

Handbook of nonwovens

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Polymer-laid web formation

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4.1 Introduction

Polymer-laid, spunlaid or 'spunmelt' nonwoven fabrics are produced by extrusion spinning processes, in which filaments are directly collected to form a web instead of being formed into tows or yarns as in conventional spinning. As these processes eliminate intermediate steps, they provide opportunities for increasing production and cost reductions. In fact, melt spinning is one of the most cost efficient methods of producing fabrics. Commercially, the two main polymer-laid processes are spunbonding (spunbond) and meltblowing (meltblown). Both are similar in principle, but the technologies used are quite different. Because of distinct differences in the structure and properties of the fabrics, these processes have grown in parallel since their inception in the late 1950s and for some applications they are also used in combination to produce bilaminates, trilaminates (e.g., SMS) and other multilayer fabrics. Advancements in polymer chemistry and extrusion technology have enabled an increasingly varied range of products to be developed based on the core spunlaid and meltblown technologies. Some of the most important research commenced in the late 1950s, and an extensive number of processing and product patents have been reported over the years. More recently, there has been a dramatic resurgence of research and development concerned with polymer-laid systems as well as an increased acceptance of the fabrics in new product areas.

4.2 Resins for spunbonding and meltblowing

In general, high molecular weight and broad molecular weight distribution polymers such as polypropylene, polyester and polyamide can be processed by spunbonding to produce uniform webs. Medium melt viscosity polymers, commonly used for production of fibers by melt spinning, are also used. In contrast, low molecular weight and relatively narrow molecular weight distribution polymers are preferred for meltblowing.

4.2.6 Rayon

Many types of rayons (including viscose and cuprammonium rayon) have been successfully processed into usable spunbond webs using wet-spinning technology. The main advantage of rayon is that it provides good drape properties and softness to web.

4.2.7 Bicomponents (Bicos) and mixed polymers

Some fabrics are composed of several polymers. A lower melting polymer can function as the binder that may be a separate fiber interspersed with higher melting fibers, or two polymers may be combined into a single fiber type. In the latter case the so-called bicomponent fibers or filaments possess a lower melting component, which acts as a sheath covering a higher melt temperature core. Bicomponent filaments are also spun by extrusion of two adjacent polymers. Polyethylene, nylon-6 and polyesters modified by isophthalic acid are used as the lower-melting point bicomponent elements. New polymers such as PTT and PTAT have been shown to produce good quality spunbond webs. PTT has an intermediate melt temperature between that of PP and PET and has no shrinkage problems compared to regular PET. PTAT is a copolyester that is biodegradable and has the definite advantage of disposability with low environmental impact. Many other new polymers, copolymers and polymer blends are being evaluated as candidates for spunbonding. Whereas each polymer or combination of polymers can claim certain advantages, the cost of these resins, at least initially, prevents their growth. Unless the property advantages offered by these new resins outweigh the higher cost, their growth will be limited to specialty applications.

Splittable bicomponents are also found in spunbond fabrics and have some interesting applications. The cross-section of these bicomponent filaments has at least two different polymer components, which in spunbonding are normally arranged sequentially in a segmented pie form. To aid mechanical splitting, the core of the filament may be hollow. Evolon® fabrics produced by Freudenberg are made of segmented bicomponent filaments that are split into microfibrils during hydroentanglement of the spunlaid web. The resulting fabrics are extremely soft, particularly after finishing, and have therefore been considered for use in clothing, hygiene and medical dressing components. Additionally, bicomponent fibres with an eccentric sheath core arrangement are used to develop crimp in spunlaid fabrics by differential thermal shrinkage of the two polymer components.

4.3 Spunbond fabric production

The concept of spunbond fabric production (or spunlaid web formation) developed simultaneously in Europe and the USA in the late 1950s but it was

later, in the mid-1960s to the early 1970s, that the commercial potential of spunbond technology was fully recognized. Numerous patents on spunbond process design were filed during this period and some were commercially adopted. In the USA, DuPont developed and commercialized the first spunbond process in the late 1950s.⁷ In 1965, research at DuPont resulted in a polyester spunbond product called Reemay[®] manufacture. This was followed by the polypropylene spunbond fabric Typar[®] and the flashspun polyethylene fabric Tyvek[®].⁸ Although DuPont subsequently sold both the Reemay[®] and Typar[®] technologies to Reemay Inc., DuPont still remains a significant force in the spunbond market with Tyvek[®] branded products.

In Europe, the German company Freudenberg filed several patents on the spunbond process in 1959. Six years later, Freudenberg introduced their first spunbond process, Lutravail[®] and made a product called Viledon M[®], made from mixed polyamides.⁹ The German company became the first European spunbond manufacturer and in 1970 Freudenberg incorporated all its spunbond activities into the Carl Freudenberg Spunbond Division based in Kaiserslautern. At this facility, polyester, polyamide, and later polypropylene spunbonded fabrics were produced. About the same time in 1970, Lurgi Kohle & Mineraloltechnik GmbH, Germany introduced the Docan[®] spunbond process and in 1971 started licensing the process in the USA. Many US and European spunbond roll goods manufacturers use the Docan[®] process with proprietary modifications.

There were comparatively few major developments in the spunbonding process from 1971 to the early 1980s until in 1984, Reifenhauser GmbH, Germany, introduced the Reicofil[®] spunbond process. A few years before its introduction, Reifenhauser had purchased the rights to an East German patent for the production of polyamide spunbond webs.⁷ Considerable research and development effort based on the original East German process resulted in the development of the Reicofil[®] system for producing webs primarily from polypropylene.⁷

Further spunbond processes have been introduced. Amoco Fibers and Fabrics, USA introduced the RFX[®] system and Sodoca, France introduced the S-TEX[®] system.¹⁰ These processes are reported to make highly uniform webs even at low basis weights, thereby providing opportunities that the earlier spunbonding processes were unable to meet. Kobelco, Japan, Neumag-Ason, Germany and Nordson, USA are also operating in this market with new spunbonding systems and in Italy, Meccaniche Moderne S.p.A is offering spunbond equipment. Spunbond machinery manufacturers are listed in Table 4.2. Reifenhauser supplies about 70% of current commercial production lines.

A primary factor in the production of spunbonded fabrics is the control of four simultaneous, integrated operations: filament extrusion, drawing, lay down, and bonding. The first three operations are directly adapted from