

Fiber Systems Technology Primer

An Introduction to Spunbond and Meltblown

Nordson Fiber Systems



INTRODUCTION

Consumer demand for nonwovens disposable and durable products has helped drive commercial production of spunbond and meltblown fabrics. Recent equipment and technological advancements make it economical for manufacturers to produce rolled goods in-house. This paper presents a comparison of these materials, production components, fabric properties, raw material characteristics and terminology.

Nordson Fiber Systems improve productivity and quality in nonwovens fabric production, using mono and bi-component meltblown, spunbond and SMS composite processes. Manufacturing capabilities include micro-fiber meltblowing equipment for filtration and fiber applications, and spunbond fiber-spinning equipment for hygiene and durables products.

Meltblowing Lines. Nordson Fiber Systems began manufacturing meltblown products in 1989 when it became a licensee of the Exxon meltblowing process. Since that time, Nordson has developed proprietary technology to enhance production efficiency. Meltblown systems heat and extrude polymers through a patented meltblowing die. The molten polymer is then attenuated by heated, high-velocity air and spun into micro-sized filaments that are collected to form a fibrous nonwoven web. Meltblown fabrics are used for filtration, insulation, absorption and barrier products. End products include surgical masks, diapers, battery separators, and liquid and air filters. Oil abatement companies use a patented Nordson process to produce absorbing meltblown mats used at oil spills.

Spunbonding Lines. Spunbond systems heat and extrude polymers through a patented spunbonding die. Molten polymer is cooled prior to being attenuated by ambient high-velocity air and spun into filaments that are collected to form a continuous fibrous nonwoven web. Spunbond fabrics are used in filtration, insulation, carrier web and geotextile products for end products such as surgical apparel, diapers, battery separators, carpet backing, roofing and liquid and air filters.

Composite Lines. Composite webs are finding rapid acceptance and integration in a variety of products. Recently developed applications for SMS (spunbond-meltblown-spunbond) and SMMS (spunbond-meltblown-meltblown-spunbond) technologies on baby diapers include standing leg gathers, soft outer cover, stretchable fastening tapes, and stretchable outer covers and panels. At least 40 to 50 percent of a diaper is made of synthetic fibers and advanced composite structures.

MELTBLOWN AND SPUNBOND SYSTEM FAMILIARIZATION

Familiarization with components and procedures is essential to understand equipment capabilities.

Polymer Feed. Polymer feedstock in pellet or powder form is conveyed from storage bins or silos to the extruder feeder section. Pellet feed methods and systems are the same for both spunbond and meltblown processes.

Extruder. Polymer feedstock is mixed with additives, color master batch, resin modifiers or other additives. This blend of raw materials is melted within the extruder barrel for spunbond and meltblown processes.

Fiber Spinning. Molten polymer mix is pumped through a heated conduit to a resin filter system. The polymer exits to a distributor (coat hanger) section that leads to spinneret units for both spunbond and meltblown processes. The spunbond spinneret usually consists of a perforated plate arranged across the width of the line. The resin is forced through many small holes in the spinneret plate to form continuous filaments. The spunbond die plate consists of a matrix of holes on a flat plate, while meltblown spin holes are arranged in a straight line along the crest of the die tip.

Quenching/Attenuation Zone (spunbond only). As the filaments emerge through the spinneret holes, they travel downward into quench chambers or chimneys. Cool air directed across the filament bundle solidifies the filaments. An air stream guides the filaments further downward into a tapered slot. A second stream of high-velocity air parallel to the filaments causes acceleration and attenuation or stretching. This mechanical action increases orientation of the polymer chains making up the continuous filament. Such orientation leads to increased filament strength, along with modification of other filament properties, including fiber denier or thickness.

Web Formation. Spunbond or meltblown filaments are deposited in a random manner on a moving, porous forming belt. A vacuum under the belt assists in web formation and removes air used in the extrusion/orientation operation. In some processes, an electrostatic charge placed on the filament bundle enhances spreading and separation of individual filaments. Other processes use deflector plates to randomly lay down the filament sheet on the forming belt.

