NONWOVEN FABRICS

Nonwovens are flexible, porous products consisting of one or more fibre layers. The separate fibres may either be preferentially oriented in one direction or may be deposited in a random manner. They are bonded by chemical, thermal or mechanical processes into textile products. Nonwovens are mainly planar structures. This relatively young branch of the textile industry has expanded enormously after the second world-war because of the high production rates and the resulting cost savings.

Contemporary nonwoven fabric dates to the early 1930s. At that time, a few textile companies began experimenting with bonded materials as a way of utilizing cotton waste. The first commercial production of the products now called nonwovens began in 1942 in the United States in an effort to produce fabric directly from fibres. The market for nonwoven products has experienced tremendous growth and has potential for more.

Nonwovens may be classified as either disposable or durable goods. Disposable, or nondurable, nonwovens include such one-time use products as diapers, medical dressings, household wipes, and disposable protective clothing. Durable goods are used for apparel interfacings, automobile headliners, road underlayments, and carpets.

Manufacture:

The basic sequence of steps in manufacturing contemporary nonwoven fabrics is as follows:
Preparation of the fibre → web formation → web bonding → drying → curing → finishing.

For films, the chemical solution is prepared and extruded, or cast, as a film.

Raw Materials:

Polyester is the most frequently used fibre in the United States; olefin and nylon are used for their strength, and cotton and rayon are used for absorbency. Some acrylic, acetate, and vinyon are also being used.

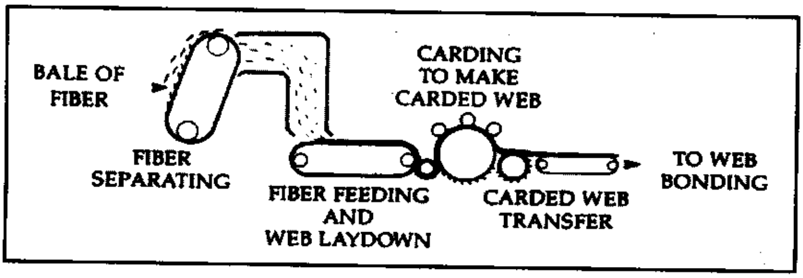
Fibres are selected on the basis of their properties and expected performance in end uses. New, first-quality fibres are preferred over reused or reprocessed fibres. Both staple and filament fibres are used, and it is possible to blend fibres of different lengths as well as fibres of different generic groups. The selection of fibres depends on the product proposed, the care typically given it, and the expected or desired durability. As in the manufacture of all fabrics, the cost of the fibres used is important, as it in turn influences the cost of the final product.

Web Formation:

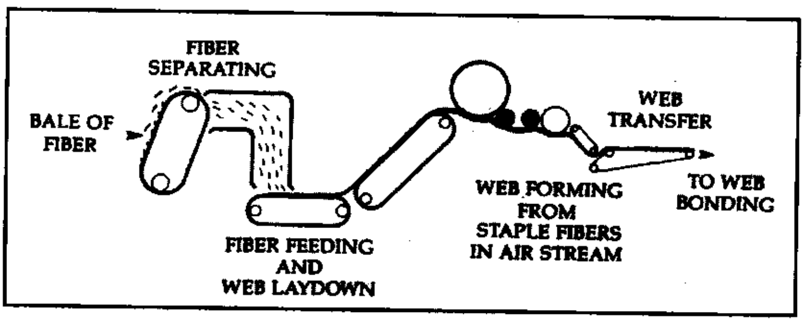
Web formation is the creation of a loosely joined sheet structure by laying down fibres in one of several techniques including, but not limited to, dry-laid and wet-laid webs, spunbonding, and casting films. Both staple and filament fibres are used to form the web, which is usually too weak to be used without additional processing.

I. Dry-laid web:

A dry-laid web is formed by a process similar to that used to produce a card sliver in spinning. Fibres can be separated by suspending them in an air stream and blowing them onto a belt or by using a mechanical card to form a uniform web on a moving belt. The fibres may be somewhat parallel to each other in a random web; they can be made perpendicular by alternating layers of fibres at right angles; or the web may have a parallel fibre arrangement similar to that of a combed yarn web. Fibre bonding is achieved either through the use of a binder or adhesive or by the inclusion in the blend of heat-sensitive fibres, which soften and fuse with other fibres, helping to seal the final fabric.



