NONWOVENS - THE ROUTE TO MILLENNIUM FABRIC MAGIC

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Abstract

This paper provides an overview of nonwoven hybrid manufacturing methods and product examples. It also gives an illustration of how the World Wide Web can be used to obtain technical illustrations of these processes.

Introduction

At the 1999 Beltwide Conference, the paper, "Nonwoven Processes and Products Applicable to Cotton and Other Cellulosic Fibers," provided a general overview of the basic technologies used to manufacture nonwoven fabrics and the product characteristics resulting from these technologies and introduced the concept of nonwoven hybrids. Essentially, these basic nonwoven technologies adapt machinery and processing principles that are traditionally used in the textile, paper, or extruded polymer industries to produce rolls of fabric as continuous processes. Common to each of these systems are four sequential phases: fiber selection and preparation, web formation, bonding, and finishing, as shown in Table I.

Fiber selection and preparation involves choosing the fiber or fiber material for a specific application and purifying it so that the process will yield a fabric with properties sufficient to perform its intended function. Web formation is the process by which individual fibers or fibrous materials are arranged in order to bring about the physical properties desired in the fabric structure. Bonding is the process by which the fibers or fibrous materials are interlocked in order to provide the integrity or strength desired in the fabric structure. Finishing includes slitting the fabric to the width desired, winding the fabric in roll form or cutting it to the length desired, and treating the fabric surface chemically or mechanically to bring about enhanced functional or aesthetic properties. These nonwoven processes and the fabrics made from each have a number of common characteristics. In general, textile-based processes provide maximum product versatility, since most all textile fibers and bonding systems can be utilized and conventional textile fiber processing equipment can be readily adapted at minimal cost. Extrusion-based processes provide somewhat less versatility in product properties, but yield fabric structures with exceptional strength-to-weight ratios (namely, spunbonds), high surface area-to-weight characteristics, (specifically, melt-blowns) or high property uniformities per unit weight (such as films) at modest cost. Paper-based nonwoven processes provide the least product versatility and require a high investment initially, but yield outstandingly uniform products at exceptional speeds.

The purpose of this paper is to demonstrate how nonwoven hybrids have expanded the domain of nonwovens by incorporating the best product and process characteristics of traditional nonwoven production methods to yield high performance structures for specific technical applications.

Discussion

Nonwoven Hybrids

It may seem like magic when two or more components are put together and the results defy the law of mixtures by yielding something synergistic or unexpectedly greater than the sum of all the parts – but it isn't. In fact, it is done every day and often taken for granted in modern genetic engineering. Furthermore, this concept has been too often forgotten as being the basis for advancements in agricultural science that have made American agriculture the world's most prolific industry. What may appear to be magic is really a form of industrial creativity and invention and can be equated to developing a fundamental understanding of a technical need and the intelligent selection of components to more efficiently satisfy that need. A specific technical need may have been known but not satisfied, and technology to satisfy the need may have been well established. Given that the technical need would be deemed useful and have anticipated commercial merit, the need must be expressed in terms of a task or function to be accomplished. The intelligent selection segment can become reality through an understanding of the components of technologies used to make products that work to satisfy a similar technical function or parts of the task to be accomplished. In the field of nonwoven fabric technology, such creativity and invention can be found by taking a closer examination of nonwoven hybrids.

Nonwoven hybrids incorporate the advantages of two or more nonwoven manufacturing systems to produce specialized fabrics with properties unattainable by any single nonwoven process. Nonwoven hybrid processes include (1) methods to *combine* two or more nonwoven fabrics made by any of the basic nonwoven manufacturing systems, (2) methods to provide a *combination* of fabric properties, and (3) methods to produce true *composite* nonwoven structures. Combining systems use lamination technology, or at least one basic nonwoven web formation or consolidation method, to join two or more fabric layers. Combination systems employ at least one basic nonwoven web formation, bonding, or finishing element to enhance the properties of one or more fabric substrates. Composite systems integrate two or more

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basic nonwoven web formation technologies to produce intimately blended web structures. In general, hybrids made by combining technologies can be separated or delaminated into their basic fabric components, while combination hybrids may or may not be separated depending on the intensity of the combining. Also, composite hybrids will maintain homogeneity, while combination systems may or may not. Composite hybrids also allow for the addition of non-fibrous materials, such as powders or granules.