Bonding. Several bonding methods are used to bond loose spunbond filaments into a strong integrated fabric. Nordson equipment uses calender point bonding for spunbond. Meltblown webs bond when deposited on the forming belt due to an inherent self-entangling process, so, additional fiber bonding is not required.

Slitting/Winding. Bonded spunbond or meltblown fabric is trimmed to eliminate non-uniform, rough edges created during manufacturing. In some operations the fabric may also be split into precise, smaller widths to provide finished rolls of specific dimensions. The fabric is then wound on a larger roll, wrapped and shipped to the customer.

POLYMER VERSATILITY

Polypropylene (PP). Possesses good strength, easy processing, a lower melting point (350° F, 160° C), good chemical resistance, moderate textile strength properties, at relatively low cost, however, is difficult to dye after processing. Polypropylene requires narrow molecular weight distribution, (MWD), which aids in fiber spinning.

Polyester (PET). Exhibits excellent physical properties, moderate processing characteristics, high melting point (450° F, 220° C), excellent textile properties, and good dye reception after spinning. PET requires pellet drying and surface crystallization prior to spinning. Polyester has strong consumer acceptance and extensive industrial use.

Nylon (PA). Contains excellent physical properties and wear characteristics with high strength, and good textile properties and dye characteristics. Nylon is moderately expensive and well accepted. PET and nylons are hydrophilic and require crystallization or drying prior to extrusion. Raw material suppliers offer crystallized and dried forms, but at higher costs per pound. It is typically more cost effective to complete this process on-site.

Polyethylene (PE). Linear low-density polyethylene provides excellent chemical resistance, very soft hand and no dye receptivity. Despite lower physical processing properties, low melting point (240° F, 115° C) and modest textile strength properties, PE is used in a wide range of products due to ease of processing and softness.

Resin Additives. Resin additives may be added to the spunbond and meltblown processes prior to extrusion. These additives impart specialized characteristics or overcome shortcomings of a particular resin. Additives can include rewetting agents, flame-retardants, antistatic agents, lubricants, ultraviolet absorbers, resin stabilizers and antioxidants.

Colorants. Colorants added prior to the extrusion process become permanently locked in the filaments, giving the color exceptional stability.

FABRIC CHARACTERISTICS

Fabric Strength. Refers to tensile strength, elongation, modulus, tear strength, burst strength or abrasion resistance. Spunbond fabrics usually have high strength and lower weights than other nonwoven processes.

Balance. Since the web is randomly formed based on an aerodynamic system, spunbond webs can be isometric structures with equal properties in all directions.

Softness. Refers to tactile properties, blending, rigidity, hand, drapability and smoothness.

Fabric Uniformity. Uniformity contributes to a fabric's opacity, covering power and formation of filament lay down. Spunbond fabrics usually have poor to moderate uniformity to accommodate the covering power that a greater number of filaments and a heavier fabric weight require. A layer of meltblown provides better covering power and barrier properties. Increased production speeds necessitate precise system control for uniform lay down of filaments. Ropiness, cloudiness and basis weight variation also result from non-uniform lay down.

Fabric Absorbency. Refers to liquid absorbency rate, absorbency capacity, wicking rate, liquid retention and water or oil absorbency. Most commercial spunbond products are derived from polymers that are hydrophobic (polyolefin) or semi-hydrophobic (PET, nylon). Spunbond fabrics often need to be hydrated with surfactants or surface modifications (plasma, corona) to improve wetting. Hydrophobic fibers made of polypropylene function very effectively in oil absorbency. The wicking action of finer fibers improves water absorbency for PET webs or PP webs, which have been surface treated for water absorbency.

Fabric Chemical/Thermal Resistance. Chemical and thermal resistance depends on the polymer used in the spunbond process. Generally, spunbond fabrics have good to excellent chemical resistance. Thermal resistance is highest in PET and decreases respectively in nylon, PP and PE spunbond fabrics.

BI-COMPONENT FIBERS

Concepts and commercial uses of bi-component fibers have existed for several decades. The complexity, cost and limited production rates of fiber extrusion equipment have historically limited commercial applications. Recent equipment and process developments resolve most limitations, resulting in rapid growth in commercialization of new and complex bi-component fiber products, particularly spunbond.