Web forming by Carding method

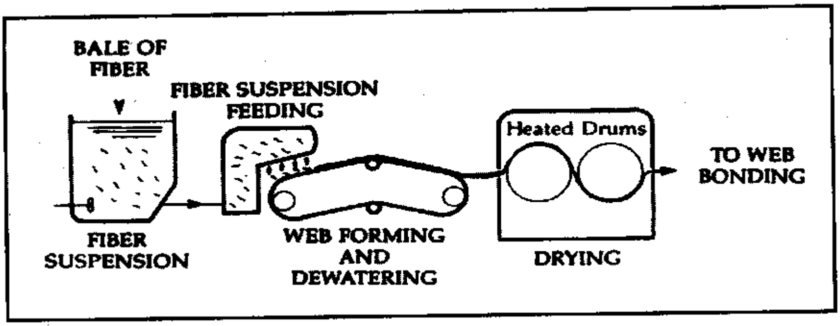


Web forming by the Air laying method

II. Wet-laid web:

A wet-laid web is formed by depositing an aqueous suspension of fibres onto a screen belt or a perforated drum. It permits manufacturers to use very short fibres, even those less than ½ inch long. Wet-laid webs are formed quite rapidly and can be less expensive than other nonwovens if waste fibre is used.

This is similar to the process of making paper. The fibres are suspended in water to achieve a uniform suspension. This flows over the moving screen. When the water filters out, the fibres remain in the form of a wet web. The remaining water is squeezed out and the fabric is dried. Further bonding may be achieved with rollers. A bonding agent, such as thermosensitive fibres or an adhesive, may be incorporated in the suspension to bind the web together as it dries. Alternatively, following formation the web can be sprayed with a binder, which seals the fibre together once the web dries.



Web forming by the Wet laying method

III. Direct-laid web:

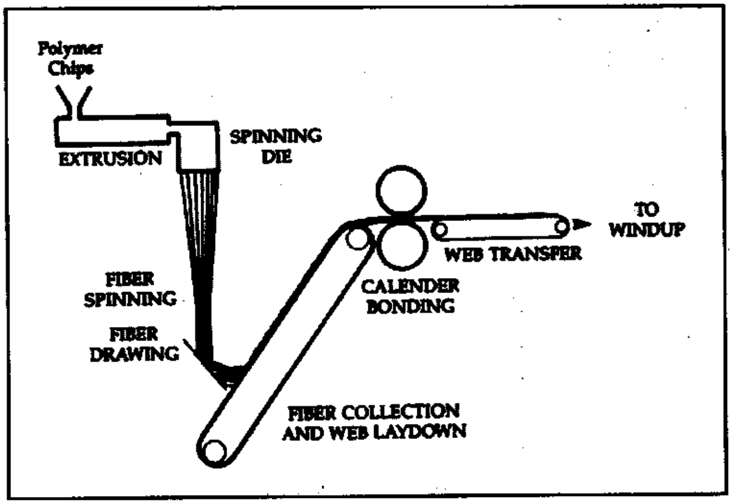
In the direct laid process, webs are made directly from fibres spun from molten polymer. The two direct-laid processes are spunbonding and melt blowing.

a. **Spunbonding:**

This method is used for man-made filament fibres that melt under heat, such as polyester. Spunbonding is a process by which fabrics are produced directly from a thermoplastic polymer such as polyester, nylon, polypropylene, or polyethylene. The molten polymer is extruded through a spinnerette, cooled slightly in the air, and laid on a moving conveyor belt to form a continuous web. As the web cools, the fibres bond.

The pattern of the spun-bonded fabric and arrangement of the fibres can be varied in several ways. The spinnerette can be rotated to deliver filaments in different patterns and arrangements; a jet of air (a controlled stream of air) can be introduced to tangle the filaments; the conveyor can be moved at variable speeds to collect different quantities of filaments at selected locations; and applying an electrical charge to make the fibres loop and crimp.

