, PP/PBT, and PE/PET have been shown to produce more fiber twisting and crimp due to the large differences in densities between the polyolefins and the PET and PBT polyesters. As was anticipated, the resultant melt blown webs had lower bulk densities and improved filtration efficiency (Zhang, et. al., 1999). Another surprising benefit of bico PP/PET MB was in minimizing heat shrinkage of PET based MB web. MB webs of 100% PET typically have heat shrinkage values of 30-40% if the web is heated without tension at temperatures greater than 90 ºC. This is because there is little stress-induced crystallization in the melt blowing of PET, thus if the web is subsequently heated above its T_G (approximately 80 ºC), it will begin to crystallize resulting in substantial shrinkage. It was found that as little as 25%PP in a PP/PET bico MB fiber web kept the shrinkage to less than 8% (Wadsworth, et. al., 1999b).

Cotton-Based Nonwovens

The above innovations in spunbonding and melt blowing technologies may be utilized in the production of cotton-surfaced nonwovens (CSN’s) and cotton-core nonwovens (CCN’s). Both CSN’s and CCN’s utilize a unique composite configuration with the potential to be produced on a single nonwoven line or as separate components, merging in the final stage of production to produce a performance oriented composite fabric. As shown in Fig. 1, CSN’s are made during spunbond polypropylene production by placing the carded cotton/PP staple fiber webs on one or both sides of SB PP filament webs prior to the SB calender. This type of composite production offers manufacturers an extremely versatile and economic process for various nonwoven hygiene and protective fabric applications. Papers describing the development of CSN’s for personal hygiene, medical apparel and other types of disposable or short-term wear cycle apparel have been recently published (Wadsworth, et. al., 2000, Sun, et. al.. 1999, Sun, et. al., 2000a, Sun, et. al., 2000b)..

CCN's are thermally bonded laminates having cotton cores with outer layers of melt blown and/or spunbond webs. Inner webs of bleached cotton staple have been used to take advantage of the unique properties of this natural fiber. Thin outer layers of melt blown (MB) polypropylene (PP) and/or SB PP webs serve as binder fibers in the thermal bonding step, incorporating specialized performance characteristics. The outer MB and SB layers are engineered to effectively transport liquid into the highly absorbent cotton core from the surface (McLean, 2000). In Figure 2, the CCN process is defined by the encapsulation of a carded bleached cotton web with outer layers of MB PP and/or SB PP during the extrusion process, prior to calendering.

The bleached cotton staple used for the initial stage of fabric development was a premium medical grade with excellent absorbency, entanglement potential, and comfort characteristics. Amidst ongoing technology advancements within the nonwovens industry, additional grades of cotton can now be incorporated into these surfaced composites with similar results as well. Cotton staple, comber, and linter processing parameters have been defined, offering a wider range of economically competitive fibers for product consideration. With this new flexibility comes the opportunity for manufacturers to consider cotton where cost and processibility were once a deterrent.

Processing Considerations

The processing and formation of cotton surfaced nonwovens may be accomplished at a single site, or in stages, dependent upon each manufacturing facilities capabilities. The potential to incorporate two unique fiber structures, one synthetic and one natural, into a performance oriented composite specifically designed for a particular end use allows manufacturers several processing options when considering such a process. The ability to cross over the synthetic - natural processing barrier is easily attained by the importation of one or the other fibers, or both, in pre-bonded form prior to the final formation processing step. Beyond the obvious benefits of staging an all inclusive nonwoven line, which would allow the cotton induction on the SB/MB line prior to calendering, equipment may also be installed to accommodate existing recommended equipment which may already be in place. Another option exists which would allow pre-formed cotton web and SB/MB to be purchased independently and formed via a sole calender into the cotton surfaced nonwoven. The following manufacturing configurations highlight various equipment configurations, which would allow the production of the cotton, surfaced structures:

- SB/MB line – carding machine – calender
- SB/MB line – airlaid machine – calender
- SB/MB line – roll stations – calender
- Carding machine – roll stations – calender
- Airlaid machine – roll stations – calender
- Multiple roll stations – calender

These configurations give a basic idea of the possible installations required for the formation of cotton surfaced nonwovens, but do not represent all possible alternatives. What is important to note is the economic versatility allowed by the importation of pre-formed webs, synthetic or natural, alleviating the need for major equipment expenditures.