Examples of combination hybrids are a tissue hydroentangled with a carded rayon nonwoven to make a wipe with large and small capillaries, and spunbond-meltblown-spunbond layers to make high strength/surface area fabrics. Commercial combined hybrids include carded polyester fiber webs hydroentangled onto extruded net grids for use as stable dust cloths and film thermoembossed to a bicomponent carded web to make a cloth-like diaper backing. Successful composite fabrics include meltblown/pulp fabrics for water and oil absorption, meltblown/polyester staple fabrics for apparel insulation, and meltblown/staple fiber/charcoal granule fabrics for respiratory masks. Hybrid roll goods producers include BBA Nonwovens, Dexter Nonwovens, Freudenberg, and PGI. Hybrid product manufacturers include business firms not readily familiar to many textile producers such as Kimberly-Clark, Proctor and Gamble, 3M, Freudenberg, Dexter, and Kao. An abbreviated search on the World Wide Web, product package disclosure descriptions, or patent databases will yield illustrations of how hybrid nonwovens are used in a variety of consumer products. Kimberly-Clark is a leader in the roll goods business as well as the consumer products field, and excerpts from their web page will be used as illustrations in this paper.

Combination and Combined Hybrids

The spunbond-meltblown-spunbond (SMS) process, shown in Figure 1, yields fabrics with both the high strength per unit weight of the spunbond structure and the high surface area per unit weight of the meltblown structure. These fabrics are used as lightweight bacteriological barriers in medical garments and breathable moisture barriers in car and boat covers, as they prohibit liquid flow while permitting air passage.

Kimberly-Clark's Scrim Reinforced Materials Process, shown in Figure 2, can be used to demonstrate the manufacture of both combination and combined hybrids. The process as depicted in Figure 2 uses soft nylon yarns interlocked into a scrim as reinforcement for layers of tissue. The scrim/tissue combination is pressed and slit to make a soft, drapable wiping product with both strength and absorbency. Embossment of a tensioned meltblown elastic between two spunbond fabrics will make a strong, lightweight structure with unidirectional stretch. Use of this technology with a rigid extruded grid as both a reinforcement and a matrix for hydroentangling splitable or small diameter textile grade polyester fibers can be used to make a dimensionally stable cloth for dust and hair removal. A lightweight web of textile fibers heat pressed onto an impermeable film yields a soft-surfaced fabric with a cloth-like touch that will partition fluid like body waste from a baby's cuddling grandparent.

Composite Hybrids

A convenient way to obtain intimately blended nonwoven structures is to arrange two or more web formation elements in parallel. Kimberly-Clark's Coform process, shown in Figure 3, illustrates this principle for meltblown pulp fibers. Use of a top film and embossing calender enables the continuous manufacture of slit rolls of material for subsequent cutting and packaging of sanitary absorbent product. Placement of a particle metering station at the fiberization/extrusion interface permits precise loading and distribution of superabsorbent powders or other functional granules. Placement of lofty textile fiber at the fiberization location can be used to produce thin apparel insulating fabric with microporous capillaries or filtration media for fine particle entrapment. Capture of the composite mixture on a form or shaped surface can yield three-dimensional articles such as face masks.

Summary and Conclusions

Nonwoven hybrid structures are the product of industrial creativity and invention and have been made possible through the development of a fundamental understanding of specific technical needs and the intelligent selection of materials and processes to most efficiently satisfy that need. They have been proven to be useful and commercially successful, because they perform better than other fabrics and often provide properties and performance levels not approachable by other fabrics. Nonwoven hybrids define a fourth dimension to the many types of fabric structures that can be made through the use of nonwoven technology; their possibilities are presently limited only by any absence of an adequate description of the function needed and the availability of appropriate fiber material.