Spunbonded fabrics are strong because of the filament fibres and are not easily torn. They are used for a wide variety of products ranging from apparel interlinings, carpet backing, furniture and bedding to bagging and packing material. Spunbonded fabrics may be used in geotextiles to control erosion or in constructing road. Some spunbonds made from olefins are used as a tough, especially durable substitute for paper in wall coverings, charts, maps, tags and the like.

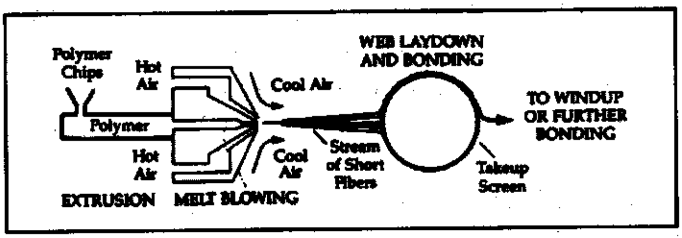


Web forming by the Spunbonding method

Fabrics made by this process include Mirafi 140, made from nylon and polypropylene; Celestra polypropylene; Reemay polyester; Tyvek polyethylene; Typar polypropylene; Bondtex polyester; Cerex nylon; and Bidim polyester.

b. Melt Blowing:

Melt blowing also forms fabrics directly from fibres, but it differs from spunbonding in that molten fibre filaments are attenuated and broken into short lengths as they exit from the spinnerettes. In this process, the molten polymer is forced through a spinnerette into a high-velocity air stream. The impact of the air breaks the filament into short fibres, which then collect on a moving belt to form a web. Cool air distributes the fibres onto a moving screen. As the fibres cool they bond, forming a white, opaque web of fine fibres. Because the fibres in meltblown nonwovens are fine, the fabrics make good filter materials.

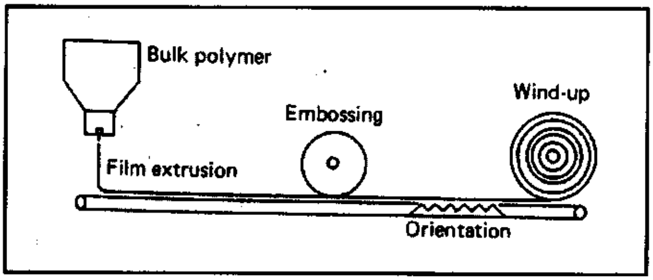


Web forming by the Melt blowing method

Specialty products can also be made by layering spunbonded and meltblown fabrics or by entrapping absorbent fibres or other materials within the meltblown structure.

IV. Film Fibrillation or Extrusion process:

There is another method of fabric construction that does not start with a fibre but with a plastic film. This film is extruded from a melted polymer (a chainlike structure from which man-made fibres can be derived) through a slotted die as a film rather than as fibre filaments. The film is embossed and then is stretched biaxially oriented, to the point where it opens into a netting of fibres. The mechanical embossing produces a weakened area in the film so that stretching the film along both axes creates openings in the film – a nonwoven net. The form of the netting is controlled by the embossing pattern. Hercules Incorporated makes such a net fabric, which it calls Delnet.



Film Fibrillation or Extrusion process

Web Bonding:

After the web is formed, bonds between the fibres must be strengthened and stabilized. Webs are bonded by one of the following processes:

1. Chemical bonding, with either latex or chemical reagents
2. Thermal or heat bonding, with either hot air or a calender
3. Mechanical bonding, by either needle punching or hydroentanglement

1. Chemical Bonding:

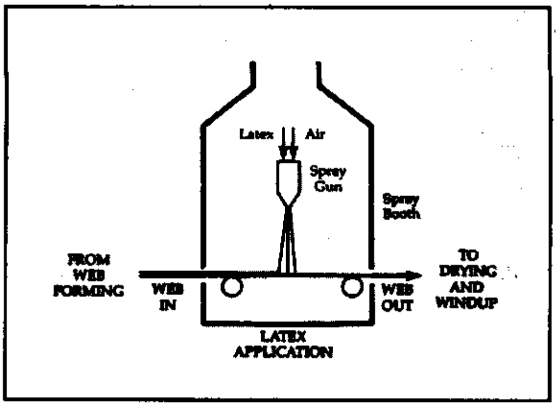
Bonding may be achieved by applying an adhesive material to the web and then setting the adhesive. This, in essence, "glues" the fibres together. Latex adhesives, in which the adhesive substance is suspended in water, are most often used. The fabric web is passed through a bath in which it is impregnated with the latex, and then dried.