CSN – CCN Short-Life Product Implementation

With the processing and basic performance attributes defined, a list of potential product categories has been developed. With such a versatile composite structure comes the potential to explore a wide range of product categories where specific parameters can be designed to deliver distinct performance characteristics. Beyond the fiber dynamics chemistry can also be incorporated to deliver additional features, extending the range of performance initially defined. The performance, related to acquisition, absorbency, retention, resiliency and protection, are all unique to the design of the cotton surfaced nonwovens and make this a highly innovative nonwoven base for product implementation. Below is a list of possible product categories suitable for variations of the cotton surfaced nonwoven structures.

- Hygiene Market
  - Diaper Components (acquisition, core, backsheet)
  - Feminine Hygiene Pads
  - Adult Incontinence (acquisition, core, backsheet)
- Wipes
  - Baby
  - Consumer
  - Industrial
- Medical/Surgical
  - Surgical Packs (barrier gown, drape)
  - Sponges
  - Bandages
- Air/Liquid Filtration
  - Cleanroom elements
  - Heating-Cooling elements
  - Hot-Cold liquids
  - Hydraulics

Cotton nonwovens produced by hydroentanglement and needlepunching technologies are gaining acceptance in nonwovens markets, particularly in products such as cotton balls, cotton swabs, cosmetic pads, medical sponges and wet filtration. Nevertheless, additional inroads may be made by utilizing air laying and carding technologies in conjunction with high speed spunbond and melt blown processes to produce cost effective cotton composites for the hygiene, wipes, medical and filtration markets.

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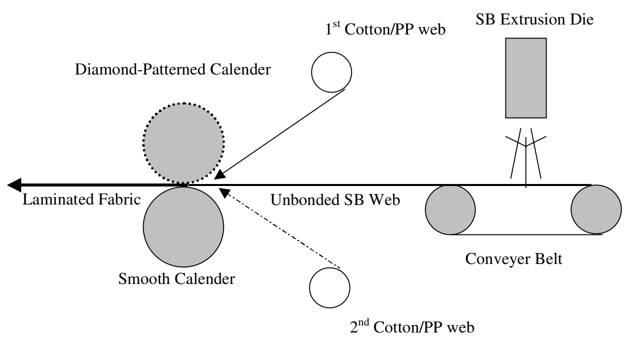

Figure 1. Preparation of Cotton-Surfaced Nonwovens (CSN's) on Spunbond Line.

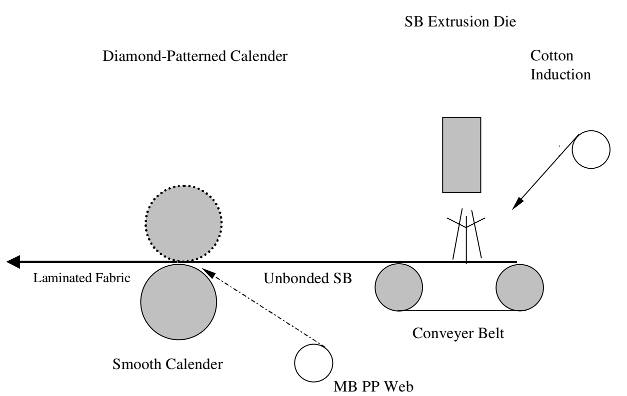

Figure 2. Preparation of Cotton-Core Nonwovens (CCN's) on Spunbond Line made of SB PP/Cotton/MB PP.