Table I. Basic Nonwoven Fabric Manufacturing Systems

	Textile			Paper		Extrusion		
	Garnetting	Carding	Air Laid Fiber	Air Laid Pulp	Wet Laid	Spunbond	Meltblown	Film
Fiber Selection And Preparation	Natural and Manufactured Textile Fibers			Natural and Manufactured Fiber/Pulp		Fiberforming Polymer Chips		
	Mechanical Opening and Volumetric Blending			Mechanical Opening Gravimetric Feeding	Wet Slurry	Mechanical, Electrostatic, Aerodynamic Filament Orientation	Aerodynamic Fiber Orientation and Shattering	Perforate, Cast; Cast and Aperture
Web Formation	Mechanical		Fluid					
	Parallel Fiber Layers Randomized Batts Crosslapped Layers		Isotropic Fiber Layers	Random Fiber Matts		Pattern Layering Controlled on Conveyor Fiber Layers	Collection on Conveyor Screen Screen or Shape	Heat,Heat Stretch, Perforate, Heat, Stretch
Web Consolidation (Bonding)	Mechanical					Mechanical	Cooling	
	Stitchbonding, Needlepunching, Hydroentangling			Hydroentangling		Needlepunching		
	Chemical							
	Sprayed Latex or Powder; Saturated, Printed, or Frothed Latex; Solvent							
	Thermal							
Finishing	Thermal Calender, Radiant or Convection Oven, Vacuum Drum or Mold, Laminating, Sonic Welding							
	Slitting, Winding							
	Other Application-Dependent Physical or Chemical Surface Treatments							

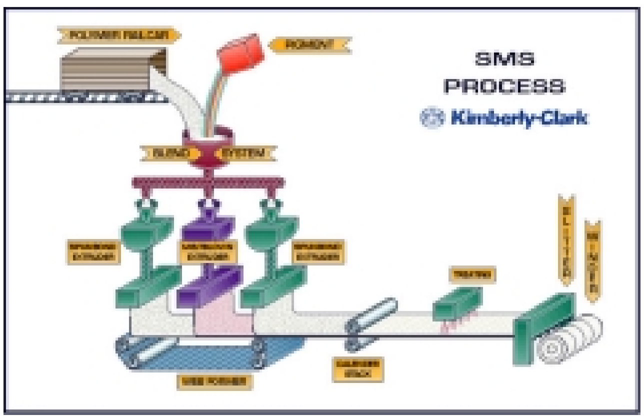

Figure 1. Kimberly-Clark's SMS process.

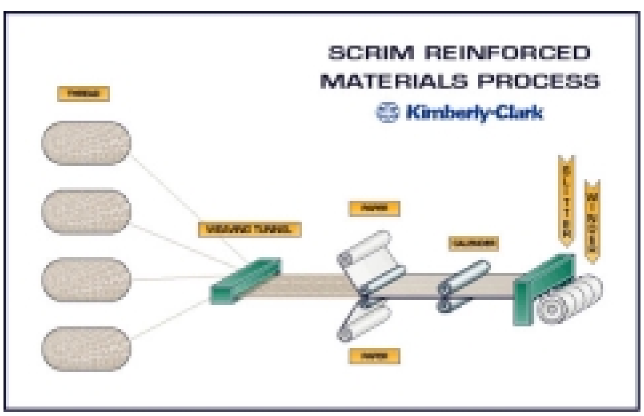

Figure 2. Kimberly-Clark's Scrim Reinforced Materials Process.

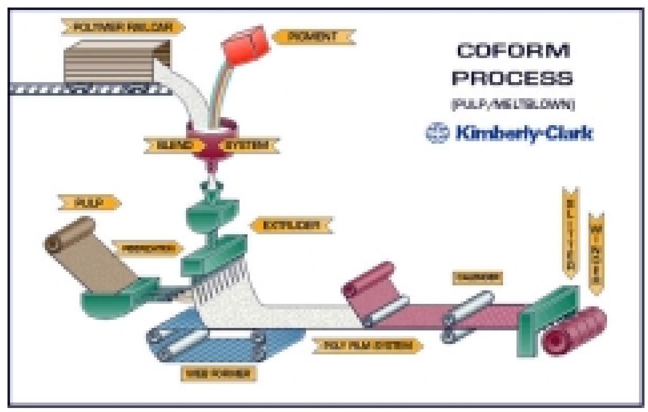

Figure 3. Composite hybrid process.