When adhesive is applied to the surface of the fibre web, it tends to make the fabric stiff and more rigid. Also, fabrics exhibit the characteristics of the adhesive material on the surface rather than those of the original fibre. To overcome this disadvantage, adhesives may be imprinted onto the surface in selected areas. The printing patterns are developed carefully to ensure that adequate bonding takes place among fibres to maintain fabric strength. Such fabrics are less rigid and have better drapability and a more pleasant surface texture than do those that have been completely coated by an adhesive.

Instead of adhesive bonding, fibres may be solution bonded by spraying a mixture of chemicals and water onto the surface of the fibres. When subjected to heat, the water evaporates and the chemical vaporizes, dissolving a small amount of fibre, usually where one fibre crosses another. When the dissolved fibres resolidify, bonds are formed that hold the fibres together.

In most instances the web is coated with a heat-activated substance. When the web is heated, the substance forms a spot-weld effect at points of contact between fibres. Any solvents that are present evaporate at higher temperatures, leaving behind a structure of fibres sealed together at the weld points. Because no extraneous material is left on the fabric, these materials are softer and have better draping properties than those bonded with adhesives.

Binder and adhesives used in making nonwoven fabrics include acrylic latexes, polyvinyl acetate copolymers, polyvinyl chloride copolymers, nitriles, ethylene vinyl chloride, and vinyl acetate-ethylene. Their singular characteristics produce different properties in nonwoven fabrics.



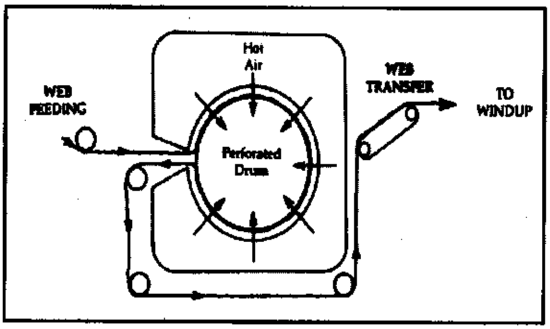
Application of latex adhesive

Acrylic latexes produce fabrics with softness, resilience, high wet-abrasion resistance, and a good hand. Fabrics designed to disintegrate, such as disposable diapers and sanitary products, are often produced with polyvinyl-acetate copolymers. Nitriles, which retain their flexibility at low temperatures, are frequently selected for luggage, footwear, and simulated leather. Ethylene vinyl chloride is used in medical and surgical products. Vinyl acetate-ethylene is used mostly in wet wipes, towels, and other products designed for one-time use.

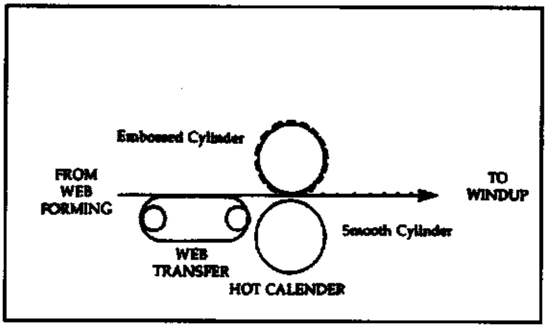
2. **Thermal Bonding:**

Thermoplastic fibres may be bonded by heat. The application of heat causes the fusing together of heat-sensitive fibres, which effectively fastens them together. As in bonding with adhesives, heat may be applied in a pattern to provide sufficient bonding for durability and to allow greater flexibility and softness in the end product. Nonwovens can also be formed with a small percentage of binder fibres of lower melting point than the predominant fibres. When the web is heated, the binder fibres melt, providing the necessary adhesion.