Bi-component (bico or conjugate) technology allows manufacturers to:

- Reduce cost
- Improve strength and softness
- Produce ultra-fine fibers
- Provide improved loft and/or crimp

Typical bi-component fiber products include sheath and core, side-by-side and split tables, (also called segmented pie).

1. *Sheath and Core Products*

There are three types of sheath and core products.

- a) Self-bonding fibers consist of low melt temperature sheath surrounding a higher melt temperature core. Common sheath/core combinations include PE/PP, PE/PET, Co-PET/PET and PA/PET. These products are used in a 100 percent form, as well as in blends with homo-polymer filaments.
- b) Filled fibers consist of a core produced from recycled, conductive or other materials that is covered by a sheath possessing specific aesthetics or properties.
- c) Sheath polymer contains expensive additives or attributes useful on the surface of the filaments. This form exemplifies a new bi-component fiber type that is economically viable with modern bi-component technology.

2. *Side-by-Side Products*

Side-by-side products are usually used as self-bulking fibers. Self-bulking is created by two polymers within a filament having a different shrinkage level or shrinkage propensity. This form offers the advantages of higher processing speeds, reduced equipment investment, more bulk, improved hand, enhanced aesthetics and elimination of downstream processes.

3. *Segmented Pie or Splittables*

Micro-fibers are produced by bi-component techniques that cause fibers to split apart. These methods produce smaller fibers than homo-polymer techniques. Filaments consist of alternating segments (pies or stripes) using two different polymers that break apart during flight or the downstream processing. Downstream processes for splitting fibers include mild chemical treatment in dyeing, and break up by hydro entanglement of staple or spunbond fibers.

EQUIPMENT PROCESSES

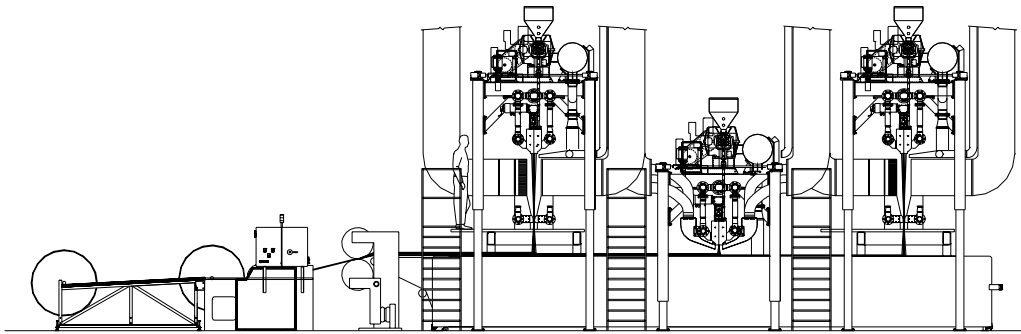


Figure 1. SMS Line

The multi-station line shown illustrates the mode for manufacturing a spunbond-meltblown-spunbond (SMS) laminate (Fig. 1). The station on the far right (station one) is the spinning assembly consisting of a spunbond die insert and moveable support structure shown in its upper position for providing the desired spinning height. Quench ducts and a filament-stretching device are in this station. The center station (station two) contains the spinning assembly with a meltblowing die insert. The moveable support structure is positioned at its lower position, placing the spinning assembly at the proper meltblowing spin height. The spunbond station on the far left (station three) is identical to station one.

The operation begins by spinning continuous filaments from the spunbond die of station one. The filaments pass through the quenching zone, which cools and prevents them from sticking together. The quenched filaments pass through a stretching zone where discharged air further draws down and attenuates the filaments. Filaments are randomly deposited on the conveyor. Air passes through the conveyor and is withdrawn by the vacuum system.

The first layer is conveyed under the spinning assembly in station two where micro-sized fibers are blown on top of the first layer, forming a meltblown layer on the spunbond. Average fiber diameter ranges from 0.5 to 15 microns. A fiber diameter of 1 to 10 microns is considered good, while 2 to 6 microns is excellent.