Heat and pressure can be applied to bind fibres into a web. The two common thermal bonding methods are calendaring and air heating. In air heating, hot air fuses fibres within the web and on the surface of the web to make high-loft, low-density fabrics. The hot air is blown through the web in a conveyorized oven or sucked through the web while it is passed over a vacuumed porous drum. In the calendaring process, the web is drawn over and between heated cylinders to produce strong, low-loft fabrics. Spunbond and meltblown nonwovens thermally bond when the molten flaments harden after extrusion. Passing the spunbonded or meltblown fibre webs between heated cylinders called calendar rolls bonds fabrics more completely. Design effects can be produced if these cylinders have patterns embossed on their surfaces. Heat can also be applied to webs by infrared radiation or ultrasound.



Air bonding process



Calendar bonding process

3. **Mechanical Bonding:**

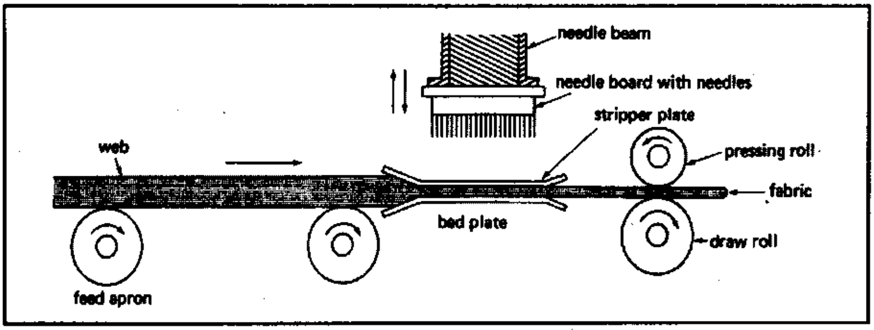
Mechanical bonding is the oldest method of producing nonwovens; it entangles fibres to impart strength to dry-laid webs. The most common mechanical methods are needle punching, spunlacing, also called hydroentangling and stitch bonding.

I. Needle Punching:

In needle punching, barbed needles are punched vertically through the web to hook and entangle tufts of fibres. Needle-punched nonwovens resemble felt in appearance, but they are made primarily from fibres other than wool. Characterized by high density combined with some bulk, they are available in weights from 50 to 285 grams (1.7 to 10 oz) and in thicknesses from 15 to 160 mils.

Two basic steps are involved in the construction of needle-punching nonwovens:

a. The fibre web, or batt, prepared by either carding, garneting, or air-laying techniques, is fed into a machine with specially designed needles.
b. The fibre web moves on a substrate between a metal bed plate and a stripper plate; the needles punch through the plates and the fibre web, reorienting the fibres so that mechanical interlocking or bonding occurs among the individual fibres.



Basic principle of needle punching

The substrate may be filaments, a scrim, or some other form. Placement of the substrate in the middle of the fibre web improves the strength and structural integrity of the finished needle-punched fabric.

The strength of needle-punched fabrics also depends on the fibre arrangement within the webs. If fibres are placed parallel to each other, the finished fabric will have good strength in that direction but will tend to be weak in the opposite direction. If the fibres are in a random arrangement, strength is equal in all directions. A two-step process first tacks the web with 30 to 60 punches per square inch (4.7 to 9.3 per square cm) and then punches with 800 to more than 2500 penetrations per square inch (125 to 390 per square cm). The higher number of punches is used for fabrics such as blankets, which are expected to be subjected to considerable handling during use and care.

The properties of needle-punched fabrics depend on the length and characteristics of the fibres, the physical properties of the web, and the techniques used to produce the web. Most needled fabrics lack any structural pattern because the needles punch and intermingle the fibres in such a random way that the fabric surface appears uniform.

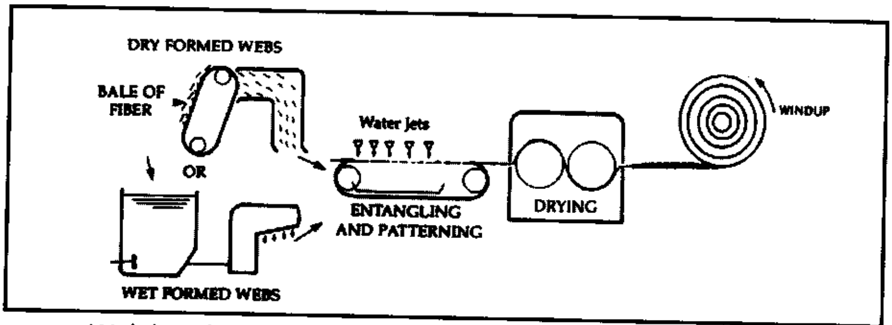
Needle-punched fabrics produced with a modified needle bed and needles that penetrate beyond the surface to form loops on the back can be made to resemble loop pile, velour, or velveteen. The loops either are left uncut or are cut and brushed to give the surface appearance of the pile-woven fabric.

Needle-punched fabrics frequently are found in carpeting and other floor coverings, wall coverings, blankets, padding material, insulation materials, industrial fabrics, and fabrics for vehicles.

II. Hydroentangling:

In hydroentangling, or spun lacing, the fibrous web is subjected to high-velocity water jets to entangle the fibres, causing them to curl and knot around each other. These materials are produced without a binder, resulting in lightweight, soft, and drapable spun-laced fabrics. The Nexus fabrics by Burlington, available in several patterns that can be dyed or printed, best typify this group. Some of these fabrics are washable; others are dry-cleanable. Fabrics range in weight from 0.7 to 2.2 ounces per square yard and in thickness from 3.5 to 25 mils. Typical end uses include quilt-backing fabrics, mattress pad ticking, and substrates for coated fabrics of various types, interlinings, curtains, table coverings, and selected items of apparel. Although most of the spun-laced fabrics on the market are made of polyester, it is possible to use other fibres. Nexus, Sontara, and Polyspun are examples of polyester spun-laced products.

Spunlacing is often used in making kitchen wipes. The wipes have a regular pattern of holes surrounded by tightly entangled fibres. Many wipes are also adhesively bonded for increased wet strength.

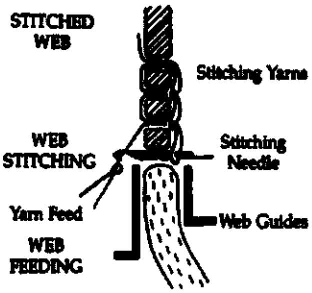


Web bonding by the spunlacing or hydroentangling process

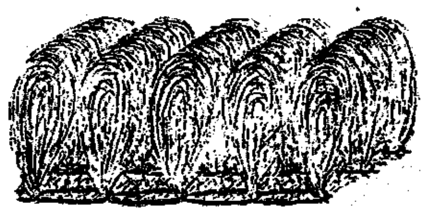
III. Stitch bonding:

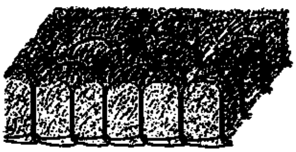
For the stitchbonding technique fibre webs are stitched through to hold the fibres together. Maliwatt fabrics are fibre webs that have been stitched together. The resulting fabrics are used as lining fabrics, furnishing fabrics, insulating materials, base fabrics for tufted goods, and in industrial and geotextiles. Malivlies fabrics, used in felts, packing materials, insulation materials, and utility textiles, are created by forming stitches from the fibres of the web itself. No additional yarns are required.

Other branded processes are kunit and multiknit. Kunit fabrics are formed by feeding a web of fibres into a machine where a type of compound knitting needle forms knitting stitches from the fibre web. These stitches hold the web together and form a fabric that may have either a plushlike, furlike, or flat appearance. Uses include linings for clothing and shoes, plush for toys, automotive interior fabrics, acoustical and thermal insulation, packaging material, and base fabrics to which coatings may be applied. In the multiknit process, two fabrics formed by the kunit process are united into a double-sided, multilayered fabric with knitting stitches made by a compound needle with a sharp point that can penetrate both fabrics. Applications include insulation materials, garment interlinings, base materials for molded textile composites, and as a replacement for foam in car and furniture upholstery.



Stitch bonding process


Kunit


Maliwatt


Malivlies


Multiknit

Finishing:

The final stage in the manufacture of nonwovens is finishing, which includes drying, curing, embossing, printing, and dyeing. Hot – air ovens, infrared lights, rollers over heated cans, or high – frequency electrical equipment can provide the drying action, which also removes any solvents remaining in the fabric. Many of these finishes are similar to those used for standard woven or knitted fabrics.

Care:

Care of nonwovens depends on several factors, including the fibre used, the thickness and direction of fibre lay in the web, the adhesive system used, and the finishes and colours applied. Obviously, the care procedures for durable products will differ from those for disposable products. Procedures for discarding disposable diapers and medical products are now regulated in some municipalities.

Important economic advantages include:

I. no weaving or knitting processes and preparatory stages to those processes;
II. no mechanical spinning process, since nonwovens are made from carded fibre webs, pneumatically made fibre webs or fibre webs made on paper machines;
III. (very) high production rates, for example up to more than ten meters per minute for dry-laid nonwovens and up to several hundreds of meters per minute for wet-laid nonwovens;
IV. savings of labour force and machinery;
V. production of cheap articles, and also dispensable items (one time use) such as nappies, briefs, towels, napkins, aprons, blankets, industrial clothing etc.

Characteristics of Nonwoven Fabrics:

The particular set of properties that a nonwoven fabric may have is dependent upon the combination of factors in its production. The range of characteristics is wide.

The appearance of nonwoven fabrics may be paperlike, feltlike, or similar to that of woven fabrics. They may have a soft, resilient hand, or they may be hard, stiff, or boardy with little pliability. They may be as thin as tissue paper or many times thicker. Nonwovens may be translucent or opaque. Their porosity may range from high, free airflow to minute to impermeable. Their strength may range from low tear and burst strength to very high tensile strength. They may be fabricated by gluing, heat bonding, or sewing. The drapability of nonwovens varies from good to none at all. Some nonwovens have excellent launderability; others have none. Some may be dry-cleaned.

Nonwovens are engineered to provide particular properties suited to desired end uses. For example, diapers can be constructed of two different layers of nonwoven fabrics: an outer layer composed of a wetting-agent treated polyester that will permit rapid fluid penetration, but with minimal lateral wicking, and an inner layer of absorbent rayon. Thin, high-filtration nonwoven fabrics for surgical masks can be composed of microdenier fibres; thick, fluffy, insulating nonwovens for ski jackets can also be made of microdenier fibres. Research continues in order to achieve or perhaps exceed certain properties of conventionally constructed cloth.

Uses of Nonwoven Fabrics:

The use of nonwoven products continues to expand. The many uses of nonwovens may be classified as disposables, durable consumer goods, and industrial materials. All these areas are making increasing use of this kind of merchandise because of its low cost and its suitability for many needs.

Disposable nonwovens are essentially made for one-time use; but some, such as dust cloths, may be laundered and reused a few times. General applications include personal hygiene products, such as diapers and sanitary napkins; medical products such as surgical gowns and drapes; surgical and industrial masks, bandages, wipes and towels; bibs and even costumes for special events. They have recently become popular for lightweight "fun" cloths that can be washed a number of times.

Durable nonwovens have wide applications. Consumer durables include both household goods or home furnishings, such as for draperies, furniture upholstery, mattress padding, towels, table cloths, blankets and carpet backing and clothing or apparel, such as for caps, linings, interlinings, interfacings and the reinforcement of other fabrics.

The many industrial uses include filters, insulation, packing materials, roadbed stabilization sheeting or road-building materials geotextiles and roofing products.

Specialty Nonwoven Products:

Fusible Nonwovens: A fusible nonwoven fabric is any nonwoven fabric with a heat-activated adhesive resin coating. More than half of the interfacings used in apparel construction are fusibles. They are placed between garment layers to provide body, shape, support, additional strength, and foundation. Heat and pressure, applied for a specified time, activate the resin to bond the interfacing to the shell fabric.

Fusible interfacings have some disadvantages. They sometimes produce a stiff or boardy hand; differential shrinkage between the fabrics being joined may produce a rippled garment; and separation of the two fabric layers may occur when improperly applied interfacings are cleaned.

Other special nonwoven products are film fabrics, coated fabrics artificial suedes and leathers etc.