The two-layer laminate is conveyed under station three where a layer of spunbond filaments is deposited on the meltblown layer, completing the SMS structure. The three-layer composite may then pass through a calender or other device to bond the layers together in the conventional manner.

GENERAL MARKETS

Nonwovens fabrics are categorized by end use as disposable or durable products.

Disposables

The largest market for nonwovens fabrics is baby diaper products. Feminine hygiene spunbonds are ranked third in facing applications, following carded thermal bonded PP and film. In adult incontinence products, spunbonds compete against carded thermal bonded materials; however, meltblown webs are gaining an increasing share of the market.

Spunbond and SMS fabrics play a significant role in healthcare products, such as surgical pack items and medical protective apparel. Spunbonds are used in fabric softener sheets where they compete against carded chemically bonded webs.

Durables

Durable fabric end uses include a variety of filtration products, as well as building and construction where nonwovens are used in geotextiles and roofing. Modified bitumen products that include a spunbond carrier are popular for residential and commercial roofing. Automobile primary carpet backing and carpet tiles use spunbond materials, which offer good moldability and high dimensional and heat stability.

END MARKETS

Product	Fabric
Disposable Diaper, Incontinence	Largest single market segment in nonwovens for cloth-like backsheet, leg cuff and cover stock
Durable Papers	Almost exclusively Tyvek® polyethylene spunbond fabric*
Disposable, Protective Apparel	Dominated by Tyvek polyethylene spunbond fabric, although growing use of polypropylene spunbond and composite materials
Bedding, Pillows, Furnishings	Competitive market segment using polypropylene and polyester spunbonds
Geotextiles	Heavyweight polypropylene and polyester spunbonds, and needlepunch polypropylene and woven fabrics

Furniture	Polypropylene spunbond fabric, polypropylene needlepunch and polyester spunbond fabric
Filtration	Spunbond and meltblown fabric for liquid and air filtration
Automotive, Carpet, Trim	Heavyweight polyester spunbond fabrics
Carpet Underlayment	Carpet backings consisting of PET, polyamide and polypropylene spunbond fabrics
Medical Products	Spunbond and spunbond/meltblown composite fabrics
Roofing	Typically polyester spunbonds

* Tyvek is a registered trademark of E.I. DuPont de Nemours & Co.

CONCLUSION

Demand for nonwovens disposable and durable products has helped drive commercial production of spunbond and meltblown technology. Consumer demand continues to drive the need for new spunbond, meltblown and composite fabrics, which is expected to grow globally by at least 3% over the next 7 years. Mono and bi-component meltblown, spunbond and SMS composite processes are being continually developed to improve processing, fabric properties and to meet growing global needs.

GLOSSARY OF TERMS

Amorphous. Not crystalline; a random arrangement of molecule chains within regions of a polymer or fiber.

Basis weight. The weight of unit area of a nonwoven; i.e., ounce per square yard and gram per square meter.

Bi-component fibers. Fibers made from two different polymers extruded one about the other (core within a sheath) or side-by-side.

Catalyst. An agent that speeds up the rate of a chemical reaction without being consumed in the chemical process.

Cross-direction. Short direction within the plane of the nonwoven that differs 90 degrees from the direction in which the nonwoven is manufactured

Cross-linking. Chemical reactions that create bonds at several points between polymer chains, causing the polymers to be less soluble and to undergo changes in elasticity and stiffness.

Crystalline. Orderly arrangement of molecules and polymer chains in a polymer or fiber.

Drape. The ability of a nonwoven to fold on itself and conform to the shape of the article it covers.

Drawing. Process of stretching a filament after it has been formed to reduce its fiber diameter. At the same time the molecules of the filament are oriented, making it stronger. The ratio of the final length to the initial length is the draw ratio.

Elastomers. Polymers having rubber-like qualities of stretch and recovery.

Entanglement. The method of forming a nonwoven by wrapping and knotting fibers in a web about each other by mechanical means.

Fiber. The basic threadlike structure from which nonwovens are made. It differs from a particle by having a length at least 100 times its width. Continuous fiber has unending length because the polymer chains are unbroken.

Fiber distribution. The random or parallel orientation of fibers and the uniformity of their arrangement in a web.

Geotextile. Permeable nonwoven used in civil engineering construction projects to stabilize and control sedimentation and erosion. Applications include paving, dams, embankments and drainage.

Hand. Quality of a nonwoven perceived by touch that includes softness, firmness, stretch, resilience and drape.

High loft. General term used for low density, thick or bulky nonwovens, as compared to flat paper-like nonwovens.

Hydrophilic. Having the affinity for being wetted by water or for absorbing water.

Hydrophobic. Lacking the affinity for being wetted by water or for absorbing water.

Industrial nonwovens. Non-apparel and non-decorative products, wipes, cable wrappings and geotextiles.

Instron tensile tester. High-precision electronic test instrument that measures the elongation or shortening of nonwovens when forces (pulling or compressing) are applied.

Isotropic. Having the same physical properties in every direction in the plane of the nonwoven. It is related to random distribution of fibers.

Machine direction. The direction in which a nonwoven is manufactured.

MFR/MFI (melt flow rate/melt flow index). The weight of polymer extruded in 10 minutes at a constant temperature (190° C - PE) through a tubular die of specified diameter (0.0825 in.) when a standard weight of 2160g is placed on the driving piston; rate or index represents extrudability.

Molecular weight (mass). Combined molecular weight of the various molecular chain lengths that make up a polymer product; i.e., short chains governing tensile, medium chains, shear and long chains, elasticity.

Molecular weight distribution. Measurement of the distribution uniformity for various molecular chain lengths that make up a polymer product.

Morphology. Study of fine, microscopic structure of a fiber or nonwoven, including its crystalline and amorphous nature.

Nonwoven. Fabric made directly from synthetic fibers or filaments without the yarn preparation needed for weaving or knitting.

Orientation. Lining up or parallelism of molecular chains in fibers.

Permeability. Property that permits the diffusion of liquids and gases.

Polymer. A compound formed by chemically linking macro-molecules together in chains. High polymer denotes substances made from very long chains. Cross-linked polymer describes a substance with molecular links between chains. Polymerization is the process for making these polymers.

Rolled goods. Nonwoven fabrics rolled on a core after it has been produced.

SMED (single minute exchange of die). Concept representing the ability to change out a component in less than 9 minutes.

Spinning. A process where filaments or fabrics made from filaments are generated directly from a molten polymer; e.g., meltblown and spunbond processes.

Spinneret. A disk or screen containing many small holes through which molten polymer is extruded to form filaments.

Staple fiber. Fibers cut to length from continuous filaments.

Substrate. Fabric on which coatings or other nonwovens are applied.

Surface charge. Electric charge to a fiber or nonwoven usually used to add filtration capability; e.g., TANTRET.

Surfactant. A chemical additive that changes the surface attraction between two liquids, or between a liquid and a solid, by altering the surface energy of one or both components.

Synthetic fiber. A man-made fiber usually made from molten polymer or from a polymer in solution.

Tear strength. Resistance of a material to tear.

Thatched roof effect. High-density fiber laydown per given area resulting from extremely low DCDs. It is achievable only with secondary air quench systems, providing extremely uniform CD and MD distributions of weight and, high waterproofing with low pressure drops.

Thermoplastic. A plastic that will repeatedly soften when heated and harden when cooled.

Tow. A bundle of continuous filaments - the form of most man made fibers being cut into staple fibers.

UV degradable. Property of a nonwoven to decay from exposure to UV light.

Wash and dry cleanability. Ability of a nonwoven to maintain its characteristics after repeated washing or dry cleaning.

Viscosity. The property of a material that defines its resistance to deformation or flow. For meltblown and spunbond processes, viscosity refers to polymer flow through a die or system at a given temperature.

Nordson Corporation is the world's leading producer of precision dispensing equipment. Headquartered in Westlake, Ohio, Nordson has direct operations in 30 countries. Nordson manufactures, markets and distributes its products worldwide through strategically located facilities supported by a network of regional offices and licensed distributors